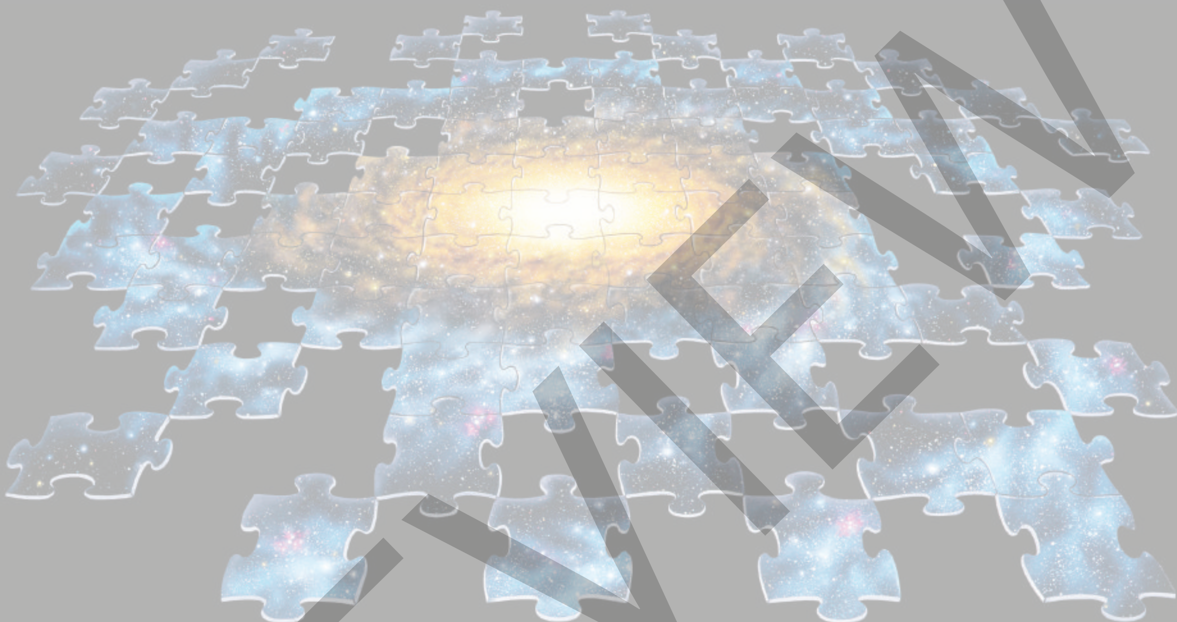
On the Geometry of Time in Physics and Cosmology

and the Fall of the Canonical Cosmological Model



Scientia vincere tenebras
"Conquering darkness by science"

Alexander Franklin Mayer

"Science is not about status quo. It's about revolution."
– Leon Max Lederman

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On the Geometry of Time in Physics and Cosmology
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First Print Edition

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(includes Chapters 1–17)

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I, however, believe that there is at least one philosophical problem in which all thinking men are interested. It is the problem of cosmology: the problem of understanding the world—including ourselves, and our knowledge, as part of the world. All science is cosmology, I believe, and for me the interest of philosophy, no less than of science, lies solely in the contributions which it has made to it. For me, at any rate, both philosophy and science would lose all their attraction if they were to give up that pursuit.

– Karl Popper, *The Logic of Scientific Discovery*, Preface to the First English Edition, (1959).

The greatest obstacle to progress in science is the illusion of knowledge — the illusion that we know already what is going on when we don't.

– Michael John Disney, *BBC documentary* (2006); see http://pdfref.com/m1/00.00.htm

Please be sure to view the 3-minute BBC video clip referenced above. ⇑

To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science.

– Albert Einstein and Leopold Infeld, *The Evolution of Physics*, 'The velocity of light,' (1938).

ordo ab chao

order from chaos

On the Geometry of Time in Physics and Cosmology and the Fall of the Canonical Cosmological Model

First Print Edition (PREVIEW)

15 June 2010

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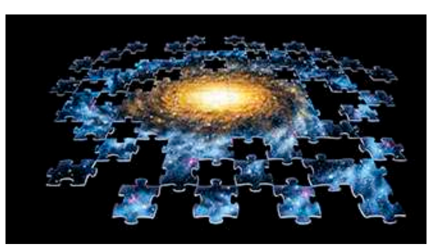

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PREFACE

The key innovation introduced in this book is a revolutionary model of time in the context of relativity. It is aimed at a broad technically educated audience that spans the spectrum of academic and industry professionals to advanced university undergraduates, select science journalists and amateurs in physics, mathematics, astronomy and other physical sciences. Like the Copernican Revolution, which replaced the Earth with the Sun as the center of the Solar System model, this new way of thinking about time is simple and obvious in hindsight. It is based on a direct physical interpretation of Minkowski spacetime geometry, rather than the conventional wisdom that Minkowski's geometric foundation for special relativity introduced a mere "mathematical convenience." The simple step of reinterpreting Minkowski's mathematics as ideal clocks measuring time in different *directions* in spacetime, instead of mistakenly treating it as nothing more than a mathematical abstraction, removes a fundamental impasse to progress in theoretical physics. In this book, students and professionals in a variety of fields will find fruitful new avenues of inquiry providing opportunities to contribute to a new revolution in physics similar to the "modern revolution" of a century ago.

Chapters 1–15 introduce the concept of geometric cosmic time and deal primarily with cosmology. It is shown that recent galaxy redshift survey data are inconsistent with the 'Hubble law' and that a quantitative model of geometric cosmic time is consistent with these data. This model also implies that the supernovae redshift-luminosity curve was mistakenly interpreted as a sudden onset of accelerating cosmic expansion. Chapters 16–25 discuss symmetric relativistic *transverse gravitational redshift* (*TGR*), a ubiquitous empirical phenomenon implying an insufficiency in general relativity because the observable is unmodeled by the Einstein field equations. Progress has been made in gravitational physics by identifying a simple error in the way general relativity models time. An equation that rests on first principles is able to accurately predict the magnitude of the phenomenon manifesting as the observed unexplained variable excess redshift of stars, being most pronounced for white dwarfs. Also, a predicted relativistic modulation of the transponded S-band Doppler tracking signal from the Lunar Reconnaissance Orbiter (LRO), which is not modeled by canonical relativity, is currently under investigation. Chapters 26–30 revisit cosmology, leveraging on the new insights in the prior chapters concerning gravitational physics. Chapters 31–38 discuss relativistic energy and introduce the concept of the momentum wave in quantum mechanics, which provides a path to elegantly solving several outstanding problems in physics, including quantum gravity.

After adopting the model of time introduced herein, it is certain that within just a few years all physical scientists will think to themselves, "How could we have ever thought otherwise?" Yet, upon being confronted with a new idea, there is a prevalent tendency for people to initially think, "That is not the way 'everyone' thinks about it," with the tacit assumption that the conventional wisdom (i.e., textbook dogma) is correct and unassailable. While building on the past is essential to progress in physical science, a bright young lady exhibiting the wisdom of youth at age ten once said to me, "Knowing stuff gets in the way of learning stuff."[1] Accordingly, it is also true that the assumption of knowledge or an emotional need to be knowledgeable in order to live up to an academic title can block intellectual progress. New understanding generally arises from a place of *not knowing* and questioning the authority of experts, including oneself. Perhaps one of the reasons that innovative thinking in physics has consistently been associated with youth is not the intellectual capacity for innovation, but the emotional state of being open to not knowing. Therefore, I encourage my readers to be youthful in their approach to reading this book. Being critical in the context of defending what is assumed to be known cannot lead to new understanding. Rather, the path to new knowledge and the exhilarating feeling of new understanding is the willingness to be critical of what is assumed to be known in the process of evaluating new ideas presented for consideration.

Ultimately, theoretical physics is not about the individual process of developing understanding, but the results of that process as determined by repeatable empirical observations that are consistent with qualitative and quantitative predictions. While the new ideas and unorthodox methods introduced herein may at first seem simplistic to those expecting a more esoteric mathematical approach, the predictive results speak for themselves. Parsimonious (rather than jejune) theory yields predictions that correlate with existing unexplained observations. Moreover, every new idea and empirical prediction appearing in this book ultimately rests on a single first principle: the invariance of the speed of light in vacuum. Confidence in each of the new ideas presented is inspired by the realization that if the speed of light in vacuum is invariant, then it must also be true (i.e., it logically follows) that the new idea is also true.

In the following graph, the nearly 800,000 individual red dots represent the entire set of conventional galaxies for which accurate spectroscopic redshifts (plotted on the horizontal axis) were measured by the Sloan Digital Sky Survey (SDSS). The vertical axis plots the measured apparent magnitude of the galaxy in the SDSS *i′*-band (near infrared) portion of the spectrum, which is centered on a wavelength of 7625 Å. Excluded from this SDSS SkyServer data set are those objects identified as QSO (quasars) according to their distinct characteristics including spectral properties. The SpecObj.z database column is plotted as the redshift. The PhotoObj.fiberMag_i column (*mag* units) is the value of the galaxy's *i′*-band magnitude. The actual SkyServer database query used to produce the plotted data points in red appears after the graph. The accompanying URL provides detailed instructions to rapidly reproduce the plotted data from the SDSS source database and the two redshift-magnitude models.

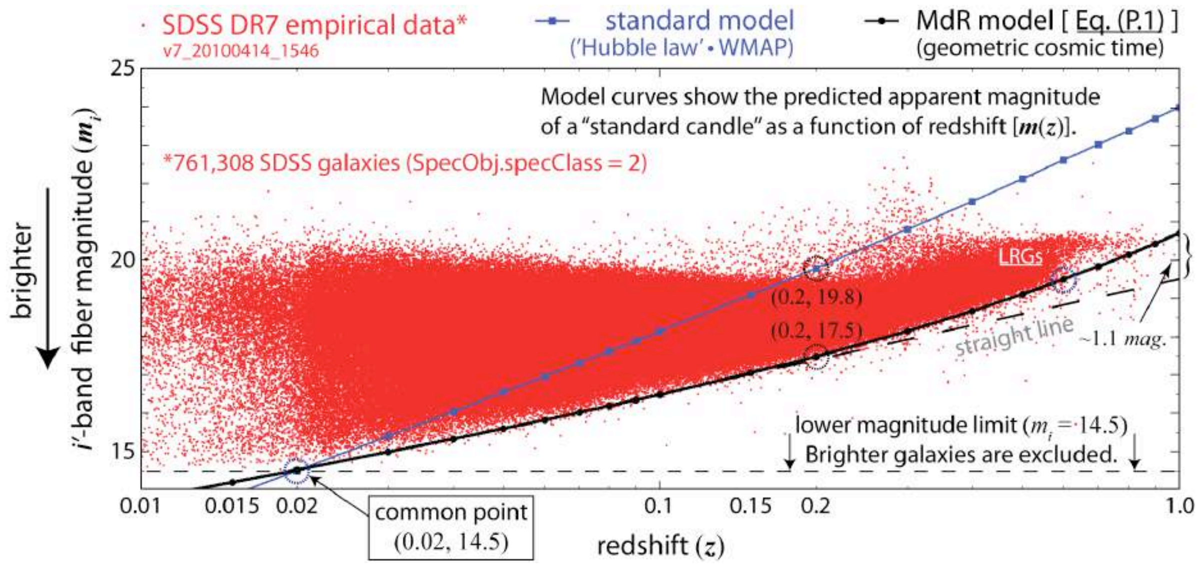


Figure P.1 | SDSS empirical data in red compared to two predictive models. It is reasonable to assume that the base of the data represents a standard candle (i.e., brightest galaxies). The standard model prediction for the dimming of a standard candle with redshift does not fit the empirical data. The empirical data is a perfect fit to the "MdR" predictive curve, which has no free parameters.

http://pdfref.com/m1/00.01.htm **This graph *anchors* the MdR cosmological model.**

```
SELECT
        s.z
,       p.fiberMag_i
FROM
        PhotoObj p
,       SpecObj s
WHERE
        s.zStatus IN (3, 4, 6, 7, 9) /* selected for high-quality redshifts */
AND     p.mode = 1               /* select primary (no secondary) objects */
AND s.    specClass = 2          /* select galaxy spectra (no QSO) */
AND     s.bestObjID = p.ObjID;   /* get the best photometric data */
```

A *lower* number on the astronomical magnitude scale represents a *brighter* object; thus the brightest galaxies are represented by the dots with the lowest vertical coordinate. Five magnitudes on the logarithmic magnitude scale is a factor $2.512^5 = 100$ in brightness (i.e., electromagnetic flux). It is reasonable to assume that the intrinsic brightness of a galaxy is a physical attribute subject to fundamental physical limitations and statistical distribution, as is true for individual stars. Thus, given a number of sufficiently large localized galaxy populations of similar spectral characteristics distributed over a cosmological distance scale, it is logical to assume that, with minor exception, the brightest galaxies in each population have nearly the same intrinsic brightness. These galaxies then function as a "standard candle" so that their change in apparent brightness with distance can be used to check predictive models of how apparent brightness of such a standard candle should change with a different direct measurable such as redshift.

The standard cosmological model is based on the assumption that the observed decrease in the frequency of electromagnetic radiation (i.e., redshift) with cosmological distance to the radiation source implies a general expansion of the Universe. This interpretation, commonly known as the 'Hubble law,' requires the relative recession speed of the source due to the expansion to increase linearly with distance to the source. Although the resulting level of detail is extraneous in Fig. (P.1), the blue curve reflects precise calculations of relative luminosity distance as a function of redshift [$D_L(z)$] according to the WMAP cosmology ($H_0 = 71$, $\Omega_M = 0.27$, $\Omega_\Lambda = 0.73$).[2,3] In the redshift regime $z < 1$, realistic variation in the free parameters of the standard cosmological model, including a positive cosmological constant associated with 'dark energy,' makes no significant change to the blue curve representing this model. The slope of the standard model curve plotted in blue reflects both the 'Hubble law' and the luminosity inverse square law; the ten-fold increase in redshift from ($0.02 \leq z \leq 0.2$) implies a ten-fold increase in distance (d) and yields a five-fold increase in modeled apparent magnitude (m_i) from 14.5 to 19.8, which implies a hundred-fold decrease in apparent luminosity (L) of a standard candle (i.e., $L \propto d^{-2}$). The additional 0.3 *mag* is primarily due to time dilation dimming; "spacetime curvature" also contributes.

The canonical model does not fit the empirical data. The average error bar (< 0.01 *mag.*) in the SDSS photometry is a tiny fraction of the typical difference between the standard model curve and the base of the empirical data, which increases to about three magnitudes (×15.85) for this data set due to the large difference in their average slope. As a statistical group, the empirical data plotted in red is known to be an accurate reflection of physical reality, so the failure of the standard model to accurately predict the observations implies that the model is incorrect. The idea that the Universe is expanding is predicated on the validity of the 'Hubble law'; a failure of that law to correspond to empirical observation implies the need for an alternative physical interpretation of the cosmological redshift.

The crisis in cosmology produced by recent claims of *accelerating* expansion, which for many reasons cannot be a real physical phenomenon, implied the need for new questions and new answers to replace prevalent unrealistic thinking constrained to support the dominant cosmological paradigm.[4] A synthesis of original ideas put forward by Hermann Minkowski (1864–1909), Willem de Sitter (1872–1934) and Bernhard Riemann (1826–1866) yields a completely new and accurate cosmological model ("MdR") to replace the conventional canonical model. For example, the apparent magnitude of a standard candle as a function of redshift is described in the MdR model by the following parsimonious equation, which is derived in detail from first principles in the body of this dissertation. This simple equation incorporates a product of three distinct terms: (**a**) a geometric term associated with a spatially finite yet boundaryless Riemannian spacetime; (**b**) a relativistic term associated with time dilation; (**c**) a second relativistic term associated exclusively with the geometric effects of "spacetime curvature" on apparent luminosity.

$$m(z) = C - 2.512\ \log\left(\frac{1}{4\pi\left[(z+1)^4 - (z+1)^2\right]}\right) \tag{P.1}$$

The constant C is determined for a given class of standard candle (e.g., brightest conventional galaxies) and bandpass filter (e.g., i'-band) according to a particular reliable empirical coordinate (z_0, m_0). Note that there are no free parameters whatsoever to fit the model to observations; this equation is among several similar *a priori* exact theoretical predictions of cosmological observables that rest exclusively on first principles.

In the preceding graph of SDSS photometric data, the redshift-magnitude coordinate (0.02, 14.5) for the brightest galaxies observed in the nearby universe yields ($C = 15.2$) for this class of "standard candle." The function $m_i(z)$ is then plotted as the series of black dots. The correlation to observation is remarkably accurate, which reflects well on the empirical data produced by the SDSS team. One should note that the curve in the empirical data is precisely matched by the predictive theoretical model and that the difference at redshift $z = 1$ between the theoretical *curve* and the dashed straight line is just over one magnitude.

The SDSS galaxy data terminates somewhat before redshift $z = 1$, so in spite of the remarkable correlation between theory and observation shown in the foregoing graph, it would be premature to accept the proposed model as an accurate reflection of physical reality on a cosmological scale prior to similar confirmation of accurate prediction at high redshift. The MdR model assumes no "galaxy evolution" over a universal cosmological timeline initiated a finite time ago; galaxies evolve, but lookback time is not over a universal time coordinate. Consequently, it is understood that galaxies and galaxy populations sharing the same general physical properties are ubiquitous in space and time, existing at all redshifts. It follows that the brightest galaxies at very high redshift have the identical intrinsic brightness as similar local galaxies for much the same reason that it must be true that subatomic particles, atoms and physical laws at very high redshift have identical properties to the same particles and laws on the Earth.

The Hubble Ultra Deep Field (HUDF) includes a population of 1308 conventional galaxies, many at very high redshift, whose fundamental properties have been reportedly measured with good accuracy by the team of R. E. Ryan *et al*. (http://pdfref.com/m1/00.02.htm). These measurements appear as the red dots plotted in the following graph. The identical predictive curves in Fig. (P.1) appear in this graph, though they are now extended to a redshift of $z = 6$. This HUDF data provides accurate empirical observations from the SDSS cutoff point ($z < 1$) to the farthest observable reaches of the Universe, also using an i'-band bandpass filter. Again, the predictive curve of the MdR model is remarkably consistent with observations.

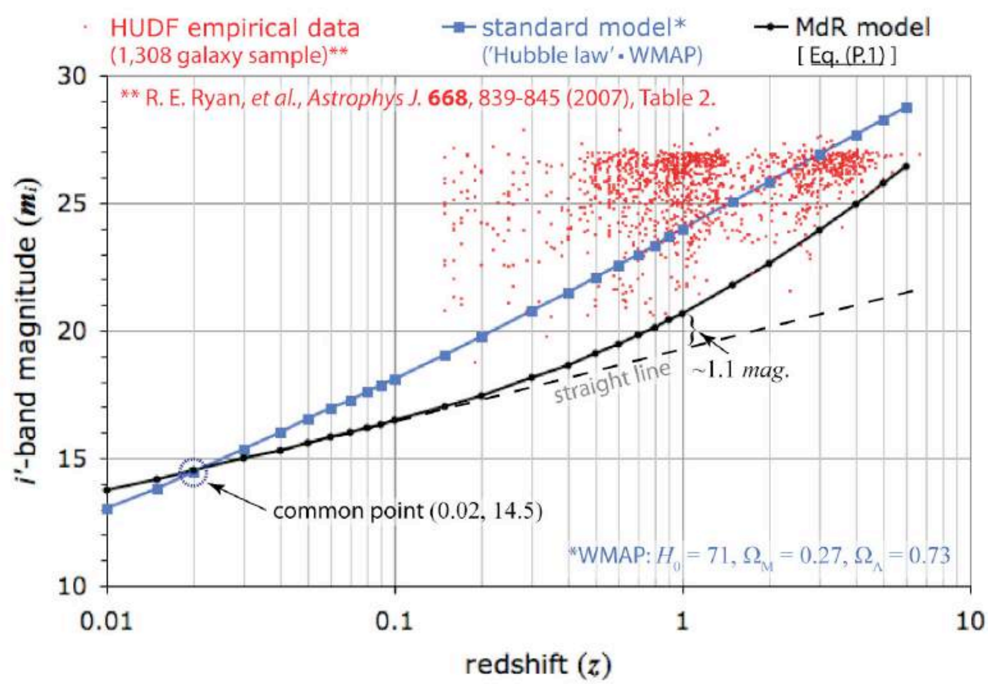


Figure P.2 | HUDF empirical data in red compared to the two predictive models. Having the same common point as the predictive curves in Fig. (P.1), these two curves simply extend those original curves out to high redshift. Hundreds of galaxies fall beneath the standard model predictive curve, yet above the MdR curve. Moreover, in the range ($1 < z < 6$) the brightest galaxies tend to accurately follow the significantly *non-linear* curve of the MdR prediction with just five outliers. Several galaxies fall on the curve. The fit of both empirical data sets to the MdR predictive curve, which was unknown to the observers, is indicative of the remarkable quality of the published data.

The *slope increase* in the empirical redshift-magnitude curve of the SDSS data, which is precisely predicted by the theoretical curve modeled by Eq. (P.1) and confirmed at high redshift by the empirical redshift-magnitude curve of the HUDF data, is similarly seen in the published redshift-magnitude curve for Type Ia supernovae. However, this observed phenomenon has nothing whatsoever to do with alleged "accelerating expansion" caused by so-called 'dark energy,' which is an unphysical fictitious product of undisciplined imaginations. Rather than having discovered an accelerating universe doomed to eventual extinction, the modern astronomical community has provided definitive empirical proof that the Universe is *not* expanding as was originally imagined by mathematician and priest Georges Lemaître.

The MdR cosmological model also yields the following differential equation describing the change in the volume of space with redshift. There are no free parameters. The constant C is a dimensionless scaling parameter that shifts the curve vertically to adjust for variable homogeneous space densities of different objects (e.g., conventional galaxies have a higher space density than those with bright active nuclei).

$$\frac{dV}{dz} = \frac{4\pi C}{\sqrt{1-(z+1)^{-2}}}\left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4}\right) \tag{P.2}$$

While few typical galaxies beyond redshift $z = 0.6$ are resolved by the SDSS telescope, evidently the brightest active galactic nuclei (AGN) are readily seen and counted at very high redshift ($z > 3$) as shown in the complete set of SDSS QSO candidates plotted in the Fig. (P.3) redshift-population histogram, below. Serendipitously, the criteria used to identify SDSS QSO candidates (SpecObj.objType = 1) yielded a uniquely useful data set of unusually bright galaxies spanning the complete range of redshift.[5,6]

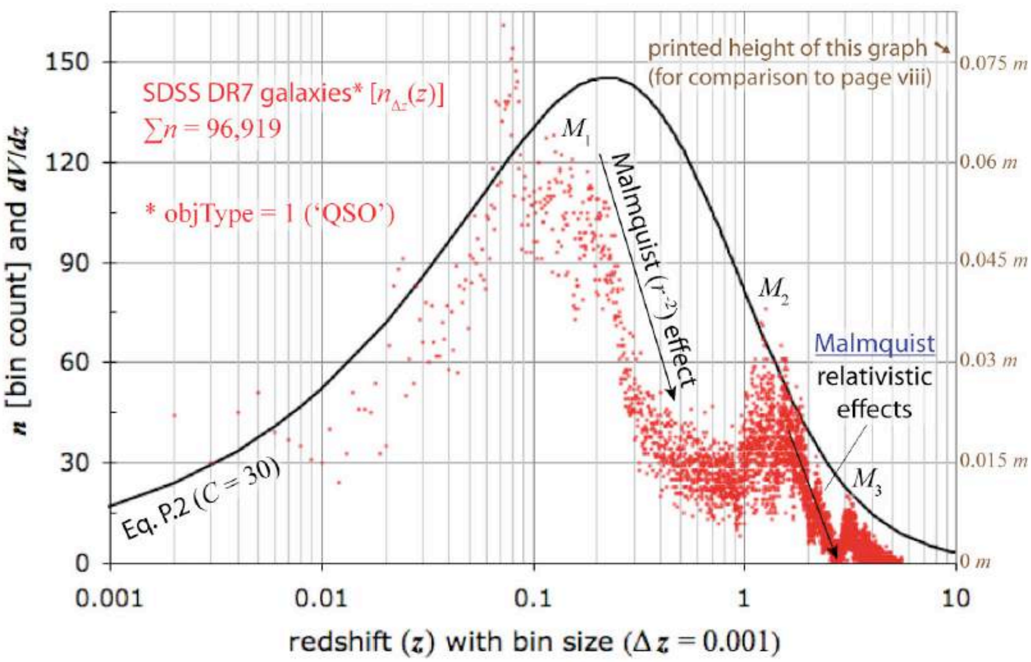


Figure P.3 | Bright galaxy ('QSO') redshift-population histogram compared to MdR model. The SDSS data plotted in red represents a subset of unusually bright galaxies, the majority of which are QSO. For more information on the empirical histogram shown, see Appendix E. The black curve plots Eq. (P.2) with ($C = 30$). The empirical data exhibits three distinct maxima labeled M_1, M_2, M_3.

The M_2 and M_3 maxima in the data require explanation. Historically, the former has been interpreted as an increase in the space density of AGN at this lookback time, estimated to be on the order of 10 billion years ago. This interpretation implies a cosmic evolutionary effect whereby a greater percentage of galaxies incorporated bright active galactic nuclei in the past than is presently the case. The foregoing discussion pertaining to Eq. (P.1) implies that this interpretation is invalid. In MdR, the cosmic space density of AGN is assumed to be uniform, similar to gas molecules inside a flask. In the redshift regime $z < 0.1$, virtually all AGN are seen and counted, so the empirical redshift-population histogram follows the theoretical dV/dz curve here. Between ($0.1 < z < 1$) as distance increases dramatically, about 80% of the less luminous AGN drop out of the SDSS sample. Above $z = 1$, nearly all of the brightest AGN making up about about 20% of the total local population are initially seen and counted, so again the empirical histogram follows the predictive curve. Relativistic effects (e.g., time dilation dimming) cause a majority of these to drop out of the sample with increasing redshift, until only an extreme variety of AGN are left in the sample at $z = 3$.

The empirical redshift bins (the identical graphed red dots) shown in Fig. (P.3) and again in Fig. (P.4) are differential shells at increasing radius from the Milky Way, so their volume (over the entire sky) is equal to the surface area of the sphere at their distance ($4\pi r^2$) multiplied by a small increase in radius (dr) represented here by ($\Delta z = 0.001$). Consequently, the bin volume scales as the square of the bin's distance. The linear portion of the canonical modeled curve in Fig. (P.4) reflects the 'Hubble law,' which assumes a linear relationship between redshift and distance; thus, galaxies at $z = 0.1$ are modeled to be 100 times the distance of galaxies at ($z = 0.001$). Accordingly, the surface area of concentric spheres associated with the respective bins at these two redshifts differ by four orders of magnitude, which is reflected by a corresponding change in the modeled dV/dz function of the identical order (10^4).

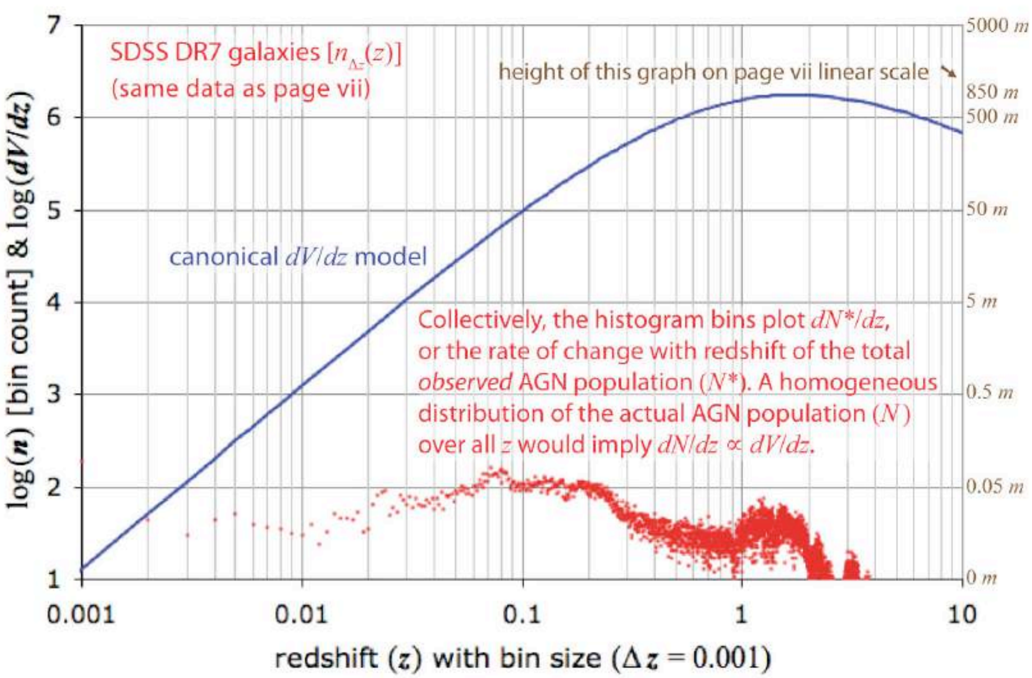
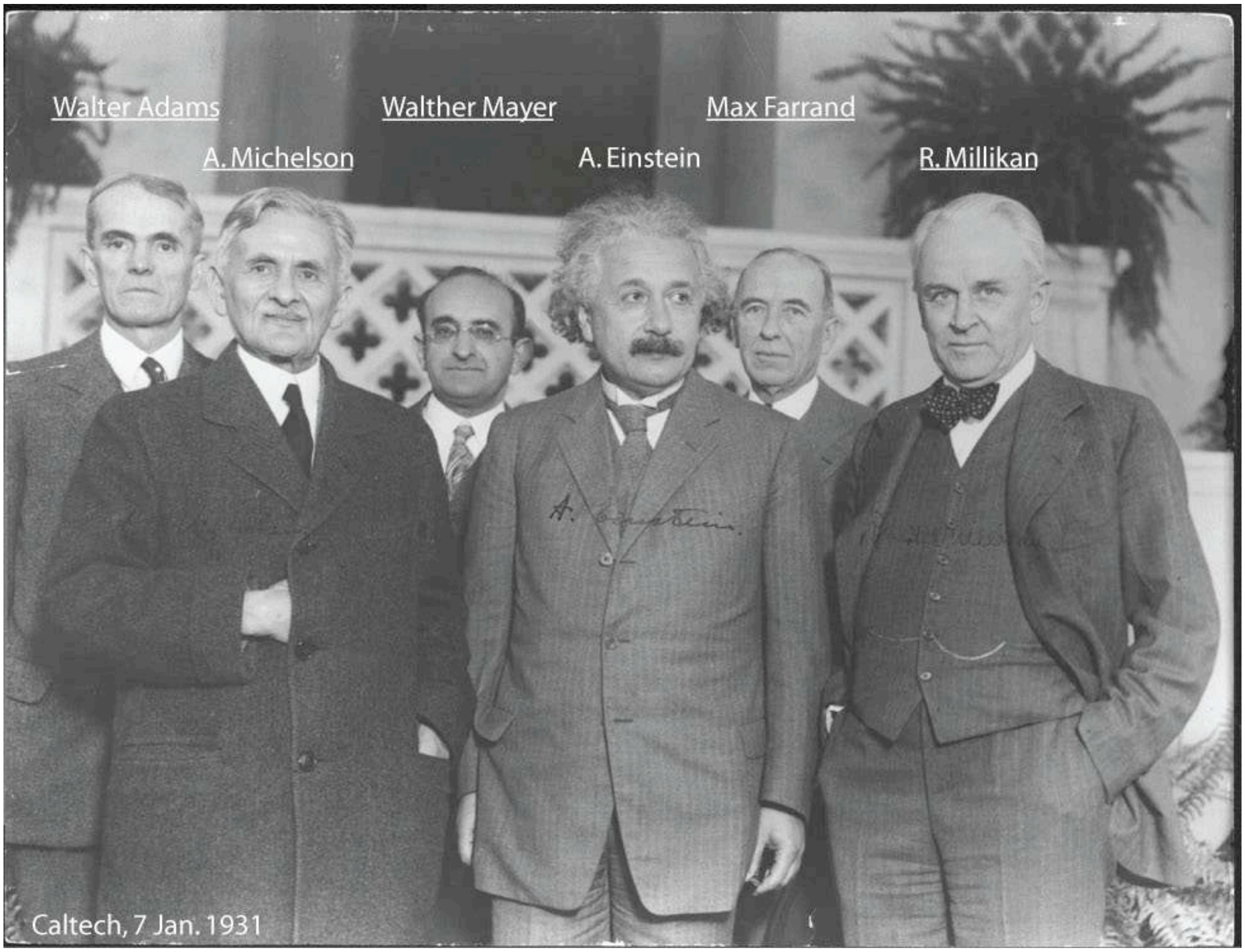


Figure P.4 | Canonical dV/dz model versus empirical redshift-population histogram (dN^*/dz). The identical data appearing in the Fig. (P.3) graph is now plotted on a log scale. Because volume scales as the cube of radial distance, the apparent error in the canonical redshift-distance model shown in Fig. (P.1) and Fig. (P.2) produces an enormous error in the canonical redshift-volume model.

As shown in the graphed empirical data, the brightest variety of AGN can be seen at limiting cosmological distance; comparing a bright AGN to a typical galaxy is similar to comparing a searchlight to a handheld spotlight. This means that AGN populations observed at high redshift, which are limited to the brightest subset of the complete population, are nearly as good at indicating population trends with distance at their distant locale as are complete populations observed in the nearby universe. This is because observed changes to the high-redshift AGN population (dN^*/dz) are exclusively limited to this extremely bright subset of galaxies, which are a representative fraction of the total AGN population there.

Imagine that the canonical dV/dz function shown in this log-log plot was instead shown using a linear bin population scale (i.e., shown for comparison in the graph on page vii over the same range of redshift). The peak value of this curve is about 1.7×10^6. As zero to 100 on the y-axis requires about 5 *cm* on page vii, an 850-meter roll of paper (*greater* than the height of the Burj Khalifa, the world's tallest building) would be required to accommodate the canonical dV/dz curve. In the bottom ten centimeters, one would see the graph on page vii contrasted to the canonical curve rising 850 meters into the sky, which allegedly matches the same data. By inspection, the canonical dV/dz model does not fit the high-quality empirical SDSS DR7 AGN data. In contrast, the new theoretical dV/dz model shown in the Fig. P.3 graph provides a remarkably good fit to the identical empirical data. It also explains the three distinct maxima.

So was he [Einstein] a saint?, I asked Balázs. “No,” he replied firmly. “He was better than that — he was human.” – Graham Farmelo (Nándor Balázs assisted Einstein for one year at Princeton circa 1952. He died in 2003.)



Courtesy Smithsonian Institution Libraries. Hyperlink overlay from Ze’ev Rosenkranz, *The Einstein Scrapbook* (2002), p. 132.

“Although Einstein was the greatest genius of the twentieth century, many of his groundbreaking discoveries were blighted by mistakes, ranging from serious errors in mathematics to bad misconceptions in physics and failures to grasp the subtleties of his own creations.”

– Publisher’s synopsis from the front jacket cover of:

Hans C. Ohanian, *Einstein’s Mistakes: The Human Failings of Genius,* (W. W. Norton & Co., New York, 2008).

Hans Ohanian is the author of several physics textbooks.
He studied relativity with John Wheeler at Princeton University.

“…we might say that an ordinary mistake is one that leads to a dead end, while a profound mistake is one that leads to progress. Anyone can make an ordinary mistake, but it takes a genius to make a profound mistake.” – Frank Wilczek in *The Lightness of Being,* (Basic Books, 2008), p. 12.

Mathematician Georges Lemaître (left), astronomers Edwin Hubble (center) and John C. Duncan (right) appear together in this photograph chronicling the Catholic priest's **1925** visit to Mt. Wilson Observatory.

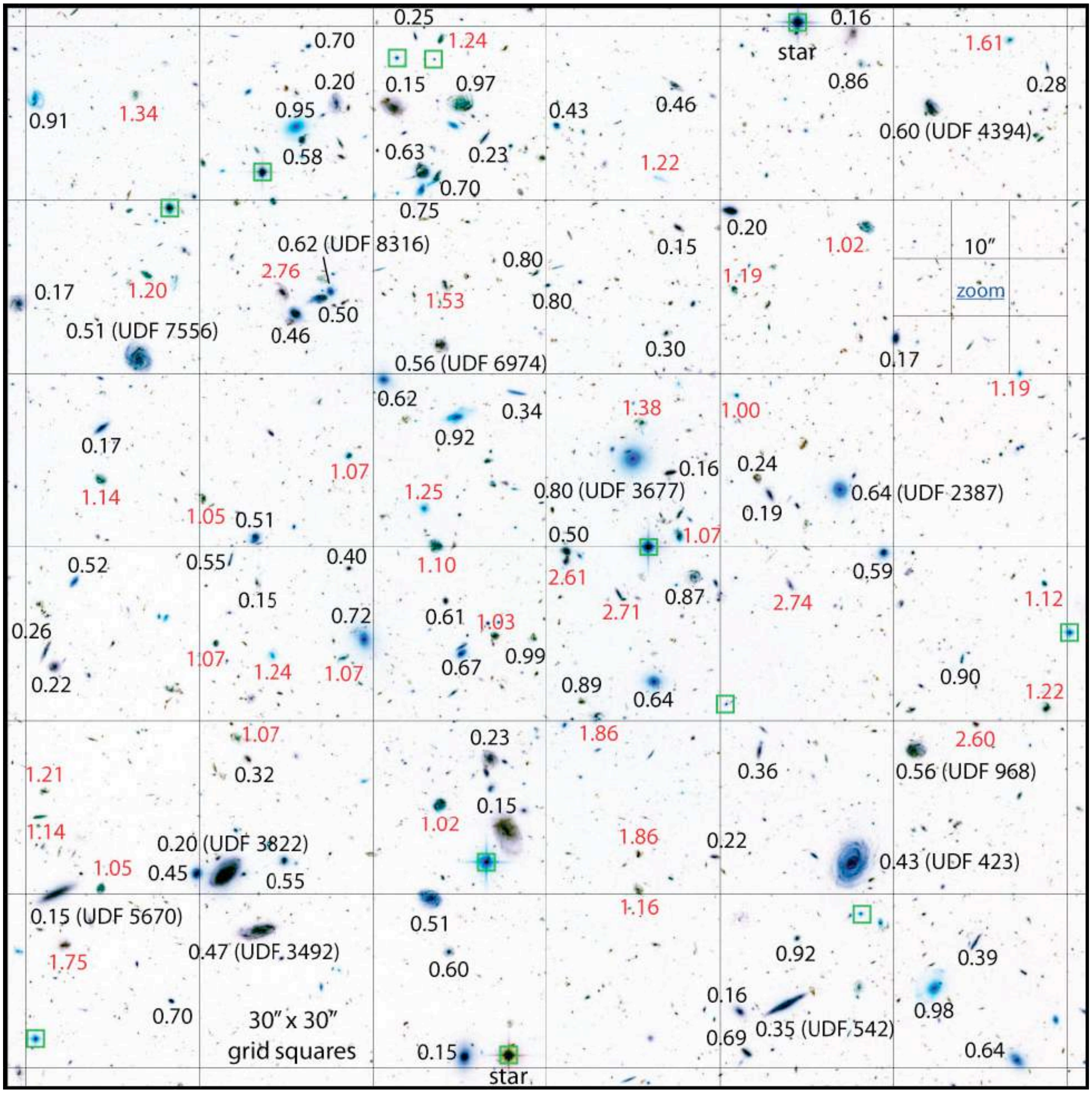
Associated Historical Timeline

- 1920 – Lemaître receives a Ph.D. in mathematics from the Catholic University of Louvain.
- 1921 – Lemaître asserts in writing his belief that, "as *Genesis* suggested it, the Universe had begun by light."[7, 8, 9]
- 1923 – Lemaître is ordained a Catholic priest following seminary at the Maison Saint Rombaut.
- 1925 – Lemaître accepts a position as lecturer at the Catholic University of Louvain.
- **1925 – Lemaître visits Edwin Hubble at Mt. Wilson Observatory (photo).**
- 1926 – Lemaître submits paper that first proposes a suddenly created expanding universe and the 'Hubble law.'
- 1927 – *Annales de la Société scientifique de Bruxelles* publishes this paper entitled, "A Homogeneous Universe of Constant Mass and Increasing Radius accounting for the Radial Velocity of Extra-galactic Nebulœ" in French.
- 1927 – Lemaître receives a Ph.D. in physics from MIT.
- **1929** – In *PNAS*, **Hubble** claims an expanding universe with $H_0 = 500\ km/s/\mathrm{M}pc$; Lemaître is not referenced.
- 1931 – A British journal (*MNRAS*) publishes an abridged English translation of Lemaître's seminal 1927 paper.
- 1931 – Lemaître in *Nature*: "...the beginning of the world happened a little before the beginning of space and time."[10]
- 1958 – *Astrophysical Journal* publishes the first major correction to 'Hubble constant': $H_0 = 75\ km/s/\mathrm{M}pc$ (A. Sandage).
- 1960 – Lemaître appointed President of the Pontifical Academy of Sciences (term ending upon his death in 1966).[11]
- **1998** – Supernovae data interpreted as a sudden onset of ***accelerating expansion*** initiates a ***scientific crisis.***

186" x 186" negative image of the Hubble Ultra Deep Field (HUDF)

The original telescope source image was cropped (http://pdfref.com/m1/hudf.0.htm)

This Hubble Telescope image of about 9,000 targets implies an average population of about 225 galaxies per 30" x 30" grid square. Here, 115 redshifts are labeled per the cited reference.



The vast majority of light in the HUDF comes from galaxies, with the exception of several stars (e.g., green squares). The positive Hubble Telescope source image is courtesy NASA, ESA, S. Beckwith (STScI) and the HUDF Team. Redshifts shown ($z \geq 1$ in red) reference the AHaH program (Mechtley, Windhorst, Cohen & Will, 2008). See http://pdfref.com/m1/hudf.1.htm and http://pdfref.com/m1/hudf.2.htm

Also see Steven Beckwith *et al.*, "The Hubble Ultra Deep Field," http://pdfref.com/m1/hudf.3.htm

Caveat: Some of the redshifts cited in the above image may be subject to correction pending precision ground-based measurements by DEIMOS to calibrate HST GRAPES measurements.

PREAMBLE QUOTATIONS

Unfortunately, a study of the history of modern cosmology reveals disturbing parallelisms between modern cosmology and medieval scholasticism; often the borderline between sophistication and sophistry, between numeration and numerology, seems very precarious indeed. Above all I am concerned by an apparent loss of contact with empirical evidence and observational facts, and, worse, by a deliberate refusal on the part of some theorists to accept such results when they appear to be in conflict with some of the oversimplified and therefore intellectually appealing theories of the universe.

– Gérard de Vaucouleurs (1918–1995)

"The Case for a Hierarchical Cosmology,"
Science **167**, 1203 (1970).

Δ

The leading idea which is present in all our researches, and which accompanies every fresh observation, the sound which to the ear of the student of Nature seems continually echoed in every part of her works, is —

Time! — Time! — Time! *

* It is very remarkable that, while the words *Eternal*, *Eternity*, *For ever*, are constantly in our mouths, and applied without hesitation, we yet experience considerable difficulty in contemplating any definite term which bears a very large proportion to the brief cycles of our petty chronicles. There are many minds that would not for an instant doubt the God of Nature to have existed *from all Eternity*, and would yet reject as preposterous the idea of going back a million of years in the History of *His Works*. Yet what is a million, or a million million, of solar revolutions to an Eternity?

– George Poulett Scrope, *The Geology and Extinct Volcanos of Central France*, (1858), p. 208; Google Books: http://pdfref.com/m1/00.03.htm

Δ

People think the problem with models is that they are limited by our minds, but the greater problem is that our minds are limited by our models.

– Kenneth G. Gayley (2008)

Δ

★ It's the things that we most take for granted that have the tendency to come back and bite us when it really matters. The nature of space and time is generally taken for granted. But our assumptions about them seem to be inconsistent and as a result, if we are honest, theoretical physics is currently derailed at its very core.

– Shahn Majid in the section "A Hole at the Heart of Science,"
On Space and Time, (Cambridge University Press, 2008), p. 58.

Δ

★ In this world, time is a local phenomenon. Two clocks close together tick at nearly the same rate. But clocks separated by distance tick at different rates, the farther apart the more out of step. What holds true for clocks holds true also for the rate of heartbeats, the pace of inhales and exhales, the movement of wind in tall grass. In this world, time flows at different speeds in different locations.

– Alan Lightman in *Einstein's Dreams,* (Vintage Books, 2004), p. 120.

Δ

A theoretical construction represented by elementary geometry and understood as an object of immediate geometrical experience leads to a strong expectation of internal consistency, more than an analytical derivation does for the outsider.

– Dierck-Ekkehard Liebscher in *The Geometry of Time,* (Wiley, 2005), p. 1.

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SCIENCE HAS AN UNSURPASSED POWER TO BRING ABOUT CHANGE

Science, which is beautiful in various and sometimes unexpected ways, has an unsurpassed power to bring about change. At times we have made sudden leaps in understanding after long years of painstaking work, such as Charles Darwin's grasp of natural selection in evolution or Louis Pasteur's remarkable breakthroughs in the causes and prevention of disease. In other cases, we have relied on changes in technology to further knowledge, such as the invention of the telescope in astronomy. Often, scientific work has been accompanied by an alchemical mixture of creativity and logic, leading to new solutions for age-old problems. All of these elements are part of the rich tapestry of the history of science. They are beautiful as ideas, as innovations, and as new understandings.

It is vital for us to remember that we are on an unknown arc toward an unknown future. There is still a great deal to be discovered and perhaps a number of current understandings to be overturned. We find beauty in the unknown realm of science as well as the known.

From the introduction to *Beautiful Science: Ideas that Changed the World*
Dibner Hall of the History of Science, The Huntington
Author: Daniel Lewis, Dibner Senior Curator

A change of concept changes one's reality to some degree, since concepts direct percepts and much as percepts impinge on concepts.

– Joseph Chilton Pearce, *The Crack in the Cosmic Egg* (Park Street Press, 2002), p. 8.

Download a free web-enabled excerpt at http://pdfref.com/m1/00.04.htm

We can survive [this century] and we can fail to survive. But, it depends not on chance, but on whether we create the relevant knowledge in time. The danger is not at all unprecedented. Species go extinct all the time. Civilizations end. The overwhelming majority of all species and all civilizations that have ever existed are now history. And if we want to be the exception to that, then logically, our only hope is to make use of the one feature that distinguishes our species and our civilization from all the others, namely our special relationship with the laws of physics. Our ability to create new explanations, new knowledge, to be a hub of existence.

– David Deutsch on our place in the cosmos (quoted verbatim from his TED 2005 talk)

That is my recommendation to all of you: Look where everybody is [going], what they are doing—go do something completely different. Don't try to improve a little bit on what somebody else is doing because that does not get you very far.

– Charles Elachi, Caltech Vice President and JPL Director (Serious Play 2008)

Be open to new ideas and new ways of looking at the world. Don't let yourself get stale and locked in some worn out paradigm. Sometimes these supposed "cranks" have really interesting and unique ways of looking at things. They may have unique backgrounds that give them a fresh perspective on certain topics including the science itself. Don't ever reject an idea simply because "it just can't be right" even if you can't find anything logically wrong with it.

– Ian T. Durham, (*Quantum Moxie*, 24 November 2009)

On the Geometry of Time in Physics and Cosmology and the Fall of the Canonical Cosmological Model

The geometric properties of time arising from insights introduced by Hermann Minkowski are discussed. A geometric model of time yields a simpler and more natural explanation of relativistic temporal effects than prevailing ideas and better explains astrophysical empirical observations, including the apparent accelerating expansion of the Universe. It is shown that new accurate and corroborating empirical data from the two largest recent galaxy redshift surveys (*2dF and SDSS*) *are inconsistent with the standard cosmological model, yet provide robust empirical support for a revised model based on temporal geometry arising from the principles of relativity.* ***This dissertation also introduces several innovative and illuminating ideas related to special relativity, general relativity and quantum mechanics.***

Accurate portrayals of nature enhance survival.
– Ed Krupp, AAS Meeting, Pasadena (10 June 2009)

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"Predictable Irrationality"

Think about how hard it is to believe that your intuition is wrong. Given the fact that we think our intuition is right, it is very difficult to accept the need to do an experiment to try and check if we are wrong. But the fact is that being wrong is a constant situation for all of us. We have very strong intuitions about all kinds of things, but unless we start *testing* those intuitions, we are not going to improve. We need to systematically challenge our intuitions by experimentation.

– Dan Ariely (paraphrased from the end of his TED 2009 talk)

1. HISTORICAL BACKGROUND

In the first decade of the 21st century, two independent mapping projects in the form of large galaxy redshift surveys (2dF in Australia and SDSS in the U.S.) provided new corroborating data that must forever alter our understanding of the physical universe. Similarly, the prospect of an accurate world map may have in part motivated the Greek philosopher-mathematicians to abandon the ancient world's model of a 'flat' Earth suggested by the illusory experience of unidirectional gravity. The key abstract concept that was required for the historical transition from a naïve to an accurate geometric model of the Earth was the understanding that the local vertical (i.e., the altitude 'dimension' of space) is not parallel over the extent of Earth's surface, in spite of persuasive superficial experience. An accurate cosmological model requires a similar paradigm shift, which concerns the geometric relationship between space and time for the Cosmos.

When Einstein's concept of "curved spacetime" was initially applied to cosmology in 1916 and 1917, it was first suspected that the totality of cosmic 3-dimensional space manifests as a finite yet boundaryless volume (S_3), which is similar in topological properties to the familiar finite yet boundaryless surface area of a 2-sphere ($S_2 = 4\pi r^2$).[12, 13] Although a finite boundaryless volume is mathematically trivial, it is something that is experientially inaccessible and therefore difficult for most people to visualize or imagine as something physically real. Einstein first rationalized the idea that maximal extension of any local line segment in physical cosmic space must produce a finite closed geodesic curve. In *real projective space*, the maximum possible distance of separation between two points is $\pi/2$ times the effective spatial radius of the Universe (i.e., the unique cosmic antipode to any galaxy is modeled at this distance as measured over a connecting geodesic pointing away from that galaxy in any arbitrary local direction).

At about the same time that Einstein proposed his relativistic theory of gravity, Vesto Slipher, Director of the Lowell Observatory in Flagstaff, Arizona, first discovered the preponderance of redshifts for the spiral nebulae (not yet confirmed to be distant collections of stars distinct from the Milky Way).[14, 15, 16] More than a decade later, Edwin Hubble at Mt. Wilson authoritatively announced in a famous 1929 paper that the galactic redshifts were indicative of a recessional radial velocity.[17] According to his astrophysical measurements, the relationship between the redshift of a galaxy and its distance (H_0) was linear, amounting to an initially proposed value of 500 $km/s/Mpc$. Hubble's paper, which appeared in the *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*), suggested that reliable empirical evidence implied that the Universe was expanding, apparently initiated by a kind of primordial explosion. According to experience, gravity is an exclusively attractive force, so a phenomenon that somehow prevents general cosmic gravitational implosion over time is required to explain the observed universe. An expanding universe appealed as a natural solution to this problem.

The idea that the Universe had a distinct beginning is credited to a Catholic priest. Ordained in 1923 at age 29, Abbé Georges Lemaître's cosmic creation idea was first published in the same year he earned his Ph.D. in astrophysics from MIT (1927). A precursor 1921 essay, *God's First Three Declarations*, was self-described as "an attempt to interpret scientifically the first verses of Genesis."[18] Later he reportedly summarized his ideas as "the Cosmic Egg exploding at *the moment of Creation*."[19] Evidently, Lemaître's concept of a suddenly created expanding universe was founded on an influential personal interpretation of the ancient Hebrew biblical creation myth that was extended to be cosmological in scope.

Lemaître met with Hubble at Mt. Wilson in 1925, which is documented by a photograph of the two together at the observatory (see preceding page x). In the following year, Lemaître submitted a paper discussing his idea of an expanding universe, which was published in 1927.[20] This paper was not widely read as it was written in French and appeared in an obscure Belgian scientific journal. An abridged English translation of this seminal paper, "A Homogeneous Universe of Constant Mass and Increasing Radius Accounting for the Radial Velocity of Extra-galactic Nebulæ," appeared in *Monthly Notices of the Royal Astronomical Society* two years after Hubble had established his reputation for discovering cosmic expansion in 1929.[21] It is typically assumed that the idea of cosmic expansion was initiated by unbiased empirical observation of galaxy redshifts, yet evidence suggests that Hubble got his ideas from the priest as early as their 1925 meeting and that his linear relation between galaxy redshift and distance passing through the origin of the graph was an unwarranted subjective interpretative fit to Lemaître's expanding universe theory. Hubble had a peculiar habit of fabricating impressive personal achievements, so it is not unreasonable to suspect that Hubble's 1929 paper may not have been as original as it may have seemed.[22]

It took three decades for astronomers to accept that Hubble's original proposal of an expansion constant of $H_0 = 500$ $km/s/\mathrm{M}pc$ was impossible, as this value would imply that the Universe was considerably younger than the minimum age of the Earth already established by geologists. A more accurate value for the 'Hubble constant' (H_0) was estimated to be about an order of magnitude lower.[23,24] This large correction to Hubble's original quantitative analysis of the astrophysical data was apparently not considered a threat to his qualitative interpretation of that data. The initially controversial idea of an expanding universe became popularly known as the *Big Bang theory*, although this moniker was originally intended by its author, famed British astronomer Sir Fred Hoyle, to mock what he felt was a ludicrous idea.

Penzias and Wilson's 1965 discovery of the cosmic microwave background radiation (CMB) lent credence to the theory as this radiation was assumed to prove the predicted existence of the ubiquitous cooled remnants of heat generated by a primordial cosmic explosion.[25,26] Also, it is known that the stellar nucleosynthesis process results in a net consumption of deuterium (^{2}H) in stars, rather than its production. The measured cosmic abundance of ^{2}H and other light elements suggests a non-stellar source of intense heat and pressure, which lends further credence to the Big Bang theory and its cosmic primordial phase. Late 20th-century high technology enabled more accurate redshift-luminosity measurements; in 1998, astronomers were shocked when the interpretation of these new measurements implied an accelerating cosmic expansion rather than one that was anticipated to be slowing down due to the effects of gravity.[27] This interpretation requires a mysterious and inexplicable cosmic energy source to fuel the phenomenon, which was dubbed "dark energy," ironically reminiscent of the Dark Ages.

Over the 20th century, the Big Bang theory evolved to become a major cornerstone of modern science, yet the fact that the theory requires an incredible event representing *the beginning of time* presents one of its greatest scientific challenges. No satisfactory explanation exists of how an event that produces spacetime and the physical universe can occur when spacetime (*and so time itself*) does not exist prior to this purported event. The purported singularity in space and time at $T = 0$ defies logical analysis.

> In the tradition of *Amadeus* and *A Beautiful Mind*, [the screenplay] "Hubble" is the magnificent story of one of history's greatest and most flawed geniuses and the even more magnificent universe he sought to map. In 1931, Edwin Hubble became the most famous man in the world. He was heralded as the greatest astronomer since Galileo. His discoveries had an irrevocable impact on both Einstein's Theory of Relativity and religious interpretations of the origins of heaven and earth. But Hubble was a haunted man, dogged by mysterious secrets from the past and by enemies that threatened to destroy everything. How could a man who spoke with a British accent, wore a cape, and carried a cane be from Missouri? Why did none of his stories of his past match the claims of others? How could his wife Grace knowingly perpetuate all of this? Driven by intense ambition and a longing for something that was lost long ago, a man whose life is cloaked in pathological lies paradoxically discovers [what is purported to be] one of science's greatest and most enduring truths.[28]

It is an odd fact of history that the foundation of 20th-century cosmology (the veritable foundation of all science and even of modern mankind's pervasive scientific ontology) is the product of an ecclesiastic with an obvious bias (Lemaître) and an inveterate fabulist (Hubble). In this light, the forthcoming revelations based on new high-quality astrophysical data and accurate predictive theory are not so very surprising.

2. GALAXY REDSHIFT SURVEY DATA

Fig. (2.1) presents data from two galaxy redshift surveys. The Two Degree Field Survey (2dF) employed the Anglo-Australian Telescope at Siding Spring Observatory in Australia.[29] Its database, completed in 2003, contains high-quality spectra for over 200,000 objects in the southern sky. The Sloan Digital Sky Survey (SDSS) has been conducted from the Apache Point Observatory in New Mexico.[30] SDSS has now mapped and analyzed more than 930,000 galaxies and more than 120,000 quasars over about one-quarter of the northern sky. Data Release 7 (DR7) of the SDSS database, first published in November 2008, includes *high-quality* spectroscopic data out to redshift $z = 5.535$ for over 800,000 galaxies and quasars.[31]

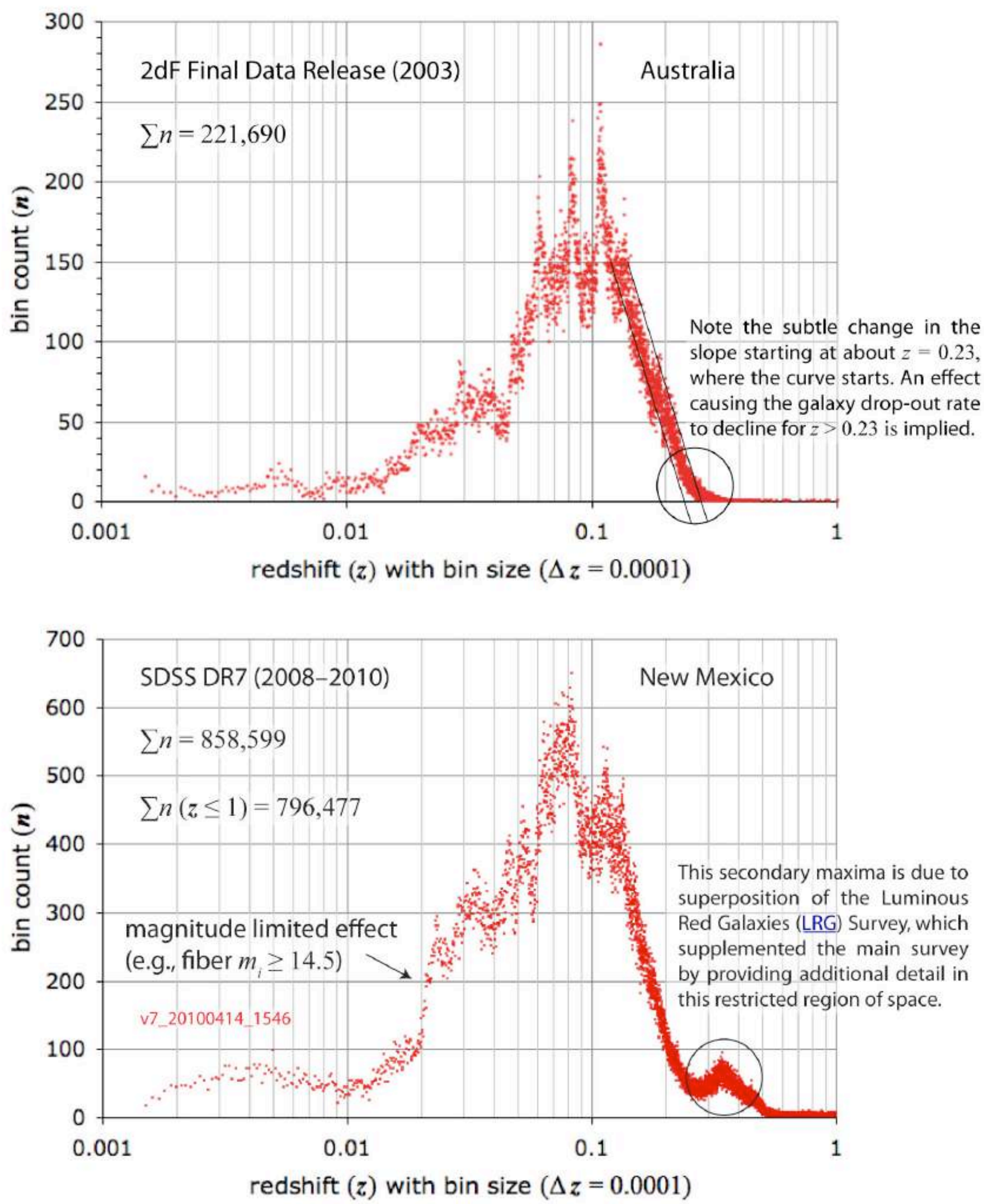


Figure 2.1 | Data from the 2dF and SDSS galaxy redshift surveys limited to $(0.0015 \leq z \leq 1)$. The low redshift cutoff $(z \geq 0.0015)$ eliminates misidentified double stars and very few galaxies.

The two histograms in Fig. (2.1) were created in a very simple way. Spectroscopic data selected for high quality was sorted into bins (represented by the dots) having a Δz of 10^{-4} and coordinates (z, n) where n is galaxy count. The graphs show the galactic population trend in redshift space (dN^*/dz). The total number of galaxies plotted in each graph is indicated as Σn. The graphed SDSS data can be easily recreated directly from the online SDSS database using the following simple Structured Query Language (SQL) statement.

http://pdfref.com/m1/02.01.htm

```
SELECT
        ROUND(z, 4) AS z
,       COUNT(1) AS n
FROM
        SpecObj
WHERE
        zStatus IN (3, 4, 6, 7, 9)    /* selected for high-quality redshifts */
AND z >= 0.0015                    /* removes misidentified double stars */
GROUP BY
        ROUND(z, 4);
```

The graphed 2dF data requires an intermediary database.

http://pdfref.com/m1/02.02.htm

```
/* This query must be performed on the online 2dF database. */
/* The WHERE clause specified below returns 233,251 rows. */
/* The limitation (extnum = 0) implies primary FITS extension (best spectrum). */

SELECT z_helio, alpha, ra2000, delta, dec2000
        FROM TDFgg
WHERE extnum = 0 AND quality >= 3; /* (quality >= 3) reduces row count from 382k to 233k */

/* This query must be performed on a local database table after importing the above data. */
/* The online 2dF MiniSQL (mSQL) database does not support the COUNT() function. */
SELECT
        ROUND(z_helio, 4)
,       COUNT(1) AS n
FROM
        TDFgg_local
WHERE
        z_helio >= 0.0015      /* removes misidentified double stars */
GROUP BY
        ROUND(z_helio, 4);
```

According to the two graphs, these two distinct surveys exhibit nearly identical qualitative results. Because they were conducted in opposite hemispheres, the surveys incorporate data on different sets of galaxies far removed from one another. Because different teams using different instruments conducted the two surveys, correlations between the data sets are certain to reflect underlying empirical reality. Due to the inherent accuracy of spectroscopy and the statistical nature of the data, these surveys represent a uniquely objective astrophysical insight into cosmology. Their corroborating galaxy maps, which have been made available only recently, provide conclusive empirical evidence that the conventional cosmological model (i.e., the Big Bang theory) incorporates fundamental errors of empirical interpretation in similar fashion to the misbegotten cosmology put forward by Aristotle in his treatise, *On the Heavens*, circa 350 B.C.E.

Although the spatial volume of the bins must increase from redshift 0.001 to 0.01, the number of selected bright galaxies per bin remains nearly constant over this range. This observed drop in galaxy space density provides strong confirmation (in the nearby universe) of Benoit Mandelbrot's pioneering assertion in his 1977 book, *Fractals: form, chance, and dimension*, that galaxies are fractally distributed.[32] When the fractal dimension of a physical structure is less than three, the number density of points decreases when the volume of space under consideration is increased. This is exactly what is observed.

The Copernican Principle or "mediocrity principle" is the rational notion in the philosophy of science that there is nothing unique about the Earth's physical location in the Cosmos. Consequently, the astronomical perspective of the large-scale Cosmos out to the limits of observation as seen from Earth is understood to be essentially the same as from a planet in any other galaxy. The cosmological principle is an extension of the Copernican Principle arising from the simple consideration that gravity is a conservative force that naturally produces isotropic symmetry. Properly formulated, the cosmological principle states that looking in any direction in space from the vantage point of any galaxy, the large-scale universe must look similar. Succinctly, this means that no observer may look out from a galaxy located at a misconceived "edge" of the universe where in one direction can be observed many other galaxies and in the other a limitless void bereft of galaxies. While galaxies exhibit a fractal distribution on a large local scale, this restriction on the physical nature of the Universe (i.e., that it is boundaryless) implies that at some observational distance, galaxies must transition to a homogenous and isotropic distribution.

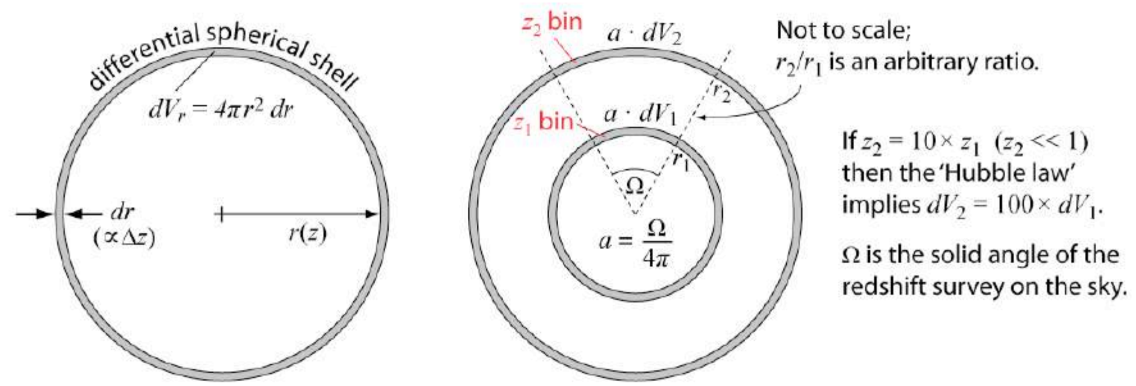


Figure 2.2 | Volume of a differential spherical shell of thickness Δz. For a given solid angle on the sky (a survey region), the observed volume fraction (a) is independent of distance. Assuming that the function $r(z)$ is linear, the volume of space represented by bins of identical Δz (i.e., identical dr) increases as the square of the spatial distance represented by the characteristic redshift (z) of the bin.

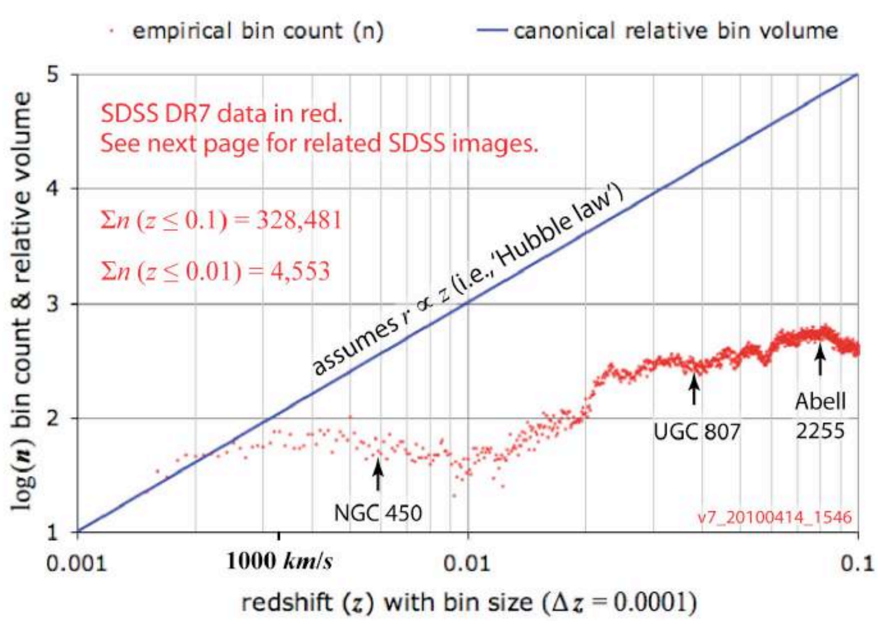


Figure 2.3 | Observed low-redshift galaxy population trend vs. *canonical* relative bin volume. A redshift of $z = 0.005$ represents the outer boundary of the local supercluster (Virgo). SDSS observes internal detail of typical galaxies well beyond this distance. The SDSS images and data on the next two pages imply that within order $z < 0.1$, *at least* 10% of survey-selected bright galaxies are counted within this redshift. The huge deficit of galaxies in the survey in the range of redshift shown here as compared to the Hubble prediction cannot be attributed to galaxies dropping out of the sample.

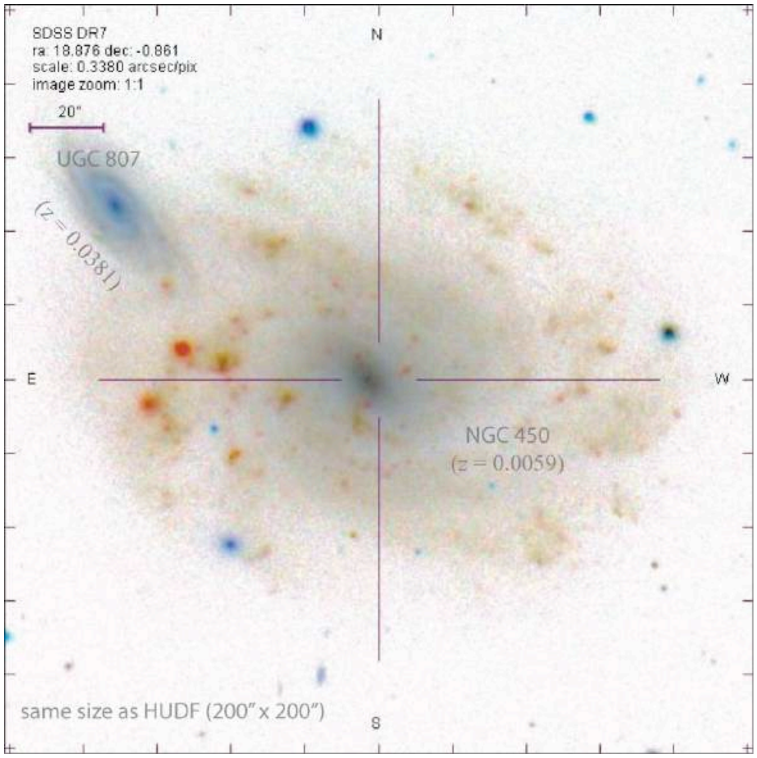


Figure 2.4 | SDSS negative (20" ticks) of the two galaxies referenced in Fig. (2.3).

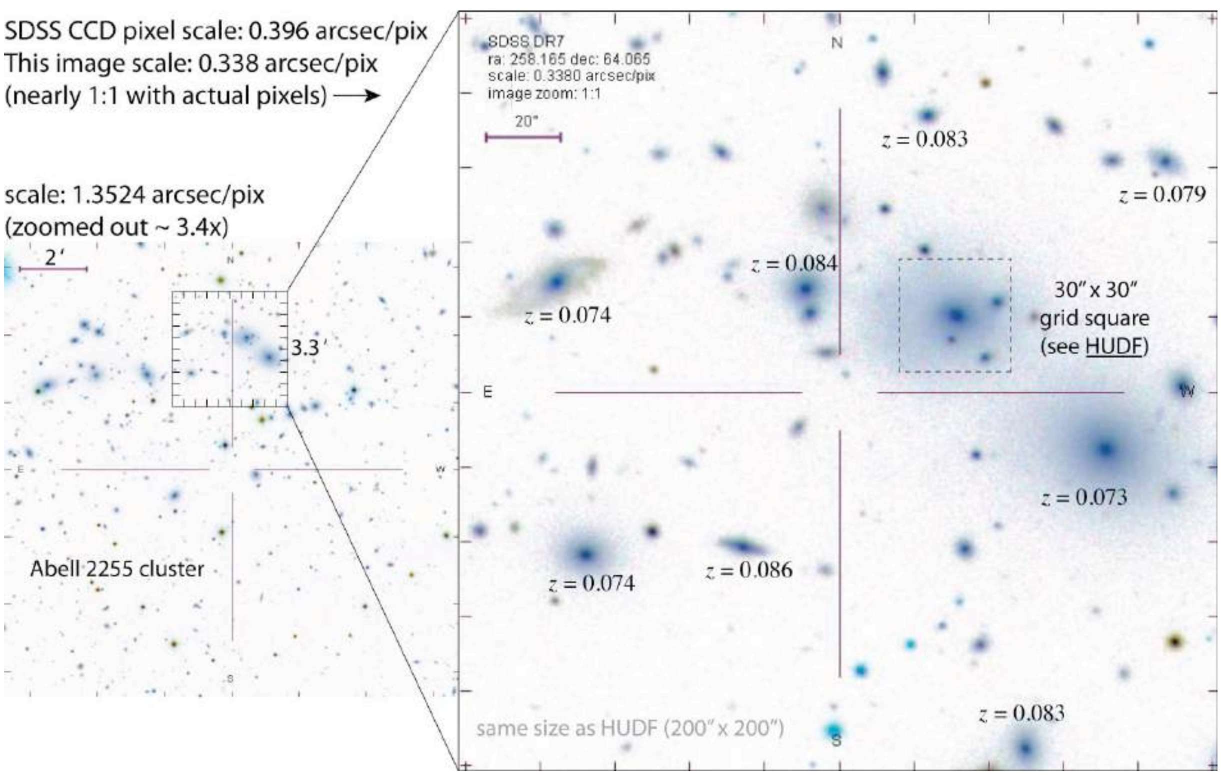


Figure 2.5 | SDSS negatives (2' & 20" ticks) of cluster Abell 2255 referenced in Fig. (2.3).

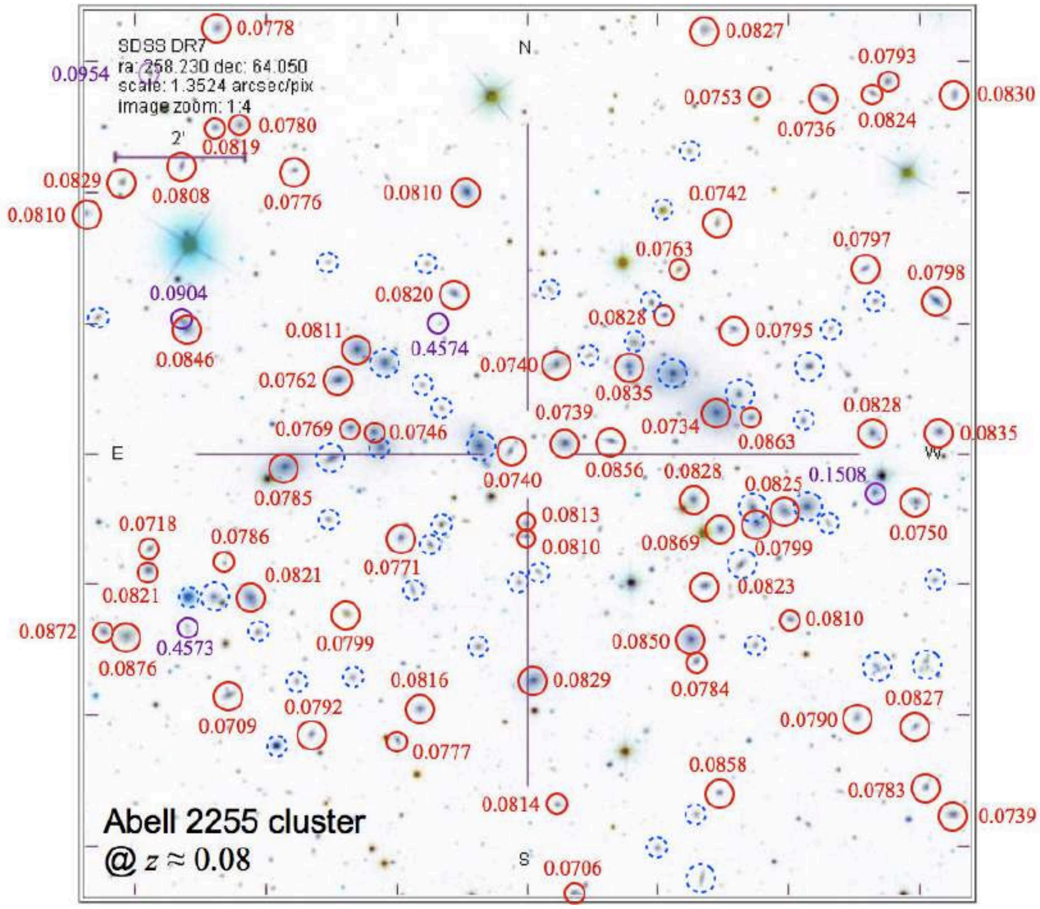


Figure 2.6 | Spectroscopic redshifts were measured for a majority of galaxies in this cluster. Blue dashed circles are likely cluster members but had no optical fiber allocated. With perhaps some exceptions, the smaller and dimmer uncircled dots are external background galaxies at higher redshift.

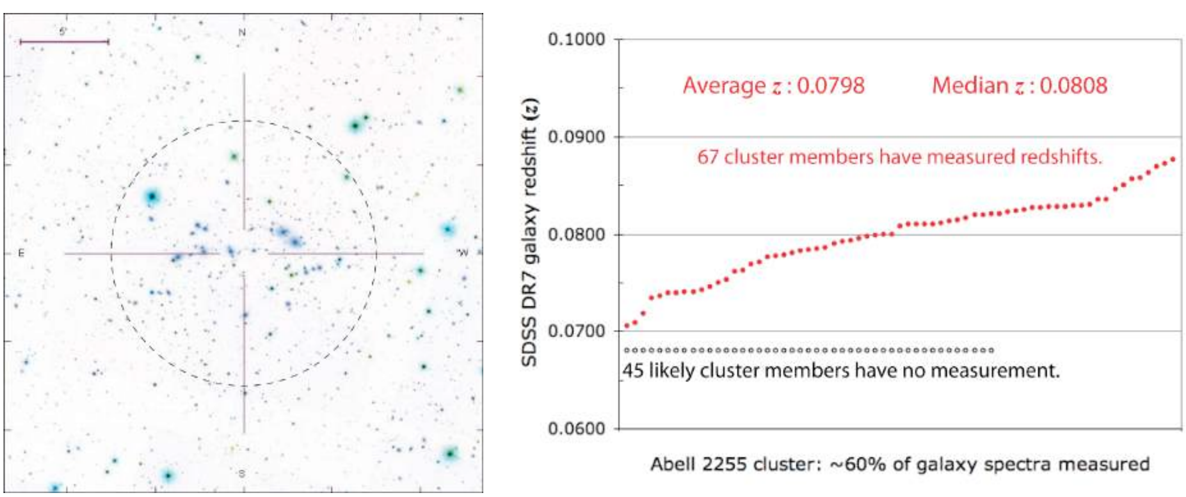


Figure 2.7 | The Abell 2255 cluster core in context (5' ticks) and its redshift measurements. The 15-arcsecond diameter dashed circle contains most of this cluster's galaxies. Clearly, SDSS has measured redshifts for a large percentage of typical $z < 0.1$ survey-selected bright galaxies in its field.

A slice of redshift (Δz) represents a spherical shell in space. The spatial thickness of this shell (dr) is the same at any redshift z within a range where the relationship between redshift and distance is linear. *Assuming a linear relationship*, the volume of space enclosed by these differential shells will increase as the square of the redshift (i.e., the square of the distance). Consequently, according to the 'Hubble law' and the simple geometry in Fig. (2.2), the spatial volume of a redshift bin plotted at $z = 0.015$ in Fig. (2.3) is about two orders of magnitude larger than a $z = 0.0015$ bin plotted in the same graph. Identically, the redshift range ($0.01 \leq z \leq 0.1$) ostensibly represents a change in bin volume by a factor of 100.

With no possibility of huge numbers of selected bright galaxies having dropped out of the sample, bin galaxy counts in Fig. (2.3) remain constant between $z = 0.001$ and 0.01, representing an apparent drop in galaxy space density over this redshift range by two orders of magnitude. In the range $z = 0.001$ to 0.1 shown in Fig. (2.3), the linear redshift-distance relationship prescribed by the 'Hubble law' implies that bin volume increases by four orders of magnitude, yet the empirical bin galaxy count increases by just one order of magnitude. As discussed in the Fig. (2.3) comments, this apparent drop in galaxy space density according to the survey data cannot be attributed to observational effects; it cannot be that the majority of survey-selected bright galaxies are of insufficient apparent luminosity to be counted as distance increases within the redshift range shown. Regardless of the apparent modeling error in the redshift-distance relationship, the observed apparent decrease in galaxy space density as the redshift survey bin volume increases to $z = 0.01$ suggests a fractal distribution of galaxies in the nearby universe as implied by a previously published more complex geometric analysis of galaxy clustering in space.[33]

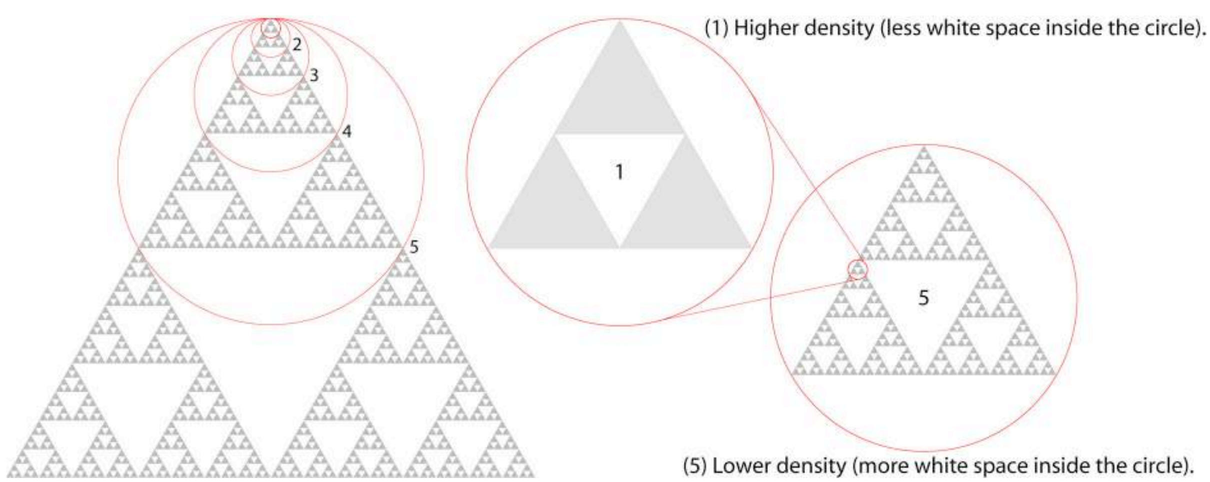


Figure 2.8 | A Sierpiński triangle formed by 6 "cluster-size" iterations exhibits large voids.
As it is constructed with three copies of the unit object, producing a new self-similar object scaled up by a factor of two, this fractal has Hausdorff dimension [$D = \log(\mathbf{3})/\log(\mathbf{2}) \approx 1.585$]. This simple illustrative example of fractal geometry in two dimensions clearly shows the characteristic increase in the space density of fundamental unit objects (smallest triangles) as the area under consideration (red circles) decreases. Also, in contrast to a homogeneous distribution of objects (e.g., gas molecules), large voids are a fundamental feature of a fractal distribution of objects. The term "supervoid" has been coined for the observed *WMAP cold spot* in Eridanus, an apparent void of cosmological scale.[34]

Assuming that the higher redshift data ($z > 0.01$) graphed in Fig. (2.1) is reasonably accurate, the closely matching spikes and dips in the two graphs show cosmically global variations in galactic space density. Also, the matching overall shape of the two curves, which exhibits a dramatic rise at about $z = 0.01$, a peak at about $z = 0.1$, and a sharp decline thereafter, is clearly of cosmological significance. The sustained sharp rise in the curve suggests onset of a rapid increase in the volume of space with redshift (dV/dz); larger bins can contain more galaxies. The sharp decline in the curve after the peak must be a reflection of a rapid decline in the apparent magnitude of galaxies due to dispersal of photons over a rapidly increasing area (dS_2/dz); increased photon dispersal with distance causes galaxies with a lower absolute magnitude to become invisible. Also, the peak in the Fig. (2.1) empirical data must closely correspond to a peak in dV/dz.

3. CRISIS IN COSMOLOGY

Assuming that the space density of galaxies is close to uniform on a scale $z << 1$, then Fig. (2.2) makes it clear that the galaxy redshift survey bins plotted in Fig. (2.1) should provide some sense of the spatial volume rate of change with redshift. We can surmise from the SDSS CCD images that within the order of $z < 0.1$, a significant percentage of the selected bright galaxies that exist in the survey's field of view are actually counted. It seems unlikely that a large percentage, let alone the vast majority (>99%), go uncounted anywhere within this range of redshift. Assuming an accurate count, the empirical curves in the Fig. (2.1) graphs, at least out to the peaks at about $z = 0.1$, should come reasonably close to matching a theoretical curve for dV/dz. When we compare the empirical data to the typical textbook theoretical curve in Fig. (3.1), the mismatch is extreme. Note that the graph's *y*-axis has a log scale. The rise in the curve for the Big Bang theoretical prediction and the corresponding empirical observable, which are expected to be at least somewhat similar, differ by several orders of magnitude. Moreover, the peaks of the model and data are separated by more than an order of magnitude in redshift space. This enormous discrepancy between canonical theory [Eq. (3.1)] and observation suggests that the standard model curve is not just incorrect but is radically so. Moreover, the error is so large that a Copernican solution is required to solve this modern scientific crisis (i.e., a fundamental shift in thinking based on what will in hindsight seem a simple truth about nature, similar to that which occurred in the 17th century).

$$\frac{dV}{dz} = 16\pi \left\{ \frac{\left[(z+1)^{1/2} - 1 \right]^2}{(z+1)^{5/2}} \right\} \left(\frac{c}{H_0} \right)^3 \textit{units} \qquad (3.1)$$

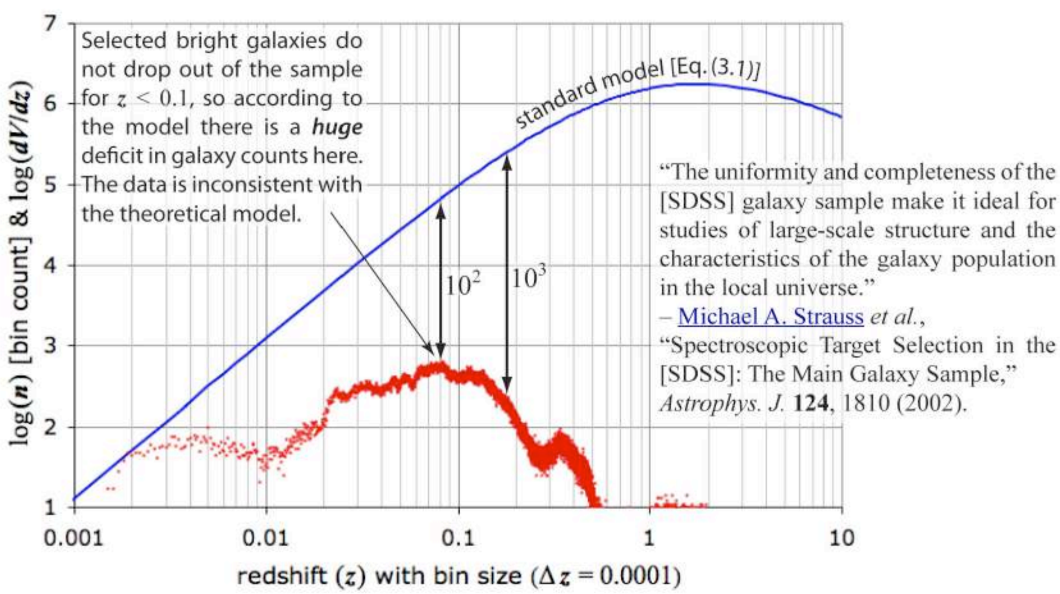


Figure 3.1 | The canonical dV/dz function vs. empirical dN^*/dz. The canonical textbook equation for the Einstein–de Sitter model is plotted in blue. Conceivable variation of assumed cosmological free parameters including omega-lambda results in no substantial change to the graph's essential features. The SDSS empirical data plotted in red (dN^*/dz) is displaced by a constant factor (10^{-6}) for comparison to the theoretical curve and, although not expected to be a perfect fit, it should exhibit a reasonable fit to a correct theoretical curve. Integration of the plotted function yields the volume function [$V(z)$]. Comparing the two curves in this context reveals the truly staggering difference between them. The conventional theoretical model is apparently in need of a radical correction. A number of published textbook versions of the conventional cosmological dV/dz function, including considered variations, can be conveniently reviewed online at http://pdfref.com/m1/03.01.htm

The misplaced faith in the validity of conventional thinking (i.e., the Big Bang theory) is so strong and prevalent that one can imagine an emotionally motivated denial process to dismiss the very compelling scientific evidence presented in all of the preceding graphs and other figures. However, denial is impossible; the empirical evidence is overwhelming due to the unprecedented quantity and quality of cosmologically relevant astrophysical data produced by the two corroborating modern galaxy redshift surveys cited.

The apparent angular size of an object is inversely proportional to distance ($\theta \propto d^{-1}$). In astronomy, this "theta-z relationship" correlates the apparent angular diameter of a galaxy (θ) to its redshift. If we make the reasonable assumption that galaxies are structurally similar such that the averaged physical properties of a statistically significant localized group of galaxies is essentially invariant over a broad range of redshift, the Petrosian radius provides a means to obtain empirical "standard rods," which should match the theoretical theta-z relationship.[35] The continuous range in redshift shown in Fig. (3.2) was chosen for several reasons, which include the consistency in the data among the four frequency bands, that the population of the redshift bins of equal depth ($\Delta z = 0.006$) is adequate and reasonably consistent and that the redshifts are cosmological (i.e., uncontaminated by peculiar velocity). Again, the mismatch between conventional theory and observation is significant and too large to be an observational effect.

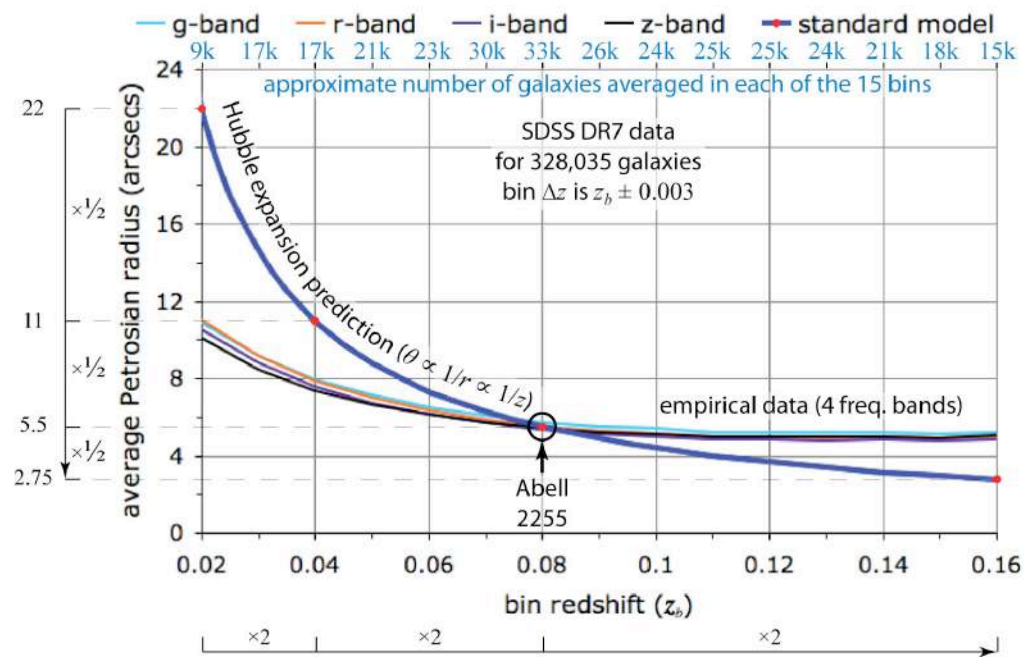


Figure 3.2 | SDSS empirical theta-z relationship. Data consists of 15 redshift bins averaging the Petrosian radius of thousands of galaxies per bin at z_b intervals of 0.01 for four frequency bands.

http://pdfref.com/m1/03.02.htm

```
SELECT /* 15 of these queries (s.z  bounds vary) produce the data in Fig. (3.2) & Fig. (3.5) */
       ROUND( AVG(s.z), 2) AS z
,      COUNT(1) AS n
,      ROUND( AVG(petroRad_g), 2) AS g_band
,      ROUND( AVG(petroRad_r), 2) AS r_band
,      ROUND( AVG(petroRad_i), 2) AS i_band
,      ROUND( AVG(petroRad_z), 2) AS z_band
FROM
       PhotoObj p, SpecObj  s
WHERE                          /* 15 different WHERE clauses are used for graphed data */
       s.z BETWEEN 0.017 AND 0.023 /* also 0.027 AND 0.033 ... 0.157 AND 0.163 */
AND    s.specClass = 2         /* galaxies (2) only */
AND    p.mode = 1              /* primary */
AND    zStatus IN (3, 4, 6, 7, 9) /* selected for high quality redshifts */
AND s.SpecObjID = p.SpecObjID;
```

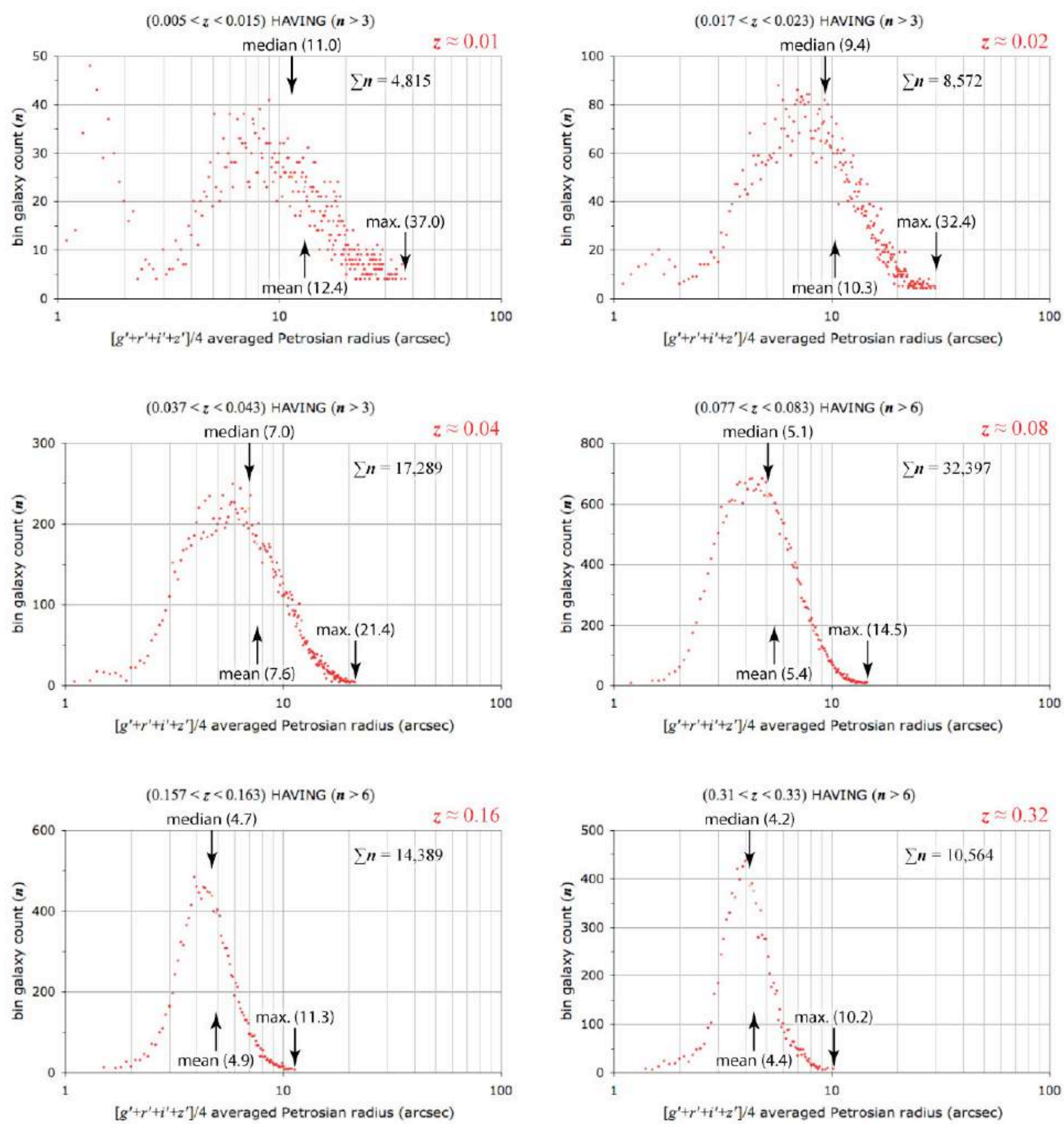


Figure 3.3 | Six SDSS redshift bins, each with a continuous local spectrum of galaxy sizes. Redshift bins are z = 0.01; 0.02; 0.04; 0.08; 0.16; 0.32, doubling the redshift for each consecutive bin. Galaxy size plotted on the horizontal axis within each redshift bin is the average of the four individual Petrosian radius measurements for the SDSS (g', r', i', and z') bandpass filters individually plotted in Fig. (3.2) for 15 redshift bins. The SDSS data implies that the largest galaxies are typically not more than about three times the physical dimension of average-sized galaxies and that the the physical dimension range of typical galaxies is not more than an order of magnitude. Some of the smallest objects at lowest redshift are likely to be misidentified double stars. The smallest objects at higher redshift may reflect unusually bright active galactic nuclei, which dominate the radiation output of the host galaxy. Bin population minimums were required to eliminate anomalous unphysical entries in the database, which were checked manually. The statistical median galaxy radius and mean galaxy radius trend closely with the observed maximum galaxy radius as a function of redshift.

http://pdfref.com/m1/03.03.htm

```
SELECT /* Six of these queries (s.z bounds vary) produce the data in Fig. (3.3) */
        ROUND((petroRad_g + petroRad_r + petroRad_i + petroRad_z)/4, 1) "radius 01"
,       COUNT(1) AS n
FROM
        PhotoObj p
,       SpecObj  s
WHERE
        s.z BETWEEN 0.005 AND 0.015
AND s.specClass = 2
AND p.mode = 1
AND zStatus IN (3, 4, 6, 7, 9)
AND s.SpecObjID = p.SpecObjID
GROUP BY
        ROUND((petroRad_g + petroRad_r + petroRad_i + petroRad_z)/4, 1)
HAVING
         COUNT(1) > 3
ORDER BY 1;
```

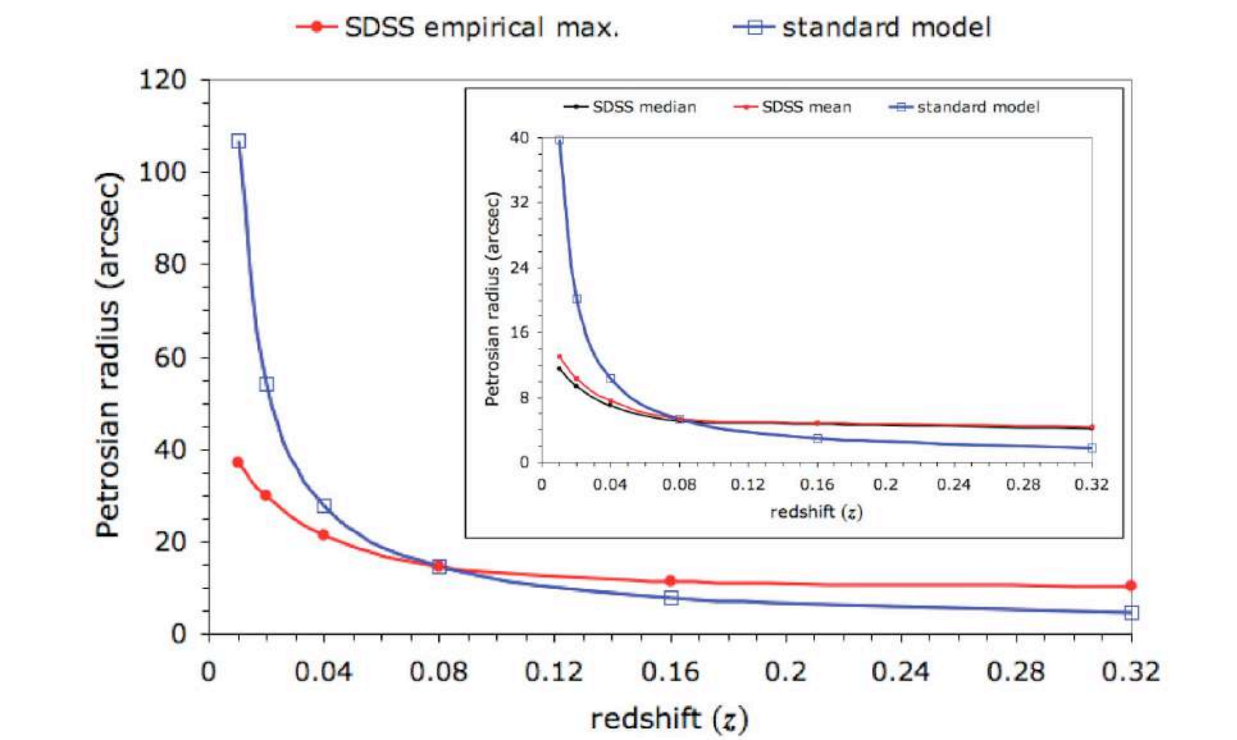


Figure 3.4 | Comparison of SDSS theta-*z* relation observations to 'Hubble law' prediction. The red curve in the main graph plots the maximum observed galaxy size for each of the individual redshift bin graphs shown in Fig. (3.3). The black and red curves in the inset graph plot the observed median and mean galaxy sizes marked in the same graphs. In both graphs, the $z = 0.08$ redshift bin is chosen as the common point with the standard model prediction as this bin represents the most robust data set with a population exceeding 32,000 galaxies. The blue curves in both graphs reflect the predicted observable based on a ΛCDM model with parameters: $H_0 = 71$; $\Omega_M = 0.27$; $\Omega_{vac} = 0.73$, although the free parameters of the standard cosmological model play a very minor role in these low redshift regime predictions. The basic 'Hubble law' dominates whereby at half the redshift the distance is assumed to be about half, implying a doubling in the observed size of a standard rod.

At face value, the graphs of empirical SDSS survey data plotted in Fig. (3.2) and Fig. (3.4) imply that the conventional interpretation of the cosmological redshift as being indicative of a general expansion of galaxies cannot be correct. To show that these measurements are an accurate representation of physical reality falsifying the 'Hubble law,' it is necessary to produce a new model that accurately predicts them.

Table (3.1) provides a historical selection of 'Hubble constant' measurements, including the original 'measurement' of 500 by Edwin Hubble in 1929. As compared to empirical measurements of the speed of light, the rest mass of an electron, or the fine structure constant, for which all measurements converge on the same value and resolution has improved over time, it is clear from the historical published data that the 'Hubble constant' is not just a misnomer, but a dubious scientific concept at best. The great mathematician John von Neumann reportedly said, "There's no sense in being precise when you don't even know what you're talking about."[36] In astronomy that is not always true because Tycho Brahe (1546–1601) made essential accurate astronomical measurements while supporting a geocentric Solar System model.

Table 3.1 | Published attempted measurements of the alleged 'Hubble constant' 1929–2007

H_0 (*km s*$^{-1}$ *Mpc*$^{-1}$)	Principal Author	Method	Year
73.2 +3.1/-3.2	D. Spergel	WMAP (Cosmic Microwave Background)	2007
72 ±6	X. Wang	Type Ia supernovae	2006
68–74	G. Altavilla	Type Ia supernovae	2004
48 ±3	C. Kochanek	Gravitational Lens Time Delays	2004
75 +7 / -6	L. Koopmans	Gravitational Lens B1608+656	2003
58 +17 / -15	V. Cardone	Quadruply Imaged Gravitational Lens Systems	2003
81 ±5 & 75 ±8	N. Tikhonov	Distances to Galaxies of the NGC 1023 Group	2002
90 – 95	D. Russell	H I Line Width/Linear Diameter Relationship	2002
60 ±10	Y. Tutui	CO-Line Tully–Fisher Relation	2001
72 ±8	W. Freedman	Multiple (HST Key Project to Measure Hubble constant)	2001
46.9 +7.1 / -6.2	M. Tada	Gravitational lens system PG1115+080	2000
50.3 +10.2 / -10.9	S. Patel	Sunyaev–Zel'dovich Effect and X-ray spectroscopy	1999
62 ±5	R. Tripp	Type Ia supernovae	1999
30 +18 / -7	C. Lineweaver	Cosmic Microwave Background	1998
64 ±13	T. Kundic	Time delay of gravitational lens system 0957+561A,B	1997
50 – 55	S. Goodwin	Galaxy Linear Diameters	1997
70 ±10	S. Kobayashi	Sunyaev–Zel'dovich Effect	1996
67 ±7	A. Riess	Type Ia supernovae	1995
42 ±11	A. Sandage	Luminous spiral galaxies	1988
67 ±4	N. Visvanathan	Virgo cluster distance	1985
55 ±7	G. Tammann	Cepheids, brightest stars, H II regions, luminosity classes	1974
100 ±10	G. de Vaucouleurs	Survey of nearby groups of galaxies	1972
47 [10%]	G. Abell	Luminosity Function of the Elliptical Galaxies in Virgo	1968
75 [×2]	A. Sandage	Brightest star	1958
500 (five hundred)	E. Hubble	Cepheids	1929

One must concede that this panoply of radically different measurements in modern times of an alleged 'constant,' which is the foundation of the Big Bang theory, is troubling. Also, the Big Bang theory is demonstrably rooted in anachronistic religious tradition and it is naïve to think that this cosmological model did not spring from the biblical cosmogonical paradigm. To interpret *Genesis I* as having anything cogent to say about cosmology, specifically Georges Lemaître's assumption that a "moment of Creation" has any scientific validity whatsoever, is essentially creationism applied to physics. Besides alleging a single creation event, the initial chapter of the *Old Testament* provides chronological details concerning the sequence of the mythic six-day creation. In no uncertain terms, it is specified that the Sun, the Moon and the stars were created *after* the land masses and seas of our planet, as well as its grasses and fruit trees. An assumption of a single primordial cosmic creation event is then closely associated with intellectually unsophisticated ideas involving popular anachronistic myth in contrast to the disciplined scientific practice of extended observational effort and rational analysis.

In *Our Cosmic Habitat* (Princeton U. Press, 2001), Martin Rees, Astronomer Royal of Great Britain and Royal Society Research Professor at Cambridge confessed "99 percent confidence" in the convincing picture of conventional cosmological wisdom that was built up over the last century. Yet, he also stated,

> I would prudently leave the other one percent for the possibility that our satisfaction is as illusory as that of a Ptolemaic astronomer who had successfully fitted some more epicycles. Cosmologists are sometimes chided for being often in error but never in doubt.[37]

Theoretical physicist Richard Price, in the introduction to *The Future of Spacetime* (Norton, 2002), made some insightful comments on this same theme.

> For the centuries of pre-Copernican astronomers there was no question whether the Earth was the center of the world. If difficulties arose, they would look elsewhere for remedies. Those astronomers constructed an extraordinarily complex calculational method to predict and explain the motion of heavenly bodies. An originally simple method of prediction was found to be inadequate when observations of planetary motion improved. Mathematical constructions, "epicycles," were invoked to improve the predictions, and the basic theory was coerced into an appearance of working. This cycle of improvements continued, first in adding astronomical observations, then in adding more unwieldy features to the method.
>
> When we look back at what they were doing, we are incredulous. How could they not see that the simple elegant idea of a Sun-centered world explained everything? They had not so much missed what now seems obvious, as they had been seduced, step by step, down the wrong path. The beginning of the path pointed in a reasonable direction, and from well along the path it was hard to see that there were alternative paths.[38]

Hubble acknowledged that the observed velocity-distance relation could reflect the "de Sitter effect."[39] In 1916, this nascent alternative path interpreted the curvature of space to imply a relativistic time dilation of ideal clocks according to their cosmological distance, but this early interpretation was later abandoned in favor of Lemaître's expanding universe model, which was consistent with the culturally embedded Western paradigm of a sudden supernatural cosmic creation event (i.e., *Genesis I*). In just eight decades (1929–2010), the synergistic achievements of astronomers, astrophysicists, engineers, computer scientists, technicians and enlightened modern scientific thinking have overturned the Big Bang theory, which is really biblical creationism applied to physics rather than to biology. It will be demonstrated that the popularized "expanding universe" model is not just wrong; it is of the same ilk as the spurious Aristotelian cosmology in which all of the astrophysical bodies were allegedly affixed to "crystal spheres" rotating around the Earth, which was imagined to be at rest at the center of the Universe. To presume that the mass-energy of $\sim 10^{80}$ nucleons comprising the entire baryonic mass of the Universe could be compressed into a singular region smaller still than a solitary nucleon and that no cosmic structure has an intrinsic age greater than about 12 billion years is nothing less than an irrational biblically inspired distortion of science.

The now mainstream idea of an expanding universe rests on the rash assumption that the observed cosmological redshift is caused by a related recessional motion of the galaxies. One seemingly reasonable assumption led to a series of other invented ideas, each needed to justify the prior, ultimately creating today's belief system of unreasonable *ad hoc* ideas. Each of these ideas invented to 'rescue' the Big Bang theory is more unlikely than the last, culminating in 'dark energy.' In contrast, physicist Howard Burton of the Perimeter Institute in Canada has written,

> The pursuit of beauty and elegance has always been a driving force in the development of scientific theories. To its most radical proponents, this bias is based on a firm, axiomatic belief that, at its core, nature simply must be beautiful.[40]

One may add the corollary that nature must be simple, beautifully. In 1908, just before his unexpected premature death, Hermann Minkowski established a fundamental geometric foundation for the special theory of relativity and thus a geometric foundation for *time* that is of elemental importance in cosmology. His creative work, which provided some of the most profound physical insights of the 20th century, was misunderstood by Einstein to be a purely formal mathematical development, and is to this day commonly (yet mistakenly) referred to as a mere "mathematical convenience."[41, 42] If one interprets the observed cosmological redshift as indicative of cosmic expansion, logic implies an unphysical singularity in space and time. It is then immediately suspect that this is the wrong interpretation of the observed phenomenon. Properly interpreting the redshift as a relativistic temporal effect that is a function of distance according to the exceedingly simple implications of Minkowski's temporal geometry yields the following two equations, which are derived in detail in later chapters. Eq. (3.3) revisits Eq. (P.2), first introduced in the preface.

$$\theta(z) = \theta_0 (z+1)^{-1} \left(1 - \frac{1}{(z+1)^2}\right)^{-\frac{1}{2}} \qquad [z > 0] \tag{3.2}$$

$$\frac{dV}{dz} = \frac{4\pi C}{\sqrt{1-(z+1)^{-2}}} \left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4} \right) \tag{3.3}$$

Ultimately, these two equations and others to follow rest exclusively on Riemannian geometry and the principle of relativity (i.e., the invariance of the speed of light in vacuum). There are no free parameters; these are precise predictive equations. The logical structure from which they evolved is a synthesis of fundamental ideas originating with Hermann Minkowski, Willem de Sitter and Bernhard Riemann. Consequently, the new model of the Universe put forward herein is succinctly and conveniently referred to as the "MdR" model. Minkowski provided the formal mathematical (i.e., geometrical) foundation for the theory of relativity, de Sitter first proposed that "spacetime curvature" should cause a relativistic time dilation as a function of cosmological distance and Riemann developed the mathematics necessary to conceive of a finite boundaryless 'curved' universe.

Plotting Eq. (3.2) in Fig. (3.5) and comparing it to the SDSS data, it is clear that this equation provides an essentially perfect fit to the accurate empirical observations at low-redshift. The empirical curve flattens out at greater distances for which it is increasingly difficult to measure small galactic radii; statistical averaging of galactic radii at high-*z* will favor intrinsically larger galaxies. The latter equation, also previewed as Eq. (P.2), similarly yields startlingly accurate predictions as already shown in the preface. All MdR predictive equations are easily derived in a few steps from first principles and geometry.

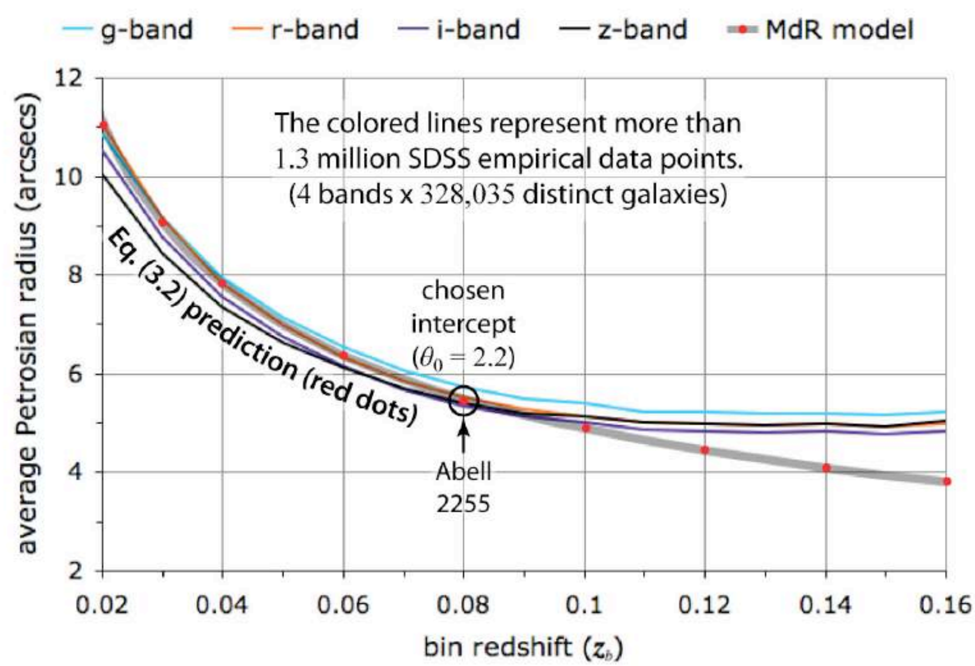


Figure 3.5 | Comparison of Fig. (3.2) SDSS theta-*z* empirical data to Eq. (3.2) prediction.
The deviation from the model at higher redshift where the empirical curve flattens out is expected. Statistical averaging will favor larger galaxies that are easier to see, thus artificially increasing the apparent average radius of a higher-redshift galaxy population. The slope of the empirical SDSS curve cannot be artificially suppressed by an abundance of small galaxies at low redshift because there are far fewer galaxies in the 0.02 redshift bin (~9,000) than in the 0.08 redshift bin (~33,000).

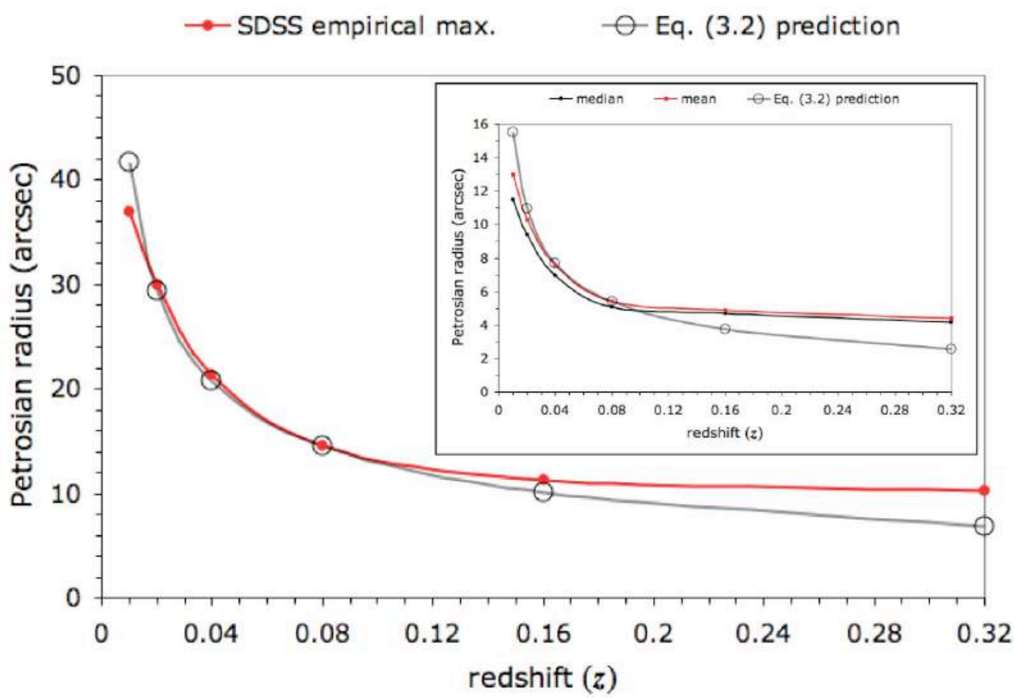
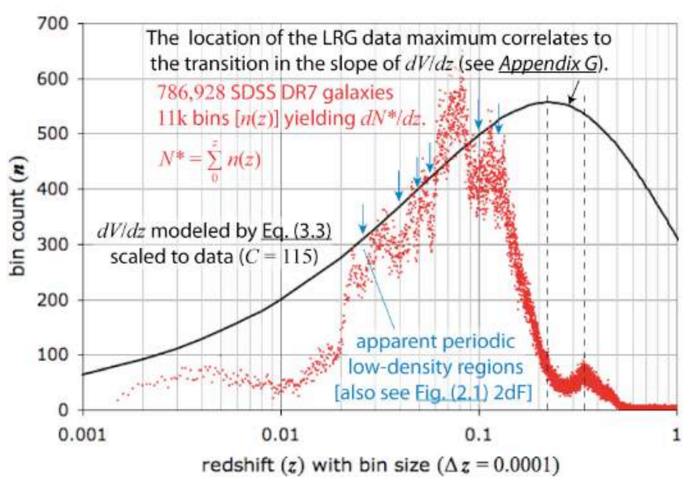


Figure 3.6 | Comparison of SDSS observations of theta-*z* relation to Eq. (3.2) prediction.
The empirical curves are identical to those shown in Fig. (3.4). The coefficient for the predictive gray curve in the main graph is θ_0 = 5.9 *arcsec*. The coefficient for the predictive gray curve in the inset graph is θ_0 = 2.2 *arcsec*. The z = 0.01 bin population is less than 15% of the z = 0.08 population. Consequently, it is reasonable to assume that it may not include the very largest variety of galaxy, which explains the slight variation between the model and the observable at lowest redshift.



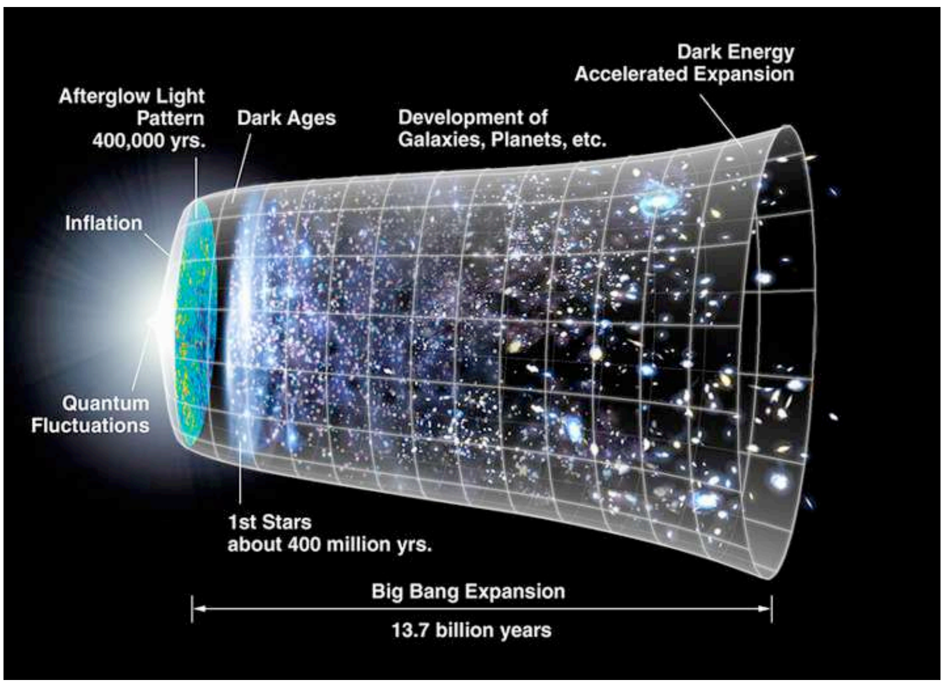
The deviation of the empirical curve from the model curve is expected. One should know that the volume of space between ($0.1 < z < 0.2$) is considerably larger than for ($z < 0.1$). A significantly smaller percentage of the selected galaxies is counted at redshifts ($z > 0.1$). This observational effect ensures the displacement of the empirical curve to the left and a sharp decline from the peak. The fractal distribution of galaxies causes the deviation from the model seen at low redshift.

Note that beyond $z = 0.02$, the empirical curve begins to *follow the theoretical curve* immediately following the stair step. This suggests a transitioning from a local fractal architecture to global smoothness, like seeing the Earth from increasing distance. The periodicity of the histogram strongly suggests fractal architecture.

Figure 3.7 | As compared to Fig. (3.1), the observations are a good fit to the physical model.
The predictive curve in black is identical to that shown in Fig. (P.3) of the preface with the empirical SDSS ‘QSO’ curve, although it has now been scaled to fit the complete SDSS spectroscopic data set. The discrepancies between the theoretical *dV*/*dz* curve and the empirical *dN**/*dz* curve are expected.

4. TIME

A discussion concerning the *physics of time* requires a broad philosophical context as an introduction, particularly in the present epoch during which there is a misunderstanding of time, indeed an insufficient model of relativistic time in physics. While various individual and cultural differences may exist, it is reasonable to assert that all humans experience time physically and psychologically as relative magnitudes between an irreversible ordered series of events that are measurable to some accuracy by various stable periodic processes. It is also generally true that the human conception of time is formed from the perspective of the present with an overview of acknowledged history. The simple daily calendar is a ubiquitous and ancient measurement device based exclusively on Earth's axial rotation; accordingly, the pervasive practical model of time employed by Western science is the timeline, which typically displays a relevant series of sequential dates or milestones. The majority of people in the world today still do not have a more sophisticated concept of time than that it is related to experiential variation marked primarily by the obvious distinction between day and night. Time is even conceived by many people to be the *cause* of observed variation in some way, rather than a physical measurement related to some transformational process.



The artistically compelling WMAP Team interpretative model of cosmological history.[43]

Figure 4.1 | The canonical linear model of universal non-relativistic cosmic time (c. 2010, Q2).

Because the curvature of the Earth is so slight (~5.4 minutes of arc over a 10 kilometer distance), ancient man experienced gravity to be unidirectional (parallel everywhere). Given this convincing illusory sensory experience, it was natural to imagine a 'flat' Earth and early claims by an errant philosopher-mathematician that the Earth must be spherical according to abstract thought would have contradicted what seemed obvious and intuitively correct according to common experience. Similarly, in modern times, experience throughout life of a uniquely ordered progression of sequential events separated by varying lengths of time readily suggests the model of a single universal timeline (i.e., a 'cosmic calendar').

The idea of relativistic time developed in the context of the preceding paradigm. Although physicists understood that the measured rate of time for distinct reference frames is not constant according to relativity, time in physics continued to be modeled as it is typically experienced: a 1-dimensional phenomenon devoid of a meaningful geometry. The much-publicized conventional interpretation of the cosmic microwave background radiation correlated with the simplistic model of cosmic history shown in Fig. (4.1) is based on a naïve conventional model of cosmological time. The alleged calendar-like history of the Universe shown in Fig. (4.1) is modeled by the ubiquitous single linear timeline, the only difference being that no historical continuum exists before the alleged singular '*Beginning*.' This "edge" of time at the purported Big Bang is of similar naïveté to concepts of a perilous Earth's "edge" found in some fanciful medieval paintings. There is a need for a paradigm shift in the scientific conception of time today that is similar to the shift in the conception of global topology that began in ancient Greece and was effectively complete in Western academia within the first century C.E.[44] The model of the Universe and cosmic time shown in Fig. (4.1) will soon be regarded as misconceived in a similar manner to the 'flat' Earth model embraced by Western civilizations before the Common Era and more recently in the East. Therefore, the new model replacing it requires a reinterpretation of the CMB and its observed anisotropy.

Consider a common object such as a particular apple to which one may associate a unique timeline. The start of the timeline is dependent on the definition of *apple*. For instance, the "genesis event" may be the inexact time when the bud from which the apple grew appeared, an inexact time related to the apple's growth curve, or perhaps the moment in which the apple was separated from its host tree. The genesis event provides a demarcation point in time prior to which the apple, as defined, did not exist. The apple's timeline also has a termination point that is not well defined. It may be the moment in which the apple was cut into pieces, some inexact time during the period in which it was eaten and digested, or some inexact time during the period in which it rotted and could then no longer be distinguished as an apple. Human perception of any physical thing is a representation of a process at a certain point in time that is similar to a photograph (i.e., a snapshot in time); anything physical is made of atoms, which are only temporarily arranged to create it. While it may not be functional to routinely think this way, *object* is not fundamental; all we ever really perceive with our physical senses (i.e., *all* of physical reality) is *process*.

Prior to the advent of special relativity in 1905, time was naïvely imagined to be a cosmic property (i.e., a single parameter relating to the whole Universe). This anachronistic concept of time models the Universe as an object existing in and moving through time so that time is a phenomenon external to an objectified universe. Albert Einstein's initial revolutionary contributions to the modern concept of time in his epochal paper *On the Electrodynamics of Moving Bodies* (translated from the original German) include localization of time coordinate, relativity of simultaneity, and relativity of time measurement.[45] In the context of special relativity, time is immediately understood to be an internal construct of the Universe and a property whose measurement is generally restricted to a limited region of space in free fall constituting a Lorentzian reference frame. Thus, relativity invalidates the idea of an objectified universe distinct from time; rather, time is an *internal* local feature of the singular holistic Cosmic Process.

5. SPACETIME

Hermann Minkowski's concept of spacetime, introduced in 1908, was an epiphany instigated by Einstein's special relativity theory. Minkowski died suddenly and unexpectedly in January 1909 and so never completed the development of his extraordinary ideas, nor was he able to properly communicate them in detail (see *Appendix C*). A querulous young Einstein initially ridiculed Minkowski's vital contribution to relativity as "superfluous erudition," and subsequently never properly understood it.[46]

Minkowski discovered that space and time are distinct transformational manifestations of a unified spacetime fabric. His critical contribution to relativity was to geometrize time. In particular, he recognized that the Lorentz transformation equations of special relativity require the strictly local time coordinate to be mathematically imaginary in contrast to the three real-valued space coordinates. Consequently, the foundations of mathematics imply that the time coordinate of a Lorentzian reference frame is fundamentally (i.e., *physically*) orthogonal to any chosen space coordinate. The conventional idea that this is merely a "mathematical convenience" is myopic. The mathematics provides critical physical insight; in the context of spacetime geometry, the time dimension is no less a physical coordinate than the space dimensions. Perhaps the most important statement in Minkowski's September 1908 address entitled *Space and Time*, which was presented to an assembly of German scientists, has been historically overlooked.

> We should then have in the world, no longer *space*, but an infinite number of spaces analogously as there are in three-dimensional space an infinite number of planes. Three-dimensional geometry becomes a chapter in four-dimensional physics. Now you know why I said at the outset that space and time are to fade away into shadows and only a world in itself [i.e., a *spacetime* Universe] will subsist.[47]

Just as each unique plane in 3-dimensional space is associated with a unique orthogonal vector, it should be clear that each unique *space* (x_n, y_n, z_n) of these "infinite number of spaces" in spacetime must have an associated geometrically unique time coordinate (t_n). Therefore, the prevalent idea that "Minkowski space" is composed of three space dimensions (x, y, z) and a single time dimension (t) is a simplistic interpretation of his mathematical insight that completely misses the point. Minkowski's "world" or "4-dimensional space-time continuum" incorporates an infinite number of geometrically and functionally unique time dimensions (t_n), not just one. Paraphrasing the preceding statement from Minkowski's talk, one may state what he made implicitly clear, though not explicitly.

> We should then have in the world (i.e., the spacetime Universe) no longer *time*, but an infinite number of time coordinates (one for each of an infinite number of distinct spaces), analogously as there are in three-dimensional space an infinite number of directions. The geometry of the local timeline becomes a chapter in four-dimensional physics.

The fundamental geometric interpretation of special relativity is that the time dimension is physically orthogonal to any space dimension in a free-falling reference frame; the distinction between what is space and what is time in the 4-dimensional spacetime manifold is only locally applicable. This is similar to the strictly local definition of the altitude 'dimension' on the surface of the Earth. Global coordinates (X, Y, Z) associated with an imagined cube circumscribed around the Earth have no physical distinction. Only the local coordinates (x_p, y_p, z_p), which are valid for the neighborhood of a single point p on the Earth's surface, are uniquely defined *physically*, with the z-axis unambiguously representing *altitude*. There is a similar difference between the generic abstract "spacetime" dimensions (X_1, X_2, X_3, X_4) and the four measurable "space-time" coordinates of an observer's reference frame (x^0, x^1, x^2, x^3), where x^0 represents local time.

Let a great circle exist in the X^1–X^2 plane of cosmic spacetime [see Fig. (8.4)]. None of the four generic spacetime dimensions (X^d) has a specific physical interpretation. The orthogonal geometric relationship between space and time that arises from the Lorentz transformation equations implies that there is no universal time dimension (X^0) for an extended interval of space represented by such a curve, which is imagined to circumnavigate the spacetime Universe. Rather, for any local region of space represented by the neighborhood of a distinct point on that curve, local time (x^0) is represented by a local geometric "timeline" orthogonal to the local tangent, (i.e., the local vertical to the curve at any point represents local time there). A symmetric change in the direction of the local time dimension from a point on the curve to another implies a symmetric relativistic temporal relationship between those points (i.e., a bilateral relativistic time dilation). This corollary arising from special relativity's geometric foundation implies the existence of a cosmological redshift-distance relationship for galaxies that is independent of frequency shift related to any relative motion, whether due to a Doppler velocity or a presumed expansion of space between galaxies.

Human thought is generally guided, limited and often confused by preconceived ideas formed in reference to familiar experience. This is why many academics prior to the late 17th century believed that the Sun, the planets and even the stars orbited the Earth and those of ancient civilizations believed that the Earth was 'flat.' In common human experience, time is measured by some sort of clock, and in one way or another, a clock is observed to record time by counting the cycles of a periodic behavior generally referred to as a "tick." It should be clear that when one observes two timepieces to tick at different rates, one is not experiencing a difference in clock rate, but rather a difference in the unit of time measurement. When relativity has no part to play in order to warrant the discrepancy, one never hears someone correctly report, "The reference time unit counted by my clock is too long." Rather, a commonly heard excuse for tardiness is, "My watch is running slow" (i.e., *falling behind* the correct reference clock). The experiential influence on the perception of time caused physicists of the past to focus their thinking on relative clock rate rather than the relative duration (i.e., relative geometric length in spacetime) of the reference time unit being counted, which produced a deficient 20th-century model of time in physics.

6. TIME DILATION

In his 1905 special relativity paper, Einstein asks the question, "What is the *rate* of this clock when viewed from the stationary system?"[48] In order to achieve greater precision in communicating physics, an equivalent but superior alternative question to pose would have been, "What is the *length* of a second in spacetime [as measured in the 'moving' reference frame] as perceived from the 'stationary' system?"

However, this would not have occurred to Einstein in 1905, particularly as this was several years before the discovery of spacetime and the geometrization of time by Minkowski.

A meter of time as a unit of time measurement is simply the time required for light to travel one meter through vacuum. That time in the context of relativistic physics should be measured in meters rather than seconds is not merely rhetorical; it is the only path toward truly understanding relativity. This is achieved according to what Minkowski called his "mystic formula," in which the speed of light in vacuum represented by the constant of proportionality c is commonly normalized ($c = 1$).

$$x = ict \tag{6.1}$$

In his famous *Lectures on Physics* at Caltech given some sixty years after Minkowski's epochal lecture, Richard Feynman stated (emphasis added),

> A difference between a space measurement and a time measurement produces a new space measurement. In other words, in the space measurements of one man there is mixed in a little bit of time, as seen by the other.
>
> …
>
> Now in [the Lorentz transformations and the Minkowski metric] *nature is telling us* that time and space are equivalent; ***time becomes space***; they should be measured in the same units.[49]

If we understand Minkowski's contribution to imply that time is to be treated mathematically and therefore conceptually in the context of geometry, it then makes perfect sense to interpret temporal effects in special relativity as an equivalent relative change in the length of the reference time unit, rather than the relative rate of clocks. A shift in thinking from the algebra of relative clock rates in one dimension (i.e., the real numbers) to the geometry of relative time lengths in 'complex' 4-dimensional spacetime (naturally measured in meters in the context of geometry) allows the inherent symmetries of physical measurements in special relativity to be modeled with unprecedented clarity. The geometric nature of relativistic time revealed by Minkowski implies an infinite number of distinct cosmological timelines, rather than just one, and distinct timelines associated with distinct cosmic regions cannot be parallel.

A puzzling aspect of special relativity is the symmetry of the time dilation phenomenon. As stipulated by the principle of relativity, two observers in unaccelerated relative motion must each find the other's ideal clock to be falling behind an identical local reference clock, which typically presents conceptual difficulties for physics students. If clock B is physically measured to be falling behind clock A, how can it also be that clock A is physically measured to be falling behind clock B? This may seem to be a logical impossibility. Needless widespread confusion concerning this issue arises from improperly thinking about the phenomenon of relativistic time dilation in the context of clock rate (i.e., algebra) rather than the *geometry* of distinct linear time coordinates. It is only with geometry that one can accurately model special relativity with complete clarity, while the algebra originally employed by Lorentz is inadequate.

Like any clock, a vehicle odometer measures *progress* in one dimension. It is understood that this common simple instrument completely ignores the underlying geometry; an odometer indicates how far a car has traveled over a virtual linear coordinate (its "proper distance") and nothing about the geometry of its motion, which is irrelevant as concerns the primary purpose of the odometer. Consider the following simple illustrative example of relative geometric measurement using familiar vehicle odometers.

Two roads in western Kansas (well known for its flat topography) intersect at a 60-degree angle; one headed northeast, the other northwest. At the intersection, two experimenters each zero the trip odometers of their respective cars. Subsequently, each drives exactly one kilometer down respective roads separated by the acute angle and each then stops at the side of the road. Accordingly, the odometer in each car reads exactly 1.0 *km*. Clearly, the westbound driver must look over his right shoulder *behind* him to see the other car. Similarly, the eastbound driver must look over her left shoulder behind her to see the other car. Because the cosine of 60 degrees is one-half, relative to the specific direction in which each odometer is measuring *progress*, the other car is 500 meters behind. Because the drivers are readily aware of the geometry involved in the measurement, it is understood that for each kilometer traveled from the intersection as identically measured by respective accurate odometers, the other car will be perceived to be falling behind by 500 meters. Each kilometer measured by the remote car's odometer corresponds to only 500 meters of progress in the distinct direction of travel being measured by the local car's odometer. Experientially, each car is simultaneously *falling behind* relative to the spatial progress of the other car, yet there is no paradox because this symmetric "relativity" of measurement is a purely geometric effect.

Although the perception of time in our daily lives is of a universal one-dimensional phenomenon, this is an illusion somewhat similar to the immediate sensory illusion of a 'flat' Earth. The progress of time measured by a clock incorporates the relativistic geometry of spacetime, but since every clock in common experience measures time in very nearly the same direction in spacetime, it is natural to imagine that the measurement of time by all clocks involves only one shared dimension of spacetime. If ideal clocks are not synchronous, then our first thought born of experience is that the clocks are measuring time at different *rates* and we stop there, short of a superior model. (The assumption of ideal clocks in theoretical physics implies that every clock faithfully records local time in reference to the same unit of time measurement so that clock discrepancies reflect physical phenomena, not clock inaccuracy.) Yet, if this phenomenon is known to be symmetric, as is true for special relativity, the model of a single timeline and two clocks recording time at different rates introduces a logical inconsistency. No symmetric relative difference in respective time coordinates (i.e., each of two clocks are locally perceived to be gaining time relative to the second remote 'moving' clock) can be modeled if the time measurements of both clocks are restricted to the same geometric timeline. Special relativity (SR) forces us to conclude that there are many possible directions of time in spacetime, just as there are many possible directions of Earth's local gravitational gradient in space (that direction being dependent on the local reference frame). A century ago, just before his unfortunate premature death, Hermann Minkowski was trying to communicate the very non-intuitive idea (in his era) that time *in physics* has a multidimensional geometry beyond the perceived single dimension of everyday practical life. Einstein never properly understood this, and therefore neither would those who assumed that Einstein's understanding of relativity was complete and accurate.

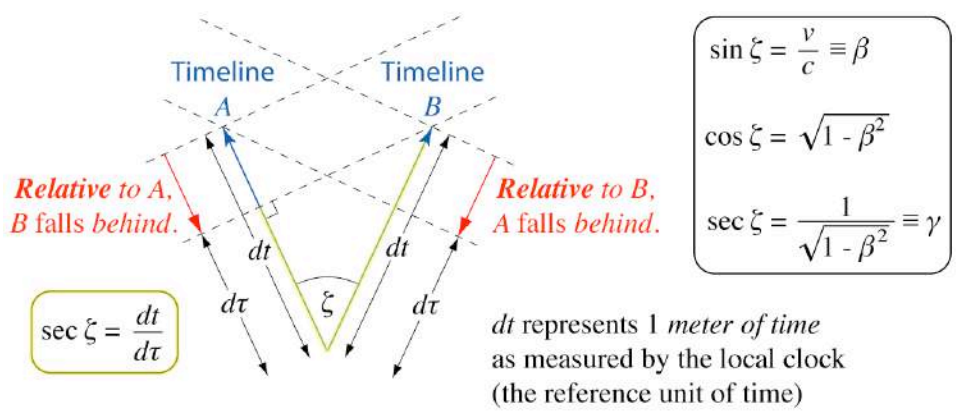


Figure 6.1 | The geometry of symmetric relativistic time dilation in special relativity.
The required breakthrough is realizing that this relative projective geometry applies to time in SR. This is a geometric model limited to relativistic temporal relationships; *space is not represented.*

In Fig. (6.1), one meter of time as measured in frame *B* represents less than one meter of time from the perspective of frame *A*. Consequently, more than one meter of time in frame *B* corresponds to the local meter of time in *A*; the length of the equivalent *B* reference time unit seems "too long." The geometry is perfectly symmetric, so from the perspective of an observer in frame *B*, all of the same is true in reference to frame *A*. When someone complains, "My watch is slow," what they really mean is that the periodic process counted by their watch is producing a reference time unit that is greater than the international standard second. Therefore, relative to an accurate clock, their watch ticks fewer times per standard hour of time, but this asynchrony is due to a mechanical failure. The same principle applies to special relativity in which all clocks are assumed to be ideal and to faithfully record local time with no error whatsoever. Fundamentally, the symmetric retardation of the 'moving' clock relative to the local 'stationary' clock is due to a change in the length of the 'moving' reference time unit, which is a symmetric geometric effect in spacetime. The measured relative rate of the ‘moving’ clock is a derivative effect caused by the more primary symmetric relative projective geometric relationship between the respective time dimensions of the distinct reference frames. Upon consideration, it is impossible for the general theory of relativity to be a geometric theory of space and time if the special theory of relativity upon which it is based is not also most fundamentally a geometric theory of space and time.

7. THE FITZGERALD–LORENTZ CONTRACTION

Hold a ruler between your thumb and index finger and then extend your arm completely; the ruler takes up its full length of about 30 centimeters in your field of vision. Now slowly rotate the ruler ninety degrees so that it is parallel with your arm. From your geometric perspective, the ruler appears to contract in length. It is understood that there is no intrinsic change to the ruler whatsoever involved in this apparent contraction; it is strictly a visual geometric effect caused by the ruler rotating from one dimension of space (x) into another distinct (i.e., linearly independent) dimension of space (y).

Recall now Feynman’s succinct and accurate description of relativity, “*time becomes space*.” Going far beyond even Einstein’s imagination, Minkowski discovered *spacetime* and understood that no fixed physical interpretation could be associated with any of its four dimensions.[50] Relativity implies that we are not entitled to restrict the measurement of time by observers in various distinct reference frames to a single dimension of spacetime. This is reflected by Prof. Kip Thorne’s perspicacious statement describing Einstein’s relativity (paraphrasing Feynman), “… *what I call space must be a mixture of your space and your time, and what you call space must be a mixture of my space and my time*.”[51] Therefore, the distinction between a particular time coordinate and its space coordinates in the 4-dimensional “world” of spacetime is dependent on the reference frame (i.e., geometric perspective in spacetime) of the observer. Accordingly, “space-time” with hyphen herein refers to a general distinction applied locally in which the abstract generic coordinates of “spacetime” or Minkowski’s “world” are resolved into distinct physical space and time coordinates.

Whereas a rotation in space (e.g., from x into y) causes an apparent visual contraction due to geometric perspective, a rotation in spacetime (e.g., from x into t) causes a real physical contraction that is also due to geometric perspective. In either case, we need only rotate with the object to see that the apparent contraction is a geometric effect, rather than an intrinsic change to the object itself. That is to say, we need to remain in the reference frame of the object such that its coordinates do not rotate relative to our perspective of observation. The Fitzgerald–Lorentz contraction is an effect whereby a component of the length of the ‘moving’ object in question exists in the time dimension of spacetime from the ‘stationary’ observer’s perspective. However, for the observer in the rest frame of the object, that observer’s time dimension is a mixture of space and time measured in the ‘stationary’ frame. If the object were traveling at a constant speed arbitrarily close to the speed of light, then one of its space dimensions would include only an arbitrarily small space component from the perspective of the laboratory. This dimension would instead be almost exclusively associated with the laboratory’s time dimension; “*time becomes space*.”

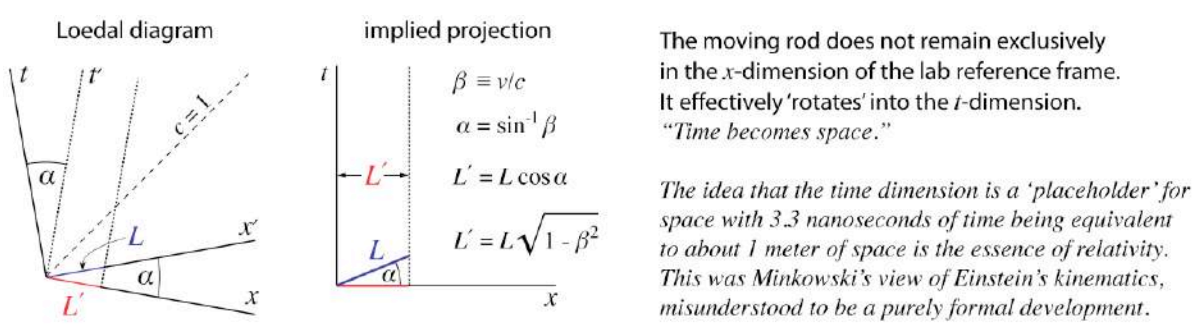


Figure 7.1 | SR length contraction interpreted as a geometric perspective *in spacetime*.
The principle of relativity implies that the contracted length of the rod (L') as defined by simultaneous events in the laboratory frame is a projection of the full proper length of the rod (L). Logic implies that the rod is projected from a mixture of space and time dimensions because it is not projected from a mixture of space dimensions, as would be the case for a normal rotation in space.

Like ancient people who must have had enormous difficulty conceptualizing the Earth as a sphere (i.e., understanding that the local altitude vector rotates 90 degrees over about a 10,000 *km* distance), for over a century physicists did not appreciate the geometric subtleties implied by special relativity; time is no more a unique dimension of spacetime than altitude is a unique dimension of space.

8. THE COSMOLOGICAL BOUNDARY PROBLEM

Philosopher-mathematicians of ancient times who were confronted with the terrestrial boundary problem lived in an era in which the topology of the Earth was not a problem of any practical concern, yet the rhetorical question probably arose as to what happens if a ship sails in the same direction without deviating from its course. If the Earth was truly flat as then popularly imagined, the ship might continue its journey to arbitrarily large distance, but only if the imagined terrestrial plane filled with the ocean extended to infinity. However, if this plane were finite in extent, then the ship would eventually have to encounter some kind of physical boundary. The existence of any boundary was logically and philosophically unsatisfactory for a number of reasons. While the first possibility (an infinitely large 'flat' Earth) was conceivable in theory, this idea seemed unlikely to be true. The task at hand was to make observations and measurements to determine the true topology and physical size of the Earth. Modern astrophysicists and cosmologists have faced the identical problem on a cosmic scale. It should come as no surprise that there is almost no difference between the two problems and their similar solutions. Yet, it *is* surprising that modern scientific professionals have exhibited confusion similar to that of their counterparts in the ancient world, who failed to understand that the Earth is round (i.e., that gravity, which is trivially observed to be locally orthogonal to the surface of the Earth, is not parallel everywhere, which is the key physical concept).

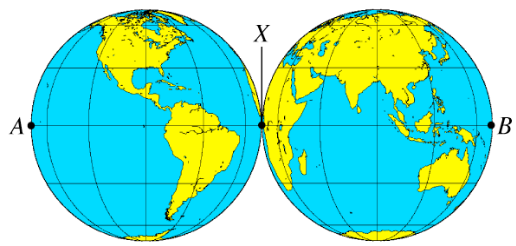


Figure 8.1 | An orthographic projection of Earth. Points *A* and *B* represent the identical location. The distance *A–X* on the map is πR, whether the path taken is a great arc over the perimeter or the map's linear diameter. Note that the local vertical (i.e., extended radii) at points along the two perimeters can represent either a direction parallel to Earth's surface, as is clearly the case at the arbitrary point *X*, or a direction perpendicular to the surface (i.e., altitude) at that mapped location.

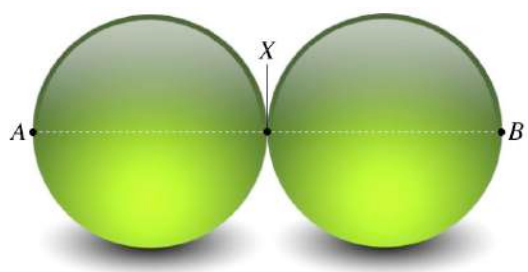


Figure 8.2 | Two spheres: a 3-D projection of the finite boundaryless spacetime Cosmos. Points *A* and *B* represent the identical location. Points *A* and *X* (equivalently points *B* and *X*) represent cosmological antipodes. The distance *A–X* on the map is the same, whether the path is represented by any great arc on the surface of either sphere or the linear diameter through the interior of a sphere. Note that the local vertical to any point on the surface of the spheres may represent local time there or may represent the local *z*-direction of space, as is most evident at the point labeled *X*.

Ignoring topography, Fig. (8.1) represents the finite boundaryless 2-D surface of a 2-sphere (i.e., the geoid). Fig. (8.2) similarly represents the finite boundaryless volumetric 'surface' of a 3-sphere. Just as the respective perimeters of the two circles in Fig. (8.1) represent the identical set of points, the respective surfaces of the two spheres in Fig. (8.2) similarly represent the same set of points. Let point X represent the location of our Galaxy. If the plane of its disk (i.e., the x-y plane) is tangent to the surface of the spheres, its axis of rotation (i.e., the z-direction) is along the interior diameter (the dashed line). The point A (and identically B, as it is the same point) represents the cosmic location antipodal to the Milky Way. The interior linear diameter A–B represents the same great circle distance as any circumference of either sphere, just as the linear diameter A–B in Fig. (8.1) represents a circumnavigation of the Equator.

Einstein's conception of the general theory of relativity (GR) as a geometric theory of the gravitational field is largely based on Minkowski's contribution to special relativity. However, due to his ingenious former mathematics professor's premature death, Einstein never really understood what Minkowski had done in geometrizing special relativity; evidently, Einstein never understood the geometric nature of time. Because of this, and a fundamental conceptual error that occurred at the beginning of his quest to unify special relativity with accelerated reference frames, Einstein's mathematical approach to general relativity was greatly overcomplicated and so too were the subsequent cosmological models based on the new theory. The fundamental interpretation of general relativity is "excess radius," which is a geometric consequence of the "spacetime curvature" modeled by the Einstein field equations. This "excess radius" exists, but not exactly as it has been conventionally defined in Einstein's version of GR. General relativity incorporates a modeling error with observable empirical consequences, which shall be discussed in a later chapter.

The *physical interpretation* of the Minkowski metric, below, involves two essential ideas.

$$ds^2 = -c^2dt^2 + dr^2 + r^2d\theta^2 + r^2\sin^2\theta\, d\phi^2 \tag{8.1}$$

1) Space and time are *physically* orthogonal dimensions in a locally Lorentzian reference frame,

2) Space and time are *physically* transformational dualities of spacetime (i.e., "*time becomes space*").

Thus, the local physical distinctions of altitude and of cosmic local time are geometrically similar.

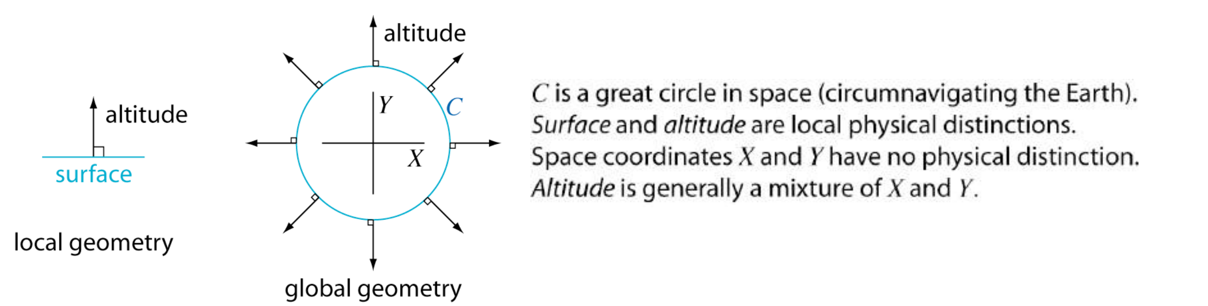


Figure 8.3 | The familiar distinction between the local and global altitude 'dimension.'

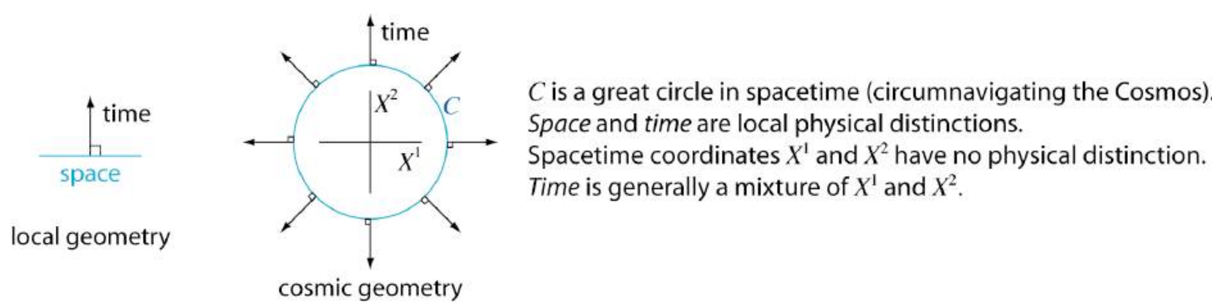


Figure 8.4 | The cosmic *local time* coordinate is similar to Earth's *local altitude* coordinate. The strictly local time dimension is generally a mixture of cosmic spacetime coordinates X^1 and X^2.

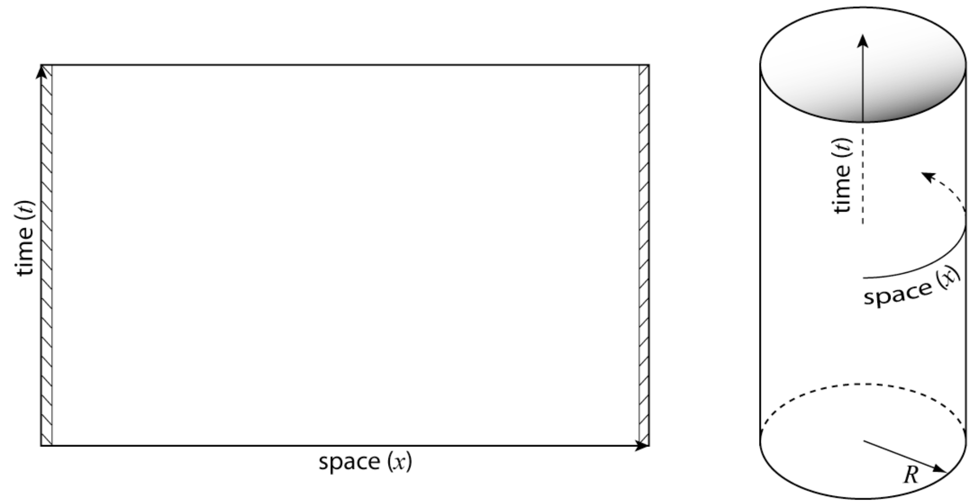


Figure 8.5 | Cylindrical space-time with one space dimension (x). The two edges of the spacetime plane on the left are connected to form the cylinder on the right. The resulting space has a Euclidean geometry but the topology of a Riemannian hypersphere. Conventional wisdom naïvely assumes that this single time coordinate model is valid for a cosmological great circle with $R = f(t)$.

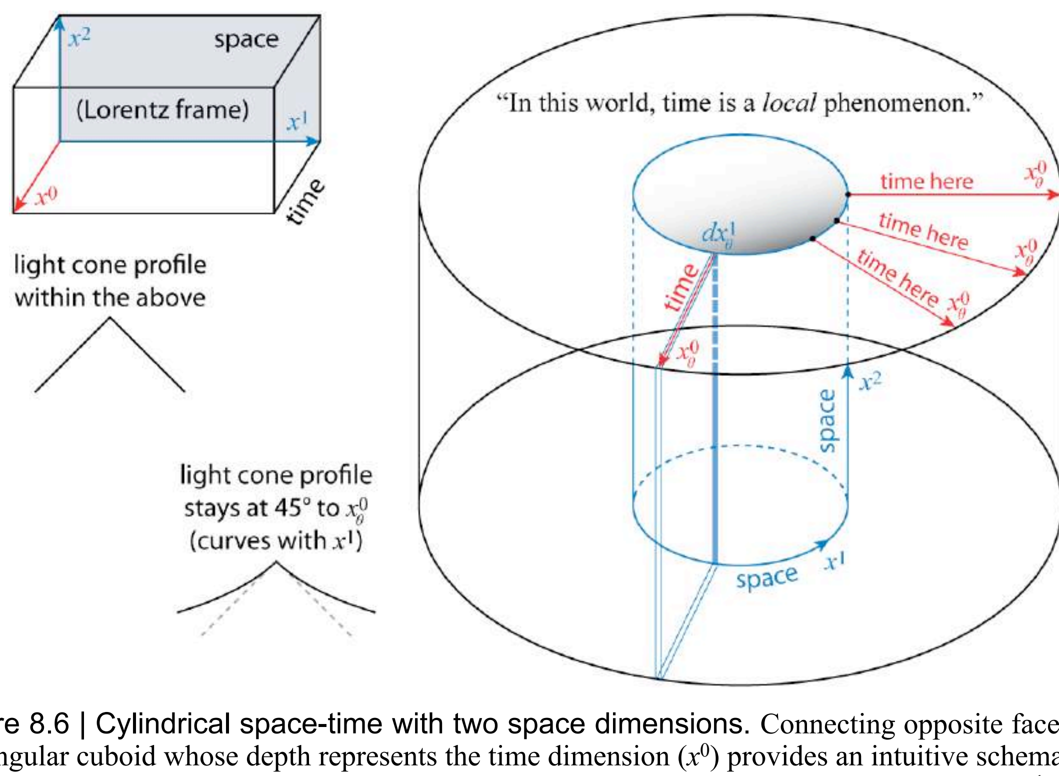


Figure 8.6 | Cylindrical space-time with two space dimensions. Connecting opposite faces of a rectangular cuboid whose depth represents the time dimension (x^0) provides an intuitive schematic of the resulting non-parallelism of local time coordinates over a connected dimension (here x^1 only). Minkowski's "infinite number of spaces" (review the quote at bottom of page 18) are here abstractly represented by each differential slice ($dx^1{}_\theta$, x^2, $x^0{}_\theta$). Clearly, each of these unique spaces has a geometrically unique time coordinate (i.e., the local radial). If one similarly connects x^2 in order to achieve a natural symmetry, the result is a sphere for which radials represent the unique local time coordinate for the neighborhood of each unique point (representing a unique "space"). The surface of the sphere represents the total cosmic extent of a local plane in space (e.g., the Galactic disk).

Like the clever Greek philosopher-mathematicians who surmised by logic that the Earth is spherical, perhaps contemplating the fate of a ship that continued to sail in one direction without deviating from its course, today we can imagine a gedanken ‘spaceship’ conceived to circumnavigate the Universe in a cosmic great circle. The perimeter of the circle in Fig. (8.4) represents a single closed (i.e., boundaryless) dimension of cosmic space, curved not in space, but in the intangible “world” of Minkowski’s spacetime. So, while the one-dimensional perimeter of the circle exclusively represents space, its two-dimensional interior represents *spacetime*. The two coordinates shown (X^1, X^2) do not have a fixed physical interpretation, but rather generally represent a mixture of space and time that depends on the physical location mapped by a point on the circle. Also, in the same way that ‘negative gravity’ does not and cannot exist in Fig. (8.3), the local experience of proper time in Fig. (8.4) is identical everywhere.

The key concept that the ancient philosopher-mathematician had to embrace before he could easily understand (with little immediate physical evidence to prove it) that the Earth was spherical was that the direction of gravity (i.e., the local vertical or altitude ‘dimension’ of space) was not parallel over an area beyond the local approximation. Similarly, the key concept that the modern astrophysicist-cosmologist must embrace before it is easily understood that the Universe is finite yet boundaryless is that the local time dimension in the spacetime Universe is not parallel over space other than to a close approximation on an immediately local cosmic scale (i.e., a radius of perhaps a few million light years).

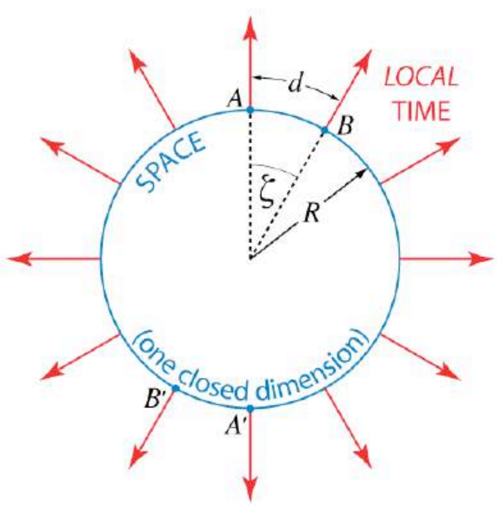
The observable physical implications of the cosmic temporal geometry shown in Fig. (8.4) are made clear in Fig. (6.1); a symmetric geometric change in the direction of time in spacetime implies a symmetric relativistic time dilation that is identical to the measurable effects of relative motion. Special relativity tells us and experiment conclusively demonstrates that the perceived rate of an ideal clock in relative motion is less than that of the ‘stationary’ laboratory clock. With no reference whatsoever to general relativity, the identical theory, when properly interpreted in the context of Minkowski’s brilliant mathematical insight, implies that the perceived relative rate of a cosmologically distant ideal clock must be less than a local clock. This symmetric relativistic temporal effect, readily observable as ubiquitous galaxy redshifts, is completely independent of relative motion. Moreover, the proportional mathematical relationship between the distance to an “ideal clock” (e.g., a light source of known emission frequency) and the corresponding redshift of such a light source due to relativistic time dilation is rigorously defined by pure mathematics (i.e., *geometry*). Additionally, there are no free parameters that can be manipulated to alter the precise prediction of observable relativistic time dilation effects as a function of distance.

9. COSMOLOGICAL LATITUDE

The new concept of *cosmological latitude* is now introduced. This is an angular parameter relative to any arbitrary point of observation in the Cosmos. It should be clear that this parameter is unrelated to astrometry, pertaining exclusively to a remote object’s distance from an arbitrarily chosen point of observation in the Universe and not to its position in the sky. As is intuitively true for the surface of a sphere, there is no preferred location in space for a finite boundaryless universe. Therefore, the vantage point from which humans view the observable universe (i.e., the Milky Way Galaxy) may be arbitrarily selected as the origin of a concentric cosmological map. Its cosmological latitude ζ (*zeta*), which is a coordinate relative to this origin rather than an absolute coordinate, is therefore defined to be zero.

Let the point *A* at 12 o’clock in Fig. (9.1) represent the spatial location of our galaxy and let the point *B* represent the location of some distant galaxy whose cosmological redshift may be accurately measured. The circle represents the closed total cosmological extent of what is locally determined to be an arbitrarily defined single dimension of space (e.g., our galaxy’s axis of rotation). The cosmological latitude of a distant galaxy at point *B* is its angular cosmological displacement from the observer up to and inclusive of *pi* radians, which represents the location of the cosmological antipode (e.g., *A–A′* and *B–B′*). Note that point *A* can just as well represent any arbitrary location in the Universe from which an observer looks out to some other distant astrophysical object labeled *B*. Providing a historical perspective of a time before the idea of an expanding universe became firmly established within scientific academia, the brief introductory section of a 1935 paper by collaborators Edwin Hubble and Richard Tolman at Caltech in the *Astrophysical Journal* entitled “Two Methods of Investigating the Nature of the Nebular Redshift” is reproduced in its entirety in the following quotation. The emphasis has been added.

> Light arriving from the extra-galactic nebulae exhibits a shift toward the red in the position of its spectral lines, which is approximately proportional to the distance to the emitting nebula. The most obvious explanation of this finding is to regard it as directly correlated with a recessional motion of the nebulae, and this assumption has been commonly adopted in the extensive treatments of nebular motion that have been made with the help of the relativistic theory of gravitation, and also in the more purely kinematical treatment proposed by Milne. Nevertheless, *the possibility that the redshift may be due to some other cause*, connected with the long time or distance involved in the passage of light from nebula to observer, should not be prematurely neglected; and several investigators have indeed suggested such other causes, although without as yet giving an entirely satisfactory detailed account of their mechanism.
>
> Until further evidence is available, both the present writers wish to express an open mind with respect to the ultimate most satisfactory explanation of the nebular red-shift and, in the presentation of purely observational findings, to continue to use the phrase "apparent" velocity of recession. They both incline to the opinion, however, that *if the red-shift is not due to recessional motion*, its explanation will probably involve some quite new physical principles.[52]



While local time points in the opposite direction in spacetime at a relative antipode, the principle of relativity implies that each local timeline is experientially identical to any other. There is no reverse flow of time anywhere that conflicts with causality or the 2nd law of thermodynamics. Observers at *A′* do not experience time in reverse as compared to those at *A* any more than 2dF astronomers working "Down Under" live an 'inverted life' as compared to their SDSS counterparts.

In *Chapter 16*, a correction to general relativity is introduced that predicts previously unexplained observed phenomena. Additionally, the Einstein-Rosen bridge is revitalized. Such a "wormhole" between cosmic antipodal regions (e.g., *A–A′*) allows for continuous dynamic mass-energy redistribution, which provides a means to prevent catastrophic gravitational collapse of the Universe indefinitely without expansion.

Figure 9.1 | The cosmological latitude *zeta* ($0 \le \zeta \le \pi$) measured between cosmic antipodes. Unlike conventional latitude, which is measured relative to an equator between positive and negative antipodes, the cosmological latitude is measured directly between cosmic antipodes. Therefore, ζ is always a positive value ranging between zero (at the arbitrary point of observation) and *pi* radians. The effective spatial radius of the Universe (coefficient R), quantifies the spatial distance between locations ($d = R\zeta$). A distance-related redshift exists between A and B even if R is time-independent.

The foregoing discussion concerning geometric cosmic time provides an alternate explanation for the observed redshift of remote galaxies that is not predicated on the general cosmic expansion model rapidly adopted by Lemaître and Hubble less than a century ago. The majority of scientific professionals are likely to have assumed that interpretations of empirical evidence presented in recent years provide conclusive evidence for an expanding universe. However, we are no longer entitled to presume this imagined expansion. A fully testable alternative explanation for the observed galactic redshift now presents itself less than a century after the Big Bang hypothesis. According to scientific principles, prior claims by recognized expert academic authorities are irrelevant, and previous alleged "facts" must now be properly treated as assumptions. The quantitative predictions arising from the new relativistic geometric model for the observed galactic redshift must be compared with empirical observations. If these predictions more accurately reflect observations and if the greater theoretical edifice arising from the concept of geometric cosmic time better integrates and explains the totality of empirical evidence without resorting to implausible inventions (e.g., 'inflation,' 'dark energy,' 'dark matter') then the Big Bang theory must be abandoned. The key result of this discussion is that in ensuing analyses we shall begin by assuming a constant value for the effective radius of the Universe (R) as it appears in Fig. (9.1). While this will greatly simplify derivations and calculations, the idea that the size of the Universe is unchanging over time is such an unexpected development in the field of cosmology today that most people would otherwise find it an invalid and even ludicrous leading assumption. This is not the case upon comparing quantitative predictions with empirical observations. Correlation of theory with observation makes it clear that performing additional analyses while assuming ($dR/dt \neq 0$) would be a waste of time.

Eq. (9.1) is taken directly from Fig. (6.1); based exclusively on simple projective geometry, the measured rate of a remote ideal clock ($d\tau$) at cosmological latitude ζ relative to a local clock (dt) is

$$\frac{dt}{d\tau} = \sec\zeta \tag{9.1}$$

Eq. (9.2) is the definition of redshift based on frequency where f_0 is the natural emission frequency and f is the observed frequency, which is typically redshifted (i.e., reduced).

$$\frac{f_0}{f} = z + 1 \tag{9.2}$$

Measurement of photon frequency is fundamentally associated with time measurement. Let a photon have a natural frequency f_0 as measured by an ideal clock #1 in its emission rest frame. If, from the perspective of a remote observer's local ideal clock #2, a relativistic phenomenon causes clock #2 to record time faster in comparison to clock #1, then according to clock #2, the same number of cycles in a periodic process is counted in a greater amount of time. Accordingly, the apparent emission frequency f of the photon in reference to clock #2 is lower than its natural frequency f_0 (as measured by clock #1) in proportion to the clock rate differential. Consequently, when the photon of natural emitted frequency f_0 according to clock #1 (τ) actually arrives at the remote location of clock #2 (t), it is physically measured by clock #2 to have the lower frequency f according to

$$\frac{f_0}{f} = \frac{dt}{d\tau} \tag{9.3}$$

Combining equations (9.2) and (9.3) yields

$$\frac{dt}{d\tau} = z + 1 \tag{9.4}$$

Combining equations (9.1) and (9.4), observed redshift is expressed in terms of the cosmological latitude.

$$z + 1 = \sec\zeta \tag{9.5}$$

$$\zeta = \cos^{-1}\left(\frac{1}{z+1}\right) \tag{9.6}$$

As we do not assume that the cosmological redshift implies a general recession of the galaxies due to cosmic expansion, but rather a relativistic temporal effect associated only with distance, let the effective radius of the spacetime Universe be fixed over all time according to any clock ($dR/dt = 0$) and normalize this cosmic radius ($R = 1$). Then the relationship between cosmological latitude and distance is simply

$$d_{AB} = \zeta_{AB} \tag{9.7}$$

Combining Eq. (9.6) and Eq. (9.7) yields a general equation (9.8) relating measured cosmological redshift and relative distance. Skeptics with a conventional mindset must refrain from prejudging this equation prior to understanding that conventional equations from Euclidean geometry for surface area and volume related to distance do not apply. More importantly, the correlation between the predictions of the proposed new model and all relevant empirical observations must be evaluated before passing judgment. Eq. (9.8) was effectively previewed in the Eq. (3.2) theta-z relationship, which demonstrated predictive accuracy.

$$d(z) = \cos^{-1}\left(\frac{1}{z+1}\right) \tag{9.8}$$

Fig. (9.2) provides a visual model of Eq. (9.6). It represents half of a complete cosmological map because the adjacent identical second sphere is not shown [see Fig. (8.2)]. The coordinates shown are relative to the Milky Way's arbitrary location. The primary purpose of this image is to show the relationship between cosmological latitude (ζ) and redshift (z). Like any 2-D map of three-dimensional Earth, this partial 3-D map of the four-dimensional spacetime Universe involves unavoidable distortion. It should be clear that the metric operating on the distorted modeled space cannot be assumed to operate identically on the actual space as is also true for any two-dimensional map of a large region of the Earth. The Fig. (9.2) map may be non-intuitive because our mind has been trained (and is thus inclined) to interpret the geometry we see in terms of what is familiar. This sphere, which is a distorted map, is curved in *spacetime*, not in space, so we must be guided by first principles (i.e., relativity), not our natural inclinations. Per the prior discussion concerning Fig. (8.2), recall that the spatial distance represented by the internal diameter of the sphere is identical to the spatial distance represented by a great arc on the surface of *pi* radians.

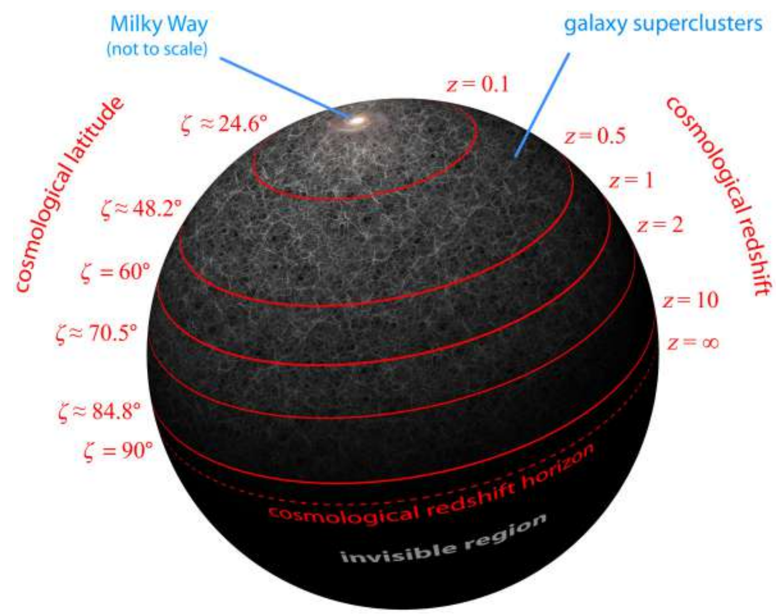


Figure 9.2 | The relationship between ζ and z in the finite boundaryless Universe. A possible initial reaction to this model is to reject it on the grounds that "we *believe* that the Universe is flat."[53] This sphere is a *projection*; the metric operating on the space modeled by the sphere's surface does not correlate to the geometry of the surface. Note that this is not a model of space but of spacetime, between which there is a broad distinction. The local vertical represents both space and time.

The model shown in Fig. (9.2) incorporates an important insight that is a completely new yet intuitive concept in cosmology. At cosmological latitude $\pi/2$ (i.e., $\zeta = 90^{\circ}$) the measured redshift of a galaxy at that distance is arbitrarily large; thus, if too great a spatial distance ($d \geq \pi/2$) separates two observers, it is impossible for them to exchange information of any kind. Relative to every observer, there is an effective radial boundary or *cosmological redshift horizon* beyond which the remaining more distant galaxies in the Universe (i.e., those in the cosmic antipodal "hemi-4-sphere") are invisible. Consequently, it is impossible for the closed spatial geometry of the spacetime Universe to produce two diametrically opposed visible images of the same object. There is nothing intrinsically unusual about the cosmological horizon; it is simply a relative cosmological coordinate. To imagine that local time flows backward beyond this boundary because the local vertical to this cosmic sphere represents local proper time is as childishly naïve as to imagine that people living on the opposite side of the Earth exist "upside down." The cosmological redshift is without doubt a relativistic temporal effect, rather than a result of expansion; Fig. (9.2) is the modern cosmological equivalent of the first terrestrial globe ever constructed by a mapmaker. The first terrestrial globe is alleged to have been made by Crates of Mallus in about 140 B.C.E. That globe, though it may have been lacking in detail, was the first truly accurate physical model of the Earth on the largest scale.

10. THE GEOMETRY OF THE UNIVERSE

The ancients naïvely imagined the Earth to be 'flat' and perhaps limitless. Similarly, people who today have little familiarity with spacetime and the 4-dimensional geometry of a Riemannian 3-sphere likely imagine cosmic space to be a kind of limitless celestial sphere (i.e., an infinitely large 2-sphere). While the mapping in Fig. (8.2) provides an intuitive visualization of finite boundaryless cosmic space, it is also necessary to first define the geometry mathematically and then to quantitatively relate it to astrophysical measurement that can be made with good accuracy (i.e., cosmological redshift, z). The derivation of Eq. (3.3), which relates an immediate and accurately measured observable (z) to an indirect observable based on galaxy counts (V), yields a true "precision cosmology." This cosmology has involves only two unknown parameters: the effective radius of the Universe (R) and extinction (A) due to the intergalactic medium (IGM). However, both of these parameters are subject to accurate estimation based on direct empirical observations, the latter by the effect of the IGM on quasar radiation.

Approximating Earth ($\mathbb{S}^3$) to be a unit ball, the geoid surface area is 4π in units of square Earth radii. Taking a similar approach for the $\mathbb{S}^4$ spacetime Universe, the radius of the envisioned cosmic 3-sphere is conveniently normalized (R=1). Accordingly, the line element of a unit 3-sphere is

$$ds^2 = d\psi^2 + \sin^2\psi\left(d\theta^2 + \sin^2\theta\, d\phi^2\right) \tag{10.1}$$

The total volumetric 'surface area' S_3 of a 3-sphere of unit radius is $2\pi^2$ according to

$$S_3 = \int_0^\pi d\psi \int_0^\pi \sin\psi \;\, d\theta \, \int_0^{2\pi} \sin\psi \;\, \sin\theta \;\, d\phi \tag{10.2}$$

$$S_3 = 4\pi \int_0^\pi \sin^2\psi \;\, d\psi \tag{10.3}$$

$$S_3 = 2\pi\left(\psi - \cos\psi\sin\psi\right)\Big]_0^\pi = 2\pi^2 \tag{10.4}$$

Referencing Fig. (9.1) and Fig. (9.2), it should be clear that the cosmological latitude (ζ) corresponds to the value of the angular parameter ψ in the foregoing geometric equations ($\zeta \equiv \psi$). What is modeled as a great arc through cosmic spacetime ($R{\cdot}\zeta$) is the radial distance measured over the shortest possible distance through space between the telescope and a remote galaxy (i.e., the path of light between the two points). Having conveniently adopted a cosmological unit radius (R = 1), Eq. (10.5), which is pure geometry, represents a physically meaningful cosmological equation for the volume of enclosed space expressed as a function of the cosmological latitude.

$$S_3 = 2\pi\left(\zeta - \cos\zeta\sin\zeta\right) \tag{10.5}$$

From Eq. (9.6) we have equations (10.6) and (10.7).

$$\cos\zeta = \frac{1}{(z+1)} \tag{10.6}$$

$$\sin\zeta = \sqrt{1-\cos^2\zeta} = \left(1 - \frac{1}{(z+1)^2}\right)^{\frac{1}{2}} \tag{10.7}$$

Substituting for the three terms in Eq. (10.5) and simplifying yields Eq. (10.9). Thus, the volume of enclosed space (S_3) is expressed directly as a function of redshift (z). Note that Eq. (10.9) is an exact formula based exclusively on geometry and first principles and that it involves no free parameters that can be manipulated to alter its fundamental empirical prediction. It is expressed in units of R^3.

$$S_3(z) = 2\pi \left\{ \cos^{-1}\left(\frac{1}{z+1}\right) - \left[\left(\frac{1}{z+1}\right)\left(1 - \frac{1}{(z+1)^2}\right)^{\frac{1}{2}} \right] \right\} \tag{10.8}$$

$$S_3(z) = 2\pi \left[\cos^{-1}\left(\frac{1}{z+1}\right) - \left(\frac{1}{(z+1)^2} - \frac{1}{(z+1)^4}\right)^{\frac{1}{2}} \right] \quad R^3 \text{ units} \tag{10.9}$$

Eq. (10.9) is graphed in Fig. (10.1). At arbitrarily large redshift corresponding to a cosmological latitude of 90 degrees, the volume of enclosed space is half of the total volumetric surface area of a 3-sphere (π^2).

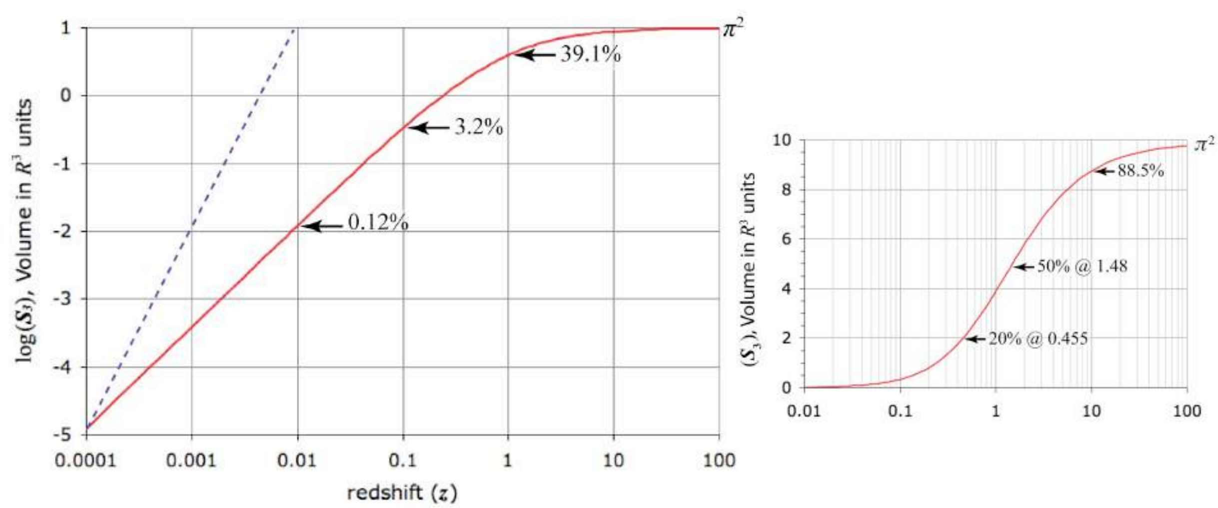


Figure 10.1 | Graphs of Eq. (10.9); volume as a function of redshift. Ignoring the R^3 units, the dashed blue line models the expected relative growth rate of volume at low redshift according to a linear (Hubble) redshift-distance relationship and $V \propto r^3$. A plot with a linear volume scale at right shows that 50% of the space inside the cosmological horizon (the 'visible' half of the Universe) is contained within ($z < 1.5$). About 10% of this total 'observable' volume is beyond $z = 10$.

Differentiating Eq. (10.9) with respect to z is a somewhat lengthy but straightforward process.

$$u = (z+1)^{-1} \quad \rightarrow \quad S_3(z) = 2\pi\left[\cos^{-1} u - \left(u^2 - u^4\right)^{\frac{1}{2}}\right] \qquad \frac{du}{dz} = -(z+1)^{-2} = -u^2 \tag{10.10}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{-1}{\sqrt{1-u^2}}\frac{du}{dz} - \frac{1}{2\sqrt{u^2-u^4}}\left(2u\frac{du}{dz} - 4u^3\frac{du}{dz}\right)\right] \tag{10.11}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} - \frac{1}{2\sqrt{u^2-u^4}}\left(-2u^3 + 4u^5\right)\right] = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} + \frac{u^3}{\sqrt{u^2-u^4}} - \frac{2u^5}{\sqrt{u^2-u^4}}\right] \tag{10.12}$$

$$\frac{dS_3}{dz} = 2\pi\left[\frac{u^2}{\sqrt{1-u^2}} + \frac{1}{\sqrt{u^2-u^4}}\left(u^3-2u^5\right)\right] = 2\pi\left\{\frac{1}{\sqrt{1-u^2}}\left[u^2+\frac{1}{u}\left(u^3-2u^5\right)\right]\right\} \qquad (10.13)$$

$$\frac{dS_3}{dz} \equiv \frac{dV}{dz} = 4\pi\left[\frac{1}{\sqrt{1-u^2}}\left(u^2-u^4\right)\right] = \frac{4\pi}{\sqrt{1-(z+1)^{-2}}}\left(\frac{1}{(z+1)^2}-\frac{1}{(z+1)^4}\right) \qquad (10.14)$$

Recall that this equation was previewed as Eq. (3.3) and initially graphed in Fig. (3.7) for comparison with the scaled SDSS empirical data. In the following larger figure, which provides more detail of the data, Eq. (10.14) is scaled and superimposed on the 2dF Survey data out to redshift $z = 1$.

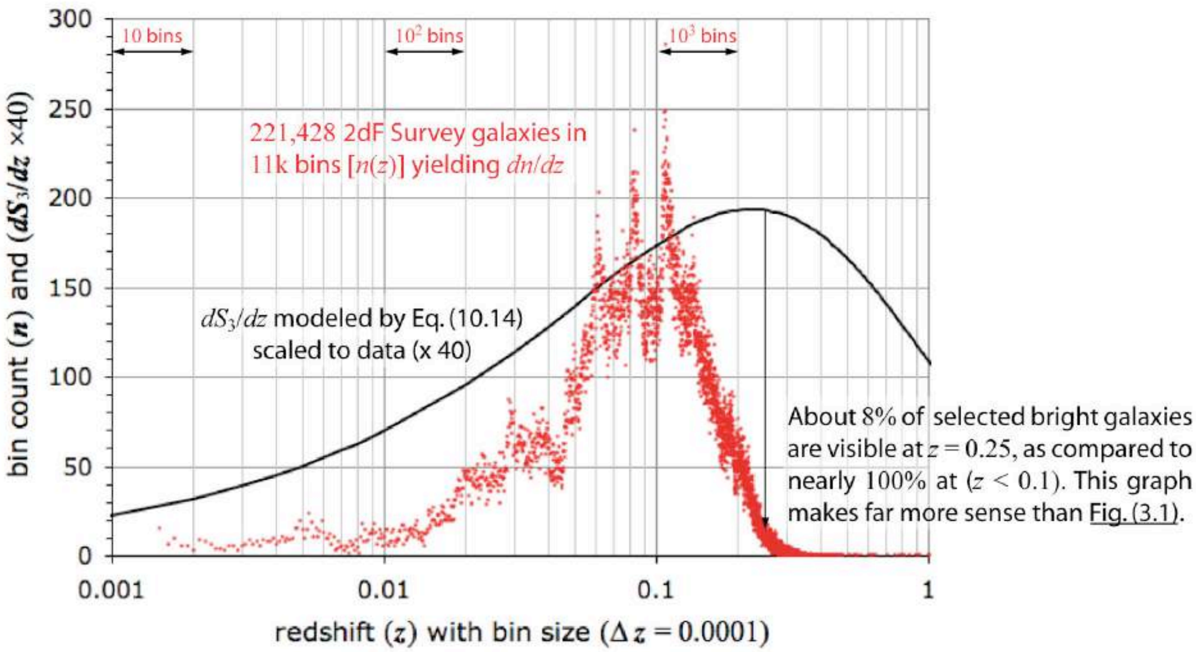


Figure 10.2 | 2dF Survey ($0.001 \le z \le 1$) in red and Eq. (10.14) in black. Redshift data selected for high quality is sorted into ($\Delta z = 10^{-4}$) bins represented by the dots. $10(10 + 10^2 + 10^3)$ bins are plotted. Variation in bin density due to fractal distribution of galaxies is apparent. The location of the peak of the empirical curve (red) on the z-axis is dependent on the resolution of the telescope used in the survey. It must increasingly shift to the left as the resolving power of the survey telescope declines because more high-z galaxies are missed. Assuming that all galaxies are counted regardless of distance in an ideal homogeneous universe, the black line is the predicted trend in redshift bin counts. The fractal distribution of galaxies at low redshift, which causes density decline with distance, depresses the empirical curve at low redshift. Few galaxies are found in the local region ($z < 0.001$).

The conventional pseudo-equivalent version of Eq. (10.9) is Eq. (10.15). V is the co-moving volume, defined as the volume in which densities of non-evolving objects (assumed to be) locked into Hubble flow are constant with redshift. Assuming a homogeneous, isotropic universe with constant curvature and zero cosmological constant (the Einstein–de Sitter model), it was thought that differential number counts of galaxies probed the co-moving volume as a function of redshift. . The derivative of Eq. (10.15) with respect to z is Eq. (3.1), which is plotted as the blue line in Fig. (3.1) and Fig. (10.3).

$$V(z) = \frac{32}{3}\pi\left(1-\frac{1}{\sqrt{z+1}}\right)^3 \left(\frac{c}{H_0}\right)^3 \text{ units} \qquad (10.15)$$

Although galaxies get harder to see at high redshift, SDSS still counts some fraction of the selected population beyond $z = 1$. An important question to ask is, what fraction? According to Eq. (10.15), the spatial volume bounded by ($1 \le z < 2$) is double that within redshift $z < 1$, so this textbook equation suggests that an ideal telescope would count twice as many galaxies in the farther region than the nearer.

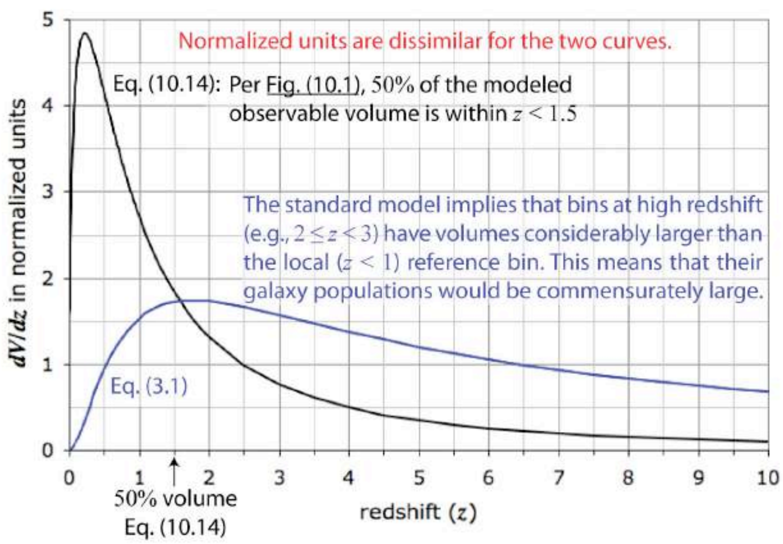


Figure 10.3 | Graph of Eq. (10.14) and Eq. (3.1) showing the volume as a bounded area. The area under the curve in black models a *physical* volume, while that for the curve in blue models *co-moving* volume. For the black curve, it can be seen that a redshift of $z = 1.5$ corresponds to half the total volume, which is about 20 of the small squares corresponding to about 5 unit squares or ($\pi^2/2$).

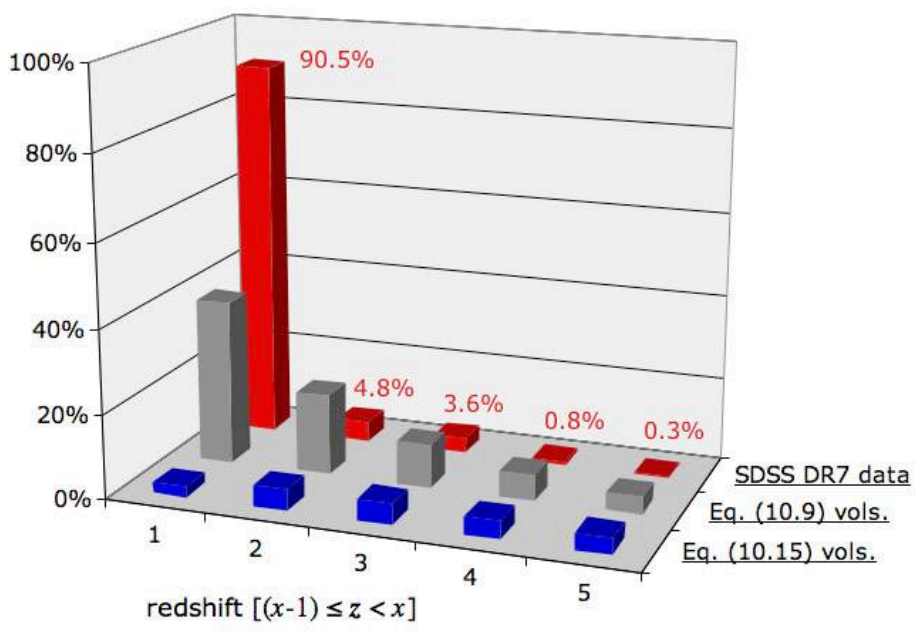


Figure 10.4 | SDSS DR7 SpecObj redshift data sorted into bins of integer redshift. Bars in red (observations) follow the modeled volume trend in gray. As the second and third red columns are of similar magnitude, the spatial depth of bins 2 and 3 must be much smaller than the depth of bin 1 because galaxies in bin 3 are almost as easy to see as those in bin 2. The volume trend in blue according to the standard cosmological model shows a doubling of volume from bin 1 to bin 2.

The graphed SDSS data in Fig. (10.4) can be recreated directly from the online SDSS database using the following SQL statement. See http://pdfref.com/m1/10.01.htm

```
SELECT
        ROUND(z, 0) + 1 AS z
,       COUNT(1)/858599.0 AS pct      /* 858599 is the total ungrouped count (z >= 0.0015) */
FROM
        SpecObj
WHERE
        zStatus IN (3, 4, 6, 7, 9)    /* selected for high quality */
AND     z >= 0.0015                  /* removes misidentified double stars */
GROUP BY
        ROUND(z, 0) + 1
ORDER BY 1;
```

There is an important difference between the black curve and the blue curve in Fig. (10.3), similarly the corresponding gray and blue columns in Fig. (10.4). The area under the black curve models a real physical volume of space. In this context, the redshift is simply interpreted as a distance (d); lookback time (d/c) is irrelevant because the model assumes no change in the volume of the Cosmos over time. The gray bars in Fig. (10.4) imply that if a survey telescope could observe and count distant galaxies just as effectively as nearby galaxies, the empirical red bars would follow the gray bars exactly, assuming a large-scale homogenous distribution of galaxies. In contrast, the co-moving volume interprets lower redshift ($z < 2$) primarily as an increasing distance that implies increasing volume and higher redshift ($z > 2$) as lookback time in an expanding universe to epochs of a decreasing volume. Thus, the same total volume of space is spread over an increasing amount of lookback time, as represented by the redshift, the farther back in time we initiate lookback. Moreover, as one approaches the mythical spacetime singularity at $T = 0$, and as the total available amount of lookback time approaches zero, the available volume of the Big Bang universe also approaches zero. Inflation was an *ad hoc* invention to allow the radius to be greater than cT near $T = 0$.

It is commonly assumed that the intensity of electromagnetic radiation from an isotropic point source is inversely proportional to the square of the distance from the source. This "inverse square law" arises from the equation for the surface area of a Euclidean sphere. While this law may apply locally, just as Euclidean rather than Riemannian geometry applies to the neighborhood of a point on the surface of a sphere, it cannot apply on the large scale for a finite boundaryless (i.e., non-Euclidean) 3-space. In the context of cosmology, photons emitted by an isotropic point source fill S_3, which is modeled by Eq. (10.9), not the naïve familiar equation for a Euclidean sphere. Being the derivative of S_3, the geometric equation for the surface area S_2 enclosing S_3 is then trivially determined simply by removing the integration from Eq. (10.3). Recall that ($\zeta \equiv \psi$). This equation provides the physically meaningful result of an increase in S_2 with distance (here expressed in terms of cosmological latitude) only within the specified interval.

$$S_2 = 4\pi \sin^2 \zeta \quad \left[0 \le \zeta \le \frac{\pi}{2} \right] \tag{10.16}$$

Substituting Eq. (10.7) into the above yields an exact formula for S_2 in terms of redshift.

$$S_2(z) = 4\pi \left(1 - \frac{1}{(z+1)^2} \right) \quad R^2 \text{ units} \tag{10.17}$$

It is important to note that Eq. (10.17) expresses ($0 \le S_2 \le 4\pi$) in terms of the normalized cosmic radius, not the corresponding physical distance from the observer ($d = \pi/2$). Consequently, at high redshift, the area of photon dispersion from an isotropic point source is modeled to be somewhat smaller than that modeled by the inverse square law arising from Euclidean geometry. The conventional practice of interpreting the apparent magnitude of an astronomical standard candle in the context of the inverse square law is naïve for a finite boundaryless universe. Indeed, it is similar to the naïve ancient practice of extending locally-valid rules of Euclidean geometry to Earth's entire surface. Even over short distances (in comparison to Earth's radius), the locally-applicable geometric approximation fails.

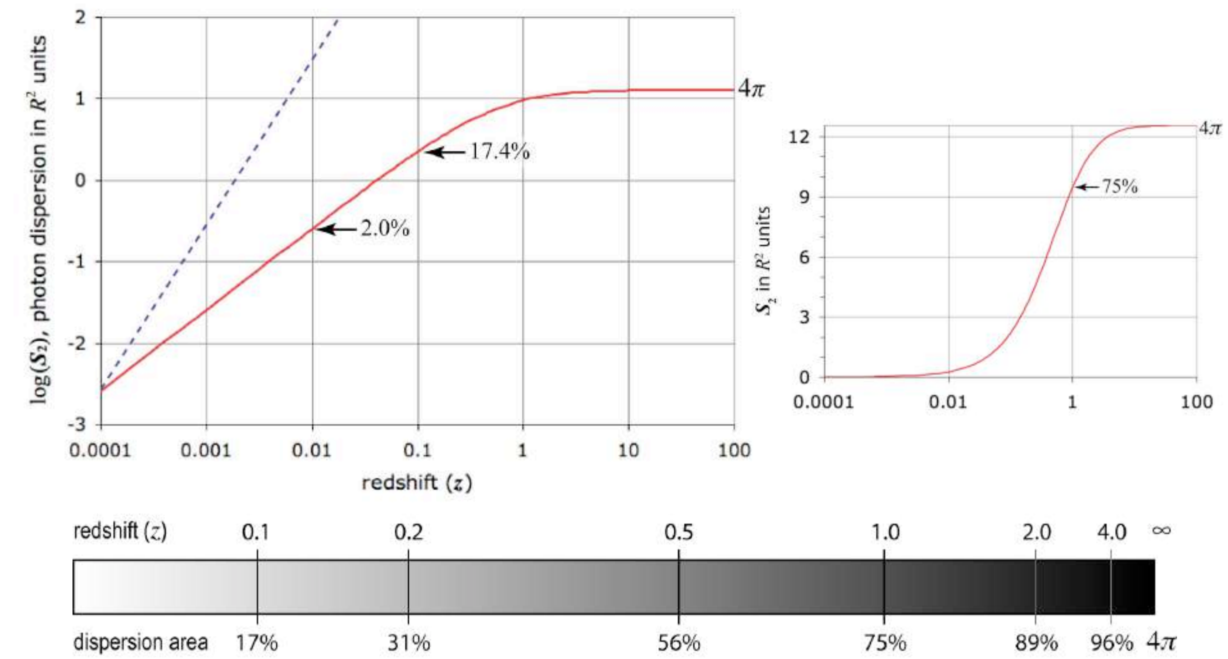


Figure 10.5 | Graphs of Eq. (10.17); Photon dispersion area as a function of redshift. Ignoring the R^2 units used for the red curve, the dashed blue line models the expected relative growth rate of surface area at low redshift according to a linear ('Hubble law') redshift-distance relationship and the Euclidean relationship $A \propto r^2$. The geometry of a Euclidean sphere is not applicable to a finite boundaryless spacetime universe for similar reasons (e.g., the boundary problem) that locally practical plane geometry is not applicable to the spherical surface of the Earth.

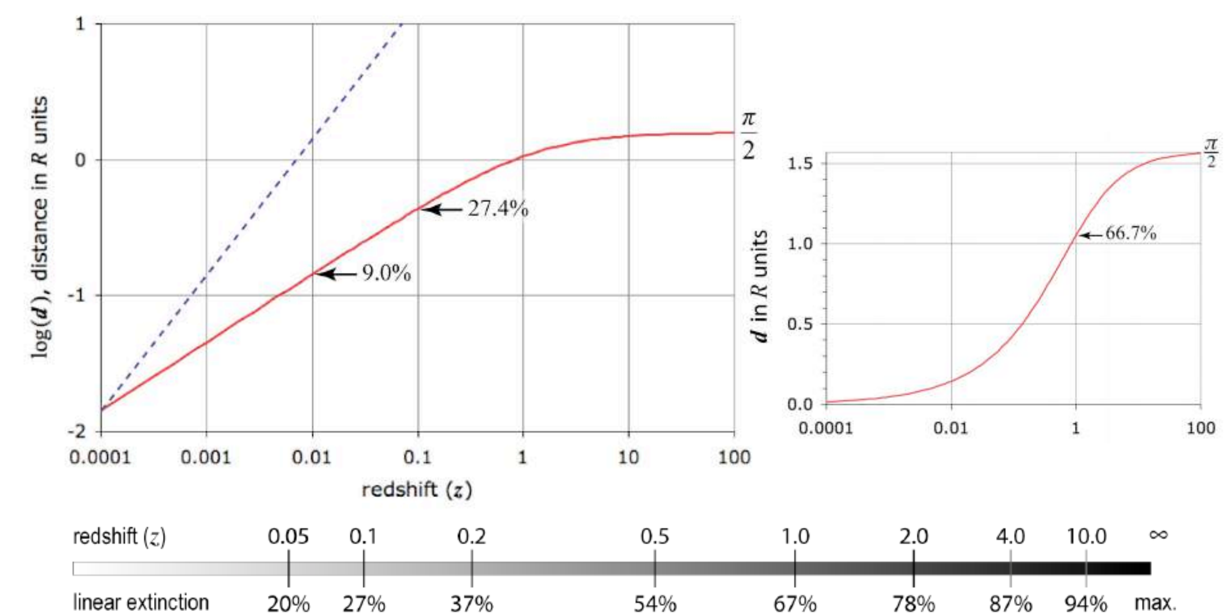


Figure 10.6 | Graphs of Eq. (9.8). Ignoring the units used for the red curve, the dashed blue line models the linear Hubble redshift-distance relationship. In addition to photon dispersion, intergalactic dust absorbs and scatters photons. It is reasonable to model this effect as linear with respect to distance, however redshifted light from distant sources better penetrates the 'local' IGM dust.

11. SPACETIME CURVATURE AND COSMOLOGICAL MEASUREMENTS

Relativity concerns coordinate transformations that fundamentally describe the physical transmutation of time into space and *vice versa*. Historically, the conventional mathematical treatment of the subject seems to have obscured this simple and natural qualitative interpretation. On this theme, relativistic length contraction is a familiar phenomenon, yet its most fundamental qualitative physical meaning seems to have been previously obscured by its quantitative 'description.' The principle of relativity implies that the the physical length contraction of a moving rod in the rest frame of the observer involves no intrinsic metamorphosis of the rod, so a compatible qualitative description is required to explain the quantitative contraction of the moving rod in the rest frame of the observer. Although the concept may be so abstract for non-physicists as to seem unphysical, it should be clear that the rest frame of a moving rod physically rotates in spacetime so that with increasing relative velocity the frame projects a decreasing component of one space dimension (the direction of motion) and an increasing component of its time dimension into a space dimension of the observer. However, unlike a space dimension, the projected time dimension presents no visual information (i.e., transmission of photons). Consequently, relativistic length contraction must also be generally associated with a *dimming* of the observed object.

The observable relativistic effects of time dilation and length contraction are associated with three distinct phenomena: relative motion, the local gravitational field and the cosmological gravitational field. All three cases involve a similar form of coordinate transformation. In the case of the cosmological gravitational field, the physical coordinate transformation (i.e. the transformation of space to time) occurs in the direction of observation. The true fundamental physical meaning of "spacetime curvature" in the context of cosmology is that the farther we look out in space, the more the rest frame of galaxies at the remote location are 'rotated' in spacetime relative to the local Galactic rest frame. Irrespective of any relative motion, the greater the distance to a galaxy, the larger the component of its time axis projected onto the radial space dimension; "*time becomes space*." This reiterates detailed discussion in Chapters 6–9.

The conventional term "spacetime curvature" is somewhat of a misnomer because while space does indeed 'curve' in spacetime analogously to the surface of the Earth curving in space, the local proper time coordinate *rotates* in spacetime analogously to the local terrestrial altitude vector, which rotates in space as it remains locally orthogonal to the planet's curving surface. However, "spacetime curvature" is a linguistically superior term to the more precise term, "space curvature – time coordinate rotation," so long as this more accurate qualitative meaning of the familiar former term is understood.

The foregoing discussion has important consequences for observational cosmology. The relativistic phenomenon of length contraction plays an important part in reducing both the apparent size of a distant galaxy as well as its apparent luminosity. Observing a very high-redshift galaxy, a telescope is 'looking' primarily at the galaxy's local time dimension, so it 'sees' comparatively little of the physical galaxy.

Hold a circular object, such as a compact disk, face-on at arms length. Designate horizontal, vertical and orthogonal axes on the disk as x^1, x^2 and x^3 respectively. If the disk is rotated through ninety degrees on the x^1-axis, the disk first appears as an ellipse and then edge-on as a horizontal line. If instead the rotation is on the x^2-axis axis, the disk first appears as an ellipse and then edge-on as a vertical line. Initially, it was the disk's x^3-axis that was projected on the line-of-sight. The first of the rotations replaces the x^3-axis with the x^2-axis on the line-of-sight while the alternative rotation replaces the x^3-axis with the x^1-axis on the line-of-sight. Consider now that the Minkowski metric [Eq. (8.1)] implies that the proper time coordinate (x^0) associated with a rest frame is a *physical* dimension of spacetime that is mutually orthogonal to all three of its space dimensions. Let us now imagine that the disk rotates *in spacetime* such that the x^0-axis replaces the x^3-axis. What will be observed? Geometry implies that the disk will remain circular and shrink in apparent size down to a point of zero dimension at ninety degrees of rotation.

The foregoing exercise aides in understanding that galaxies observed at high redshift (i.e., $\zeta \to \pi/2$) have a significant component of their time dimension projected on the line-of-sight. As no radiation propagates in this 'direction' in spacetime, both apparent galaxy size and luminosity are affected by the relativistic 'rotation' [see Fig. (11.4)], which is indirectly quantified as a function of redshift by Eq. (9.6). The apparent luminosity decreases in direct proportion to the decrease in the area due to relativistic 'length contraction' of a face-on galactic radius. Quantitatively, that length contraction is the cosine of the cosmological latitude, which according to Eq. (9.6) is simply $(z+1)^{-1}$. Consequently, the individual *contributions* of relativistic length contraction to the decrease in apparent size and related decrease in apparent luminosity of a galaxy with distance (i.e., redshift) are as follows.

$$r'(z)=r_0(z+1)^{-1} \quad \rightarrow \quad \theta(z)=\theta_0(z+1)^{-1} \tag{11.1}$$

$$L(z)\propto\left[r'(z)\right]^2 \quad \rightarrow \quad L(z)=L_0(z+1)^{-2} \tag{11.2}$$

In common experience, the apparent angular size of an object is inversely proportional to its distance. This is simply because angular size is defined as the ratio of the arc length of the observed object to the full circumference of the 2π radian circle at its observed distance.

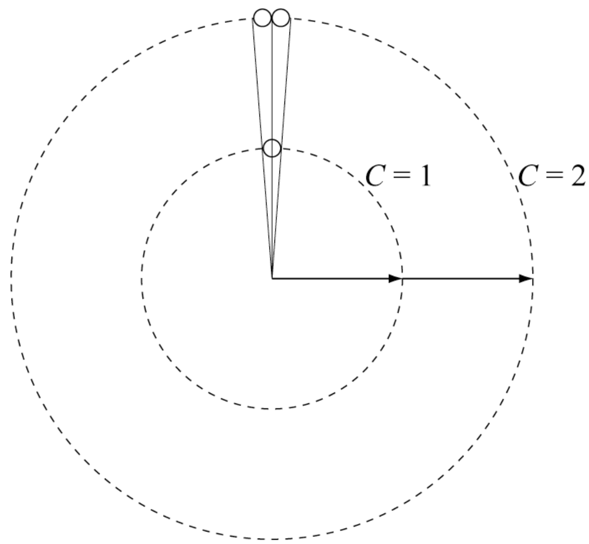


Figure 11.1 | The same object on a circle of twice the circumference subtends half the angle. This is a universal geometric principle, *regardless of the applicable radii*. For a non-Euclidean geometry the ratio of the spatial radii will not be the same as the ratio of the circumferences.

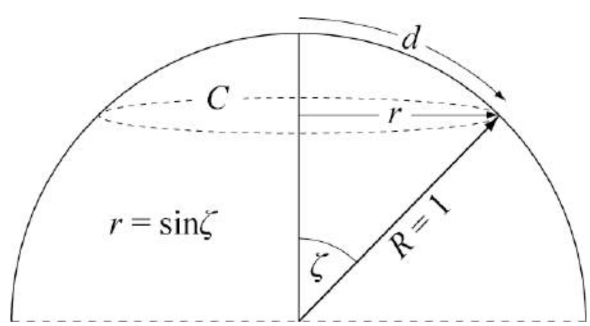


Figure 11.2 | The relationship between cosmological latitude (ζ) and Euclidean radius (r). The spatial radius (d) is restricted to the curved surface, but the spatial circumference (C) at that distance is determined by the effective Euclidean radius (r).

In accord with Fig. (11.2), the spatial circumference is expressed in terms of cosmological latitude. Substituting for the sine term from Eq. (10.7) yields the normalized spatial circumference expressed as a function of redshift in cosmic radius units (R).

$$C = 2\pi \sin\zeta = 2\pi\left(1 - \frac{1}{(z+1)^2}\right)^{\frac{1}{2}} \tag{11.3}$$

The angle subtended by an object of standard dimension is inversely proportional to *C*.

$$\theta(z) \propto \left(1 - \frac{1}{(z+1)^2}\right)^{-\frac{1}{2}} \tag{11.4}$$

Combining the geometric distance effect [Eq. (11.3)] with the relativistic distance effect [Eq. (11.1)], yields the general cosmological theta-*z* relationship, which was previewed as Eq. (3.2). The constant θ_0 is determined by observation for a particular object assumed to function as a cosmological standard rod.

$$\theta(z) = \theta_0 (z+1)^{-1}\left(1 - \frac{1}{(z+1)^2}\right)^{-\frac{1}{2}} \qquad [z > 0] \tag{11.5}$$

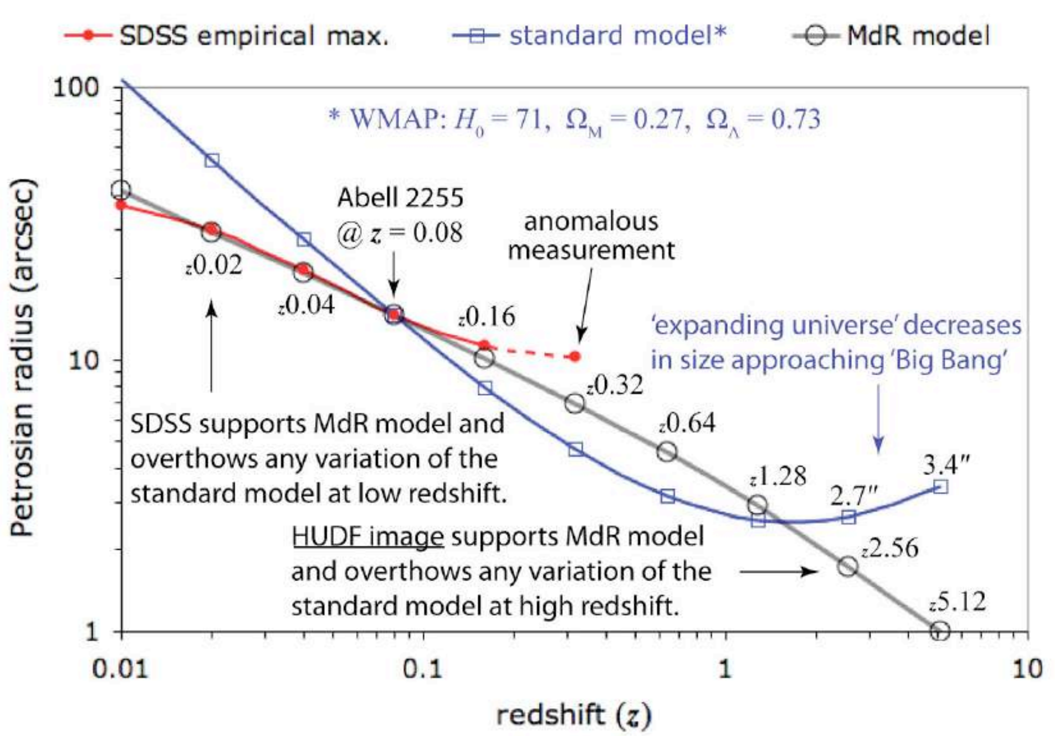


Figure 11.3 | MdR theta-*z* model [Eq. (11.5)] compared to standard theta-*z* model. The standard model curve shown in blue was produced according to calculation of angular size distance (D_A) using Ned Wright's Javascript Cosmology Calculator calibrated to the empirical datapoint (0.08, 14.5) for the maximum observed galaxy radius for that redshift bin plotted in Fig. (3.3). The standard model is overthrown by empirical observations at both low redshift and high redshift. Galaxies seen at high redshift appear much smaller than the standard model prediction shown here although some are known to be unusually large mature galaxies (e.g., HUDF-JD2).

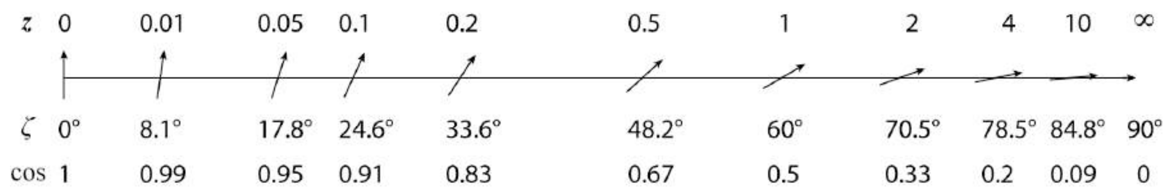


Figure 11.4 | Cosmic linear map relating z, ζ and relativistic length contraction [$\cos(\zeta)$].
Length contraction of galactic radii plays the dominant role in the theta-z relationship at high redshift. The rotating arrow represents the relativistic space-time transmutation with cosmological distance.

From Fig. (11.2) we may relate the unknown magnitude of the normalized cosmic radius (R) to the effective Euclidean radius (r) at some redshift (z), which implies a known value of cosmic latitude (ζ).

$$r = R\sin\zeta \tag{11.6}$$

Combining Eq. (11.6) with Eq. (10.7) (i.e., expressing $\sin\zeta$ in terms of z) yields

$$R = r(z)\cdot\left(1-\frac{1}{(z+1)^2}\right)^{-\frac{1}{2}} \tag{11.7}$$

Let δ be the proper length of a cosmological standard rod, which may be the mean galactic radius as represented by one of the Fig. (3.3) redshift bins. The observed size of δ in radians at some redshift is equal to the ratio of its relativistically contracted size to the effective Euclidean radius at that distance.

$$\theta_\delta(z) = \frac{\delta(z+1)^{-1}}{r(z)} \quad\rightarrow\quad r(z) = \frac{\delta(z+1)^{-1}}{\theta_\delta(z)} \tag{11.8}$$

Combining Eq. (11.7) with Eq. (11.8) yields

$$R = \frac{\delta(z+1)^{-1}}{\theta_\delta(z)}\cdot\left(1-\frac{1}{(z+1)^2}\right)^{-\frac{1}{2}} \tag{11.9}$$

Fig. (3.2) implies that at redshift $z = 0.08$, an average-sized galaxy has a radius of about 5.5 arcseconds or $\theta_\delta(0.08) = 2.7\times10^{-5}$ *radians.* This is a statistically reliable empirical measurement as it is based on averaging the Petrosian radius of 32,526 galaxies within the redshift bin ($0.077 < z < 0.083$). Plugging this θ_δ into Eq. (11.9) yields an order-of-magnitude estimate for the effective cosmic radius. The accuracy of an estimate for R, measured in light years, is primarily dependent on an accurate estimate for δ.

$$R = \frac{\delta(0.08+1)^{-1}}{2.7\times10^{-5}}\cdot\left(1-\frac{1}{(0.08+1)^2}\right)^{-\frac{1}{2}} = 9.1\times10^4\delta \quad\rightarrow\quad R\sim10^5\delta \tag{11.10}$$

From Fig. (3.3) it is known that the radii of typical galaxies do not vary by more than a factor of about ten, so δ must be similar to the estimated radius of the Milky Way or $\delta \sim 10^5$ *ly*. Then the cosmological redshift horizon is $\pi R/2$, or ~15 billion light years distant and less than 10^{11} *ly* circumnavigates the Cosmos. The calculated volume of the theoretically 'observable' half of the Universe ($z < \infty$) is $\pi^2R^3 \sim 10^{16}\delta^3$. The HUDF image suggests a population of $\sim10^4$ galaxies observed in $\sim10^{-7}$ of the sky or a total population on the order of 10^{11} galaxies in the Cosmos. The average separation between galaxies is on the order of 10^1 galaxy diameters because on average each galaxy occupies a volume of $10^{16}\delta^3/10^{11} = 10^5\delta^3$.

12. THE APPARENT LUMINOSITY OF EXTRA-GALACTIC SUPERNOVAE

Per Eq. (10.17), the bolometric flux of a standard candle solely due to geometric *dispersion* of photons is

$$F_d(z) = \frac{L}{4\pi\left(1 - \frac{1}{(z+1)^2}\right)} \tag{12.1}$$

Time dilation causes fewer photons to impinge on a CCD per unit time by a factor of $(z+1)^{-1}$ and reduces their energy by a factor of $(z+1)^{-1}$ yielding a total time dilation effect of $(z+1)^{-2}$. Also, per Eq. (11.2), "spacetime curvature" causes the number of photons propagating over the line of sight to the target to be reduced by a factor $(z+1)^{-2}$. Combining both relativistic effects, we multiply Eq. (12.1) by $(z+1)^{-4}$.

$$F(z) = \frac{L}{4\pi\left[(z+1)^4 - (z+1)^2\right]} \tag{12.2}$$

Norman Pogson, a 19th century British astronomer at Oxford, mathematically formalized the existing system of stellar magnitudes handed down through antiquity.[54] This was done according to a logarithmic scale with a 100-fold increase in apparent brightness being equal to a difference of exactly five magnitudes in order to approximately match the stellar magnitude scale initiated by the Greek astronomer Hipparchus (190–120 BCE). Hipparchus completed the first star catalog having some 850 entries in about 130 BCE for which the brightest stars, considered the most important, were of the first magnitude with increasing numbers for those of lesser brightness. Pogson's equation defining the astronomical magnitude scale is

$$m = C - 2.512\log(b) \qquad \left[2.512 = 100^{1/5}\right] \tag{12.3}$$

The arbitrary constant C is set by convention to determine what observed value of the luminosity ($b \equiv F$) corresponds to a magnitude of zero. This convention uses the observed constant brightness of the star Alpha Lyrae (Vega) to set the zero-point of the scale.

It is convenient to represent Eq. (12.2) as a bolometric apparent magnitude with L normalized to unity

$$m(z) = C - 2.512\ \log\left(\frac{1}{4\pi\left[(z+1)^4 - (z+1)^2\right]}\right) \tag{12.4}$$

It is this equation that was previewed as Eq. (P.1) in the preface and which so spectacularly predicts the statistically robust empirical observations shown in Fig. (P.1) and Fig. (P.2). For supernovae, the arbitrary constant C is chosen so that a redshift of $z = 0.01$ corresponds to a magnitude of $m = 14$ per Fig. (12.2). Accordingly, Eq. (12.5) and the Fig (12.2) graph share the common intercept (0.01, 14).

$$m(0.01) = 14 \quad \rightarrow \quad m(z) = 15.48 - 2.512\ \log\left(\frac{1}{4\pi\left[(z+1)^4 - (z+1)^2\right]}\right) \tag{12.5}$$

In his famous book, *The Structure of Scientific Revolutions*, Thomas Kuhn wrote (emphasis added),

> That scientists do not usually ask or debate what makes a particular problem or solution legitimate tempts us to suppose that, at least intuitively, they know the answer. But it may only indicate that neither the question nor the answer is felt to be relevant to their research. *Paradigms may be prior to, more binding, and more complete than any set of rules for research that could be unequivocally abstracted from them*.[55]

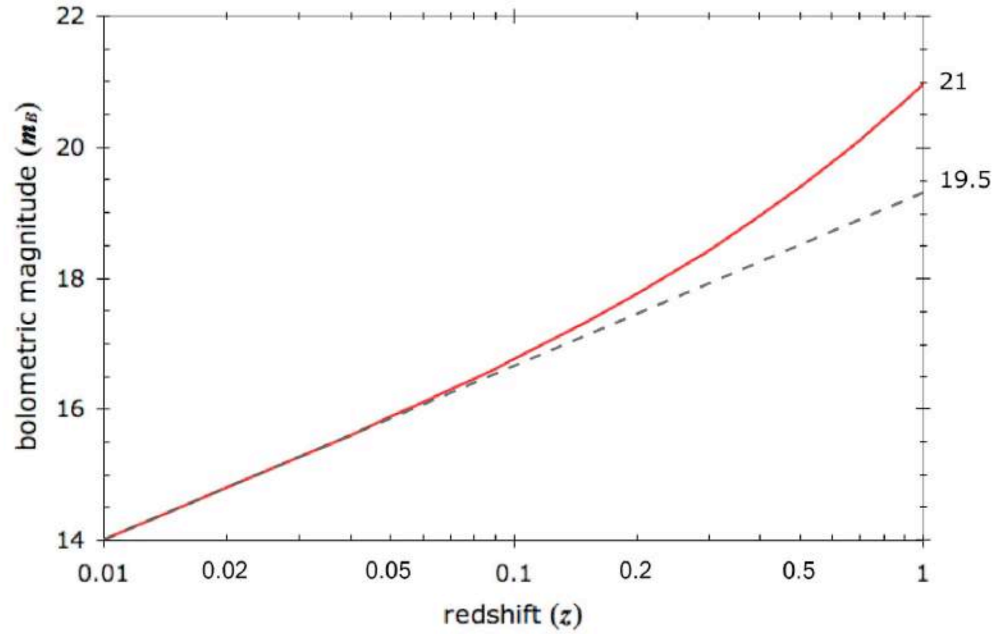


Figure 12.1 | Graph of Eq. (12.5). At about $z = 0.1$, the modeled redshift-magnitude curve in red begins to deviate up from a straight line (dashed). This behavior is what led astrophysicists to conclude that the alleged cosmic expansion is accelerating. The alleged transition from deceleration to acceleration is not just unlikely, it is a physical interpretation of the observable that is contrary to the laws of physics (i.e., like Ptolemy's epicycles or an expedient "miracle," it is unequivocally *physically impossible*).

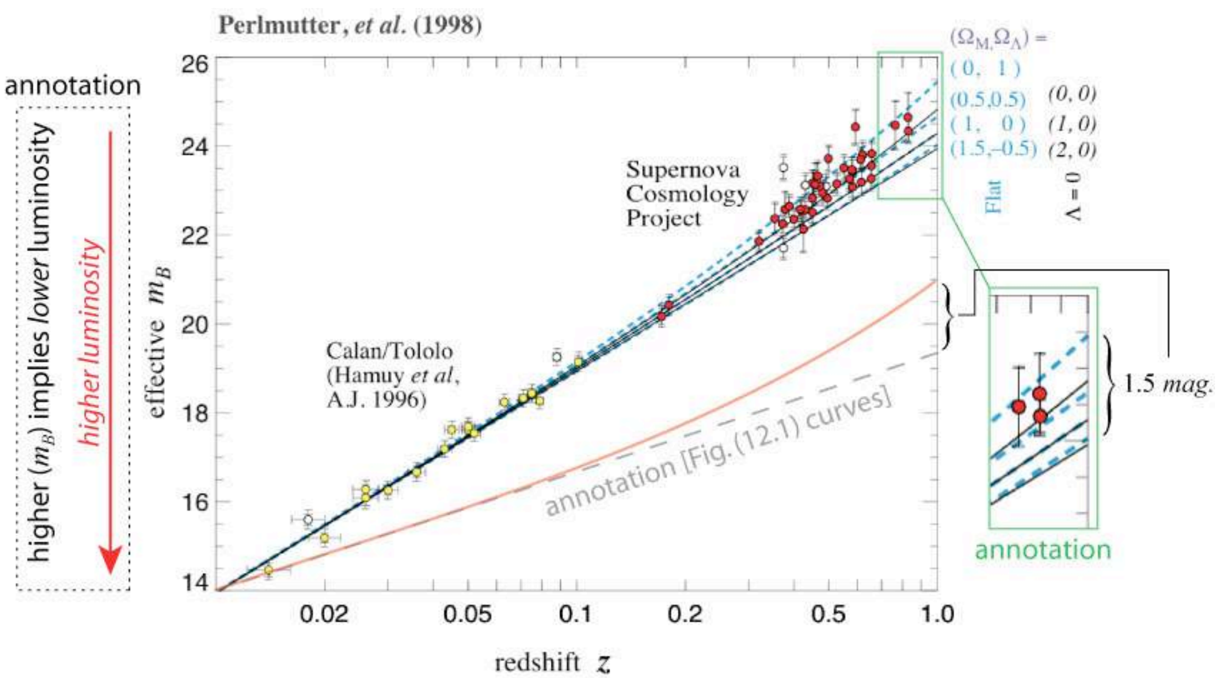


Figure 12.2 | Published supernovae apparent bolometric magnitude curve.[56] The original graph has been annotated with the curves shown in Fig. (12.1). The MdR model has been proven correct; consequently, the data shown in this graph was falsified to conform with the Big Bang paradigm.

Conventional textbook cosmology employs a Euclidean inverse square law for luminosity and assumes that a decade increase in redshift (e.g., 0.01 to 0.1) corresponds to a decade increase in distance. Then the *expected* decrease in the luminosity of a standard candle over this same range of redshift is one hundred (100), or about +5 magnitudes. A two-decade increase in redshift (e.g., 0.01 to 1) is expected to cause a change of +10 magnitudes. The alleged empirical curve in Fig. (12.2) is an example of how scientific research is similar to all other human activities in that it is controlled to an extreme degree by the dominant paradigm. Over two decades of redshift (0.01 to 1.0), the allegedly objective measurements of Type Ia supernovae apparent luminosity decreases by almost exactly the ten magnitudes (Δm = 24 - 14) prescribed by the Big Bang paradigm. Note the telling use of the added word "effective" as a caveat in the label of the apparent luminosity axis. It is as if its authors (Perlmutter *et al.*) are saying, "This *average* slope is not what we actually observe, but we observe an *effective* slope increase in the redshift-magnitude curve, given software analysis of telescope CCD data constrained by the Big Bang paradigm and what we are permitted to report in a peer-reviewed scientific journal."

Eq. (12.4) is derived *a priori* from first principles and it is obviously no accident that it provides what is an almost perfect fit to the SDSS redshift-magnitude data set in Fig. (P.1). As discussed in Fig. (10.6), extinction (A) due to the intergalactic medium (IGM) can be accurately approximated as a linear function of distance. Distance is modeled as an exact function of redshift by Eq. (9.8), so modeling extinction (light dimming due to absorption and scattering by dust) as a linear function of distance simply requires including a coefficient (ε) in the distance equation.

$$A = \varepsilon \ \cos^{-1}\left(\frac{1}{z+1}\right) \tag{12.6}$$

Accordingly, the general form of the cosmological redshift-magnitude equation is

$$m(z) = C - 2.512 \ \log\left(\frac{1}{4\pi\left[(z+1)^2 - 1\right]}\right) + \varepsilon \cos^{-1}\left(\frac{1}{z+1}\right) \tag{12.7}$$

Upon inspection of Fig. (P.1) and Fig. (P.2), it is clearly the case that extinction due to IGM dust is not a significant factor for observations, especially as concerns the i'-band. A slope increase to the predictive curve in black yielding higher magnitudes at higher redshift would detract from the accuracy of the prediction, rather than improve it. However, it is reasonable to suppose that for shorter wavelengths of radiation, extinction may have measurable effect on high-redshift observations. It is important not to be confused by the apparent significant increase in the slope of the SDSS redshift-magnitude diagram for shorter wavelengths (e.g., the g'-band, *not shown*). Rather than being due to IGM extinction, this is an artifact that is caused by the Luminous Red Galaxies (LRG) Survey, which manifests as the prominent ($0.3 < z < 0.5$) maxima in the the SDSS redshift-population histogram [see Fig. (2.1)].

The very small error bars for the SDSS photometry provide some indication of current technological capabilities in determining the true apparent luminosity of a distant bright target. As the luminosity of a supernova is similar to that of an entire galaxy, one can expect apparent magnitude measurements for bright galaxies and Type Ia supernovae (SNe Ia) to have roughly the same accuracy. The overwhelming evidence in support of the MdR model implies that a standard candle must follow the redshift-magnitude curve defined by Eq. (12.7) where ($\varepsilon \ll 1$). If SNe Ia are indeed standard candles, then the annotated curve in red superimposed on the Fig. (12.2) graph represents the true empirical relationship for these objects, given the initial SNe Ia redshift-magnitude reference point (0.01, 14). The magnitude of the difference between the alleged empirical curve and what must be the true curve for a standard candle according to the MdR theory leads to an inescapable conclusion: all previously published standard candle redshift-magnitude diagrams that supported the standard cosmological model (i.e., the 'Hubble law') by expectation involved falsification of data. Trust that this published astrophysical data was accurate within the specified error bars precluded the possibility of developing an accurate cosmological model.

The ‘empirical’ graph in Fig. (12.2) was produced for a specific purpose. Originally, astronomers and astrophysicists, who were all operating under the controlling influence of the Big Bang paradigm, were expected to accurately measure both the alleged ‘Hubble constant’ and the ‘deceleration parameter’ (*q*). The slope of the SNe Ia redshift-magnitude diagram was expected to *decline*, indicating a gravitational *deceleration* of the assumed comic expansion. As has been made evident by the MdR model, it is no accident or error that they discovered the unexpected slope increase in the diagram. It is now also evident that for several decades almost all allegedly accurate empirical astrophysical data was significantly adulterated in order to make it conform with the Big Bang paradigm. Ironically, too much of a deviation from this paradigm would have rendered the data unpublishable and would have led to ridicule of the researchers who produced the ‘deviant data.’

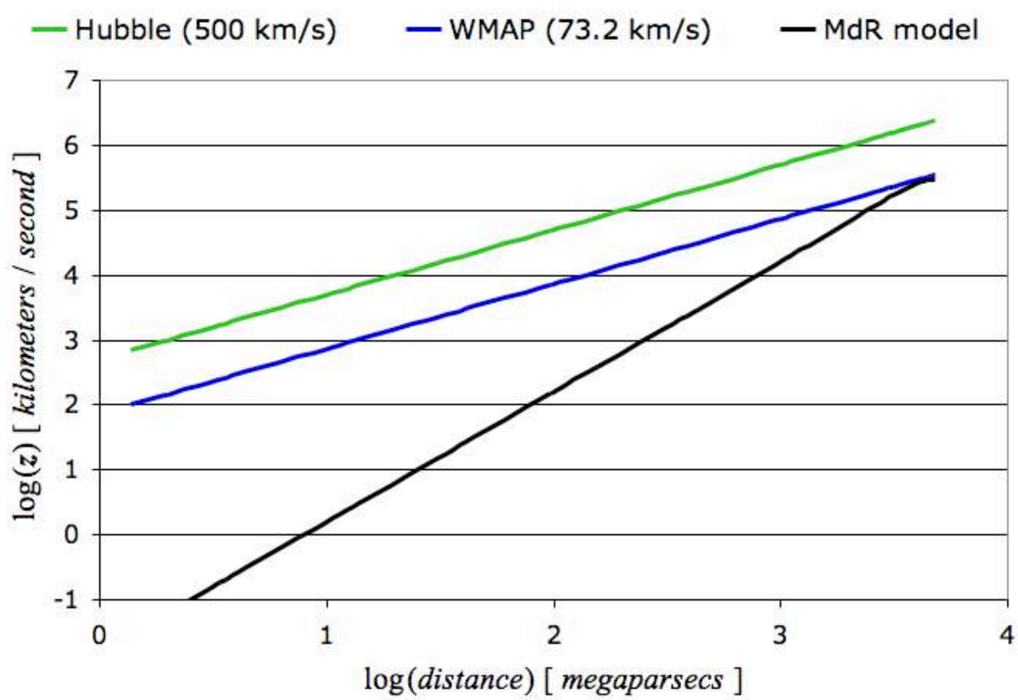


Figure 12.3 | Comparison of three Hubble diagrams (also see *Appendix F*). Based on multiple accurate correlations between the MdR model predictions and empirical observation, it is certain that the MdR model Hubble Diagram is a close reflection of empirical reality while the standard model (i.e., WMAP) curve has no bearing whatsoever on physical reality.

The “enduring truth” that Edwin Hubble discovered was that there was some fundamentally *unknown* relationship between distance to a galaxy and its redshift. His famous graph of galactic redshifts with a constant slope of 500 *km*/*s*/M*pc* was in effect another one of his typical departures from the truth; his published data was inaccurate and did not justify the linear redshift-distance relationship that he claimed. Because the inverse of H_0 yields the Hubble time, it later became clear that the slope he claimed for this relationship was too steep by about an order of magnitude, or else the purported “expanding universe” would have to be younger than the already well-established minimum geologic age of the Earth.

History repeats itself. If the alleged redshift-distance relationship data plotted by the ‘empirical’ data points and their error bars in Fig. (12.2) is accurate, then at an arbitrary point in cosmic history, the decelerating effect of gravity suddenly and inexplicably transmuted into a repulsive accelerating potential. Additionally, this would mean that the massive number of corroborating unbiased redshift observations that comprise the 2dF and SDSS galaxy surveys are misleading, while the slope of the supernovae data that is inconsistent with this data is not. Moreover, the Universe is orders of magnitude younger than is evidently required to build the structures it contains.

Fritz Zwicky, an eminent astrophysicist at Caltech who coined the terms "supernova" and "neutron star," made a confident statement in a 1960 paper concerning the age of the largest structures in the Universe.

> The age of 10^{18} years for rich compact clusters of galaxies may be shortened somewhat by considering certain interactions between galaxies that lead to more inelastic and resonant encounters between galaxies. Unless, however, far greater efficiency for the transfer of energy and momentum is postulated for such interactions than is compatible with our present-day knowledge of physical phenomena, the age of rich spherically symmetrical and compact clusters of galaxies is clearly greater than 10^{15} years.[57]

Prior to the advent of geologic time, which was largely initiated by James Hutton (1726–1797), biblically inspired estimates for the age of the Earth that were accepted as fact by most academics in elite institutions of higher learning were off by about six orders of magnitude, which is about the same difference between Zwicky's numbers and the current constraint on the age of all astrophysical objects according to the Big Bang paradigm. It is now necessary to concede that 20th-century cosmology is largely based on a loose interpretation of mystical writings by primitive Hebrew tribesmen living in the desert thousands of years ago who had no understanding of biological, geological, or *cosmological* history. The Big Bang theory represents a misstep in the scientific process that requires a major correction. The slope of Hubble's original diagram precluded Earth's existence; so too, the slope of the SNe redshift-distance relationship in Fig. (12.2), as currently interpreted, precludes the existence of observed galaxy clusters.

13. EVIDENCE OF LARGE-SCALE HOMOGENEITY

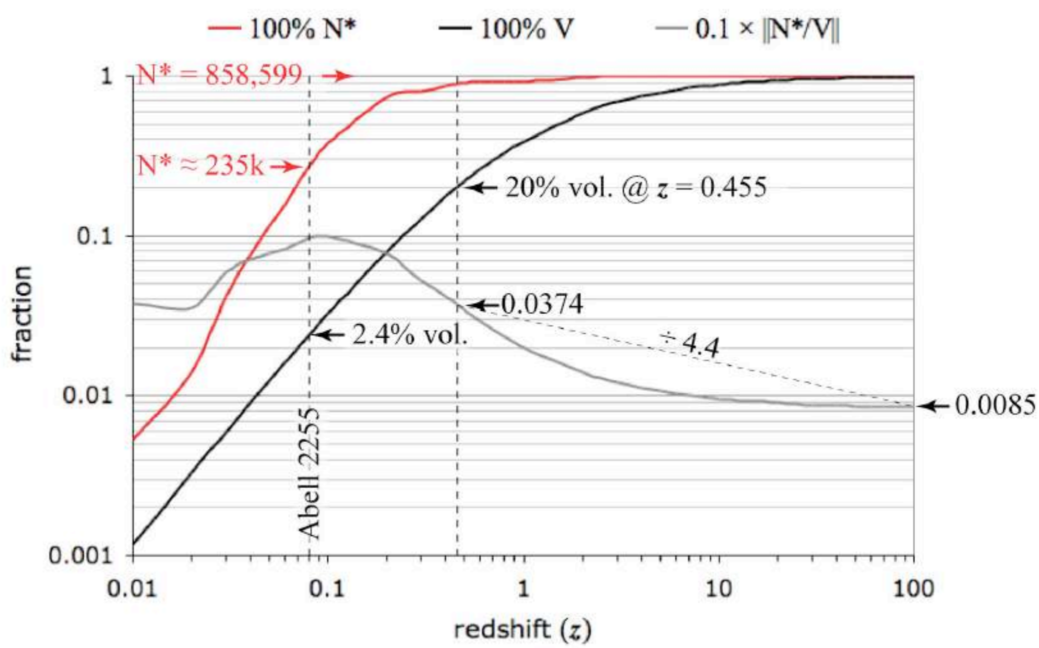


Figure 13.1 | Empirical SDSS galaxy count (N*), modeled volume (V) and their relative ratio. The increase in apparent density (blue curve) at low redshift ($0.02 < z < 0.1$) implies a transition from a low density fractal architecture to a homogeneous distribution of galaxies. This is corroborated by the periodicity seen in Fig. (2.1). In the regime ($z < 0.1$) the Malmquist bias evidently causes much less than an order of magnitude reduction in SDSS galaxy counts, as observed in Fig. (2.6) and Fig. (2.7). If no galaxies whatsoever were counted beyond $z = 0.455$ (20% volume), the apparent density would decline by a factor of five. The apparent density curve declines by a factor of 4.4, given that about 11% of the SDSS redshift survey population exists beyond this redshift.

The graphed cumulative SDSS DR7 galaxy count data (the red line) in Fig. (13.1) can be recreated from the online SDSS database using the following SQL statement.

http://pdfref.com/m1/13.1.htm

```
SELECT
       COUNT(1) as N                 /* each z queried to yield one datapoint (z, N*) */
FROM
       SpecObj
WHERE
AND    zStatus IN (3, 4, 6, 7, 9) /* selected for high quality */
AND    z >= 0.0015               /* mostly removes misidentified double stars */
AND    z <= 0.01;                /* also 0.02, 0.03, 0.04, ... 6.0 */
```

In his 1970 article in *Science* entitled "The Case for a Hierarchical Cosmology," written some years before Mandelbrot brought forth the concept of fractals, Gérard de Vaucouleurs posed a critical question.

> In fact, since [the mean density of the Universe] ρ is so evidently not a constant independent of space coordinates in our neighbourhood, how large a volume of space do we need to consider before the average density in this volume may be accepted as a valid estimate of ρ? [58]

As mentioned at the end of Chapter 11, preliminary analysis of the Hubble Ultra Deep Field (HUDF) suggests that the total cosmic galaxy population is on the order of 10^{11} galaxies. Making the reasonable assumption that the local 20% of the theoretically observable cosmic volume ($z < \infty$) has a homogenous galaxy distribution, it is then expected to contain about 2×10^{10} galaxies. Multiplying the Sloan galaxy redshift survey (¼ of the northern sky) by eight to encompass the entire sky, about 0.03% of the actual galaxy population within this region is apparently included in the redshift survey. The number of SDSS spectroscopic targets is about 1% of the survey's photometric database, which suggests that the photometric data may include about 3% of the actual ($z < 0.0455$) galaxy population.

Einstein's homogeneous and isotropic universe must naturally have a constant galaxy space density, graphed as a horizontal line over the complete range of redshift beyond the local region, which exhibits a fractal distribution of galaxies. In a sense, the planet Earth is a microcosm of the entire Universe. On its surface, we see chaos in the form of fractal geometry down to the scale of a rock that we can hold in the palm of our hand. One might literally hold a rock out at arm's length against the background of a distant mountain range and easily visualize the rock to be another peak in the range. Yet, from a sufficient distance, the Earth (the proverbial "blue marble") appears to have a perfectly smooth surface, which is due to the fact that gravity naturally causes spherical symmetry.

According to the general theory of relativity the metrical character (curvature) of the four-dimensional space-time continuum is defined at every point by the matter at that point and the state of that matter. Therefore, on account of the lack of uniformity in the distribution of matter, the metrical structure of this continuum must necessarily be very complicated. But if we are concerned with the structure only on a large scale, we may represent matter to ourselves as being uniformly distributed over enormous spaces, so that its density of distribution is a variable function which varies extremely slowly. Thus our procedure will somewhat resemble that of the geodesists who, by means of an ellipsoid, approximate to the shape of the earth's surface, which on a small scale is extremely complicated. – Albert Einstein (1916) [36, 37]

The identical geometric principle applies to the Universe as a whole, although it manifests as a 4-D spacetime structure mapped by Fig. (8.2) and Fig. (9.2). Just as gravity precludes the Earth from having any significant deviation from an isotropic mass distribution, the same applies to the entire Universe; so, just as the Earth is round and smooth on a large scale, the same is true for the spacetime Universe. It is apparent that a fractal architecture manifests at least to ($z = 0.1$). Figure (10.6) implies that at this redshift telescopes are probing out about 27.4% of the distance to the redshift horizon and Fig. (10.1) reveals that this distance corresponds to about 3.2% of the observable volume of space. Answering de Vaucouleurs's question, this is a rather small volume relative to the totality of cosmic space, yet it represents a significant percentage of the distance to the most distant theoretically observable region of the Cosmos.

14. OBJECTS OBSERVED AT VERY HIGH REDSHIFT

A 1994 NASA press release entitled “Hubble [Telescope] Uncovers New Clues to Galaxy Formation” has an introductory section entitled *The Paradox: Grown-up Galaxies in an Infant Universe.*

> Hubble Space Telescope’s recent observations identify fully formed elliptical galaxies in a pair of primordial galaxy clusters that have been surveyed by teams lead by Mark Dickinson of the Space Telescope Science Institute and Duccio Macchetto of the European Space Agency and the Space Telescope Science Institute. Although the clusters were first thought to be extremely distant because of independent ground-based observations, the Hubble images provide sharp enough details to confirm what was only suspected previously.
>
> The surprise is that elliptical galaxies appeared remarkably “normal” when the universe was a fraction of its current age, meaning that they must have formed a short time after the Big Bang.
>
> Dickinson, in studying a cluster that existed when the universe was nearly one-third its current age, finds that its red galaxies resemble ordinary elliptical galaxies, the red color coming from a population of older stars.
>
> This has immediate cosmological implications, since the universe must have been old enough to accommodate them. Cosmologies with high values for the rate of expansion of space (called the Hubble constant, which is needed for calculating the age of the universe) leave little time for these galaxies to form and evolve to the maturity we’re seeing in the Hubble image, Dickinson emphasizes.
>
> [Macchetto and Giavalisco identified] a whole cluster of primeval galaxies in that region of the sky...
>
> “The very presence of the cluster ... is unexpected and counter to many theories of cluster and galaxy formation,” says Macchetto.[59]

A different NASA press release entitled “Hubble [Telescope] Identifies Primeval Galaxies, Uncovers New Clues to the Universe’s Evolution” appears more prominently on the *HubbleSite* News Release Archive.[60]

A decade later, Andrea Cimatti *et al.* published similar observations in a July 2004 issue of *Nature*. The following is the abstract from their article entitled “Old galaxies in the young Universe.”

> More than half of all stars in the local Universe are found in massive spheroidal galaxies, which are characterized by old stellar populations with little or no current star formation. In present models, such galaxies appear rather late in the history of the Universe as the culmination of a hierarchical merging process, in which larger galaxies are assembled through mergers of smaller precursor galaxies. But observations have not yet established how, or even when, the massive spheroidals formed, nor if their seemingly sudden appearance when the Universe was about half its present age (at redshift $z < 1$) results from a real evolutionary effect (such as a peak of mergers) or from the observational difficulty of identifying them at earlier epochs. Here we report the spectroscopic and morphological identification of four old, fully assembled, massive (10^{11} solar masses) spheroidal galaxies at $1.6 < z < 1.9$, the most distant such objects currently known. The existence of such systems when the Universe was only about one-quarter of its present age shows that the build-up of massive early-type galaxies was much faster in the early Universe than has been expected from theoretical simulations.[61] [http://pdfref.com/m1/14.01.htm (2010) revisits this theme again.]

Professor Hans Jörg Fahr of Universität Bonn in Germany exhibits exceptionally rare vision and courage for a professional academic in the field with the following remarkably accurate insights.

> When galactic objects are seen at redshifts larger than $z = 6$ then it means that they must have emitted their light at a phase when the Universe only had a radius of one seventh (i.e., a volume of 1/350!). According to most of the cosmological models, this phase can only be less than one billion years after the Big Bang event. Since these galactic objects for sure should have ages of more than one billion years, they thus cannot be objects of this Big Bang universe, unless present cosmologies are completely wrong. Then the idea may be suggested as a solution that possibly the Universe may not have an age at all, it only runs through cycles of always repeating processes of production and destruction of objects and hierarchical cosmic structures at all scales of time and space. The Universe is something like a self-sustaining system of nonlinearly interacting non-equilibrium subsystems, dissolving themselves at some places and thereby driving action flows which create identical cosmic entities at other places (see Hoyle *et al.*, 1993, Fahr, 1996, 2002).[62]

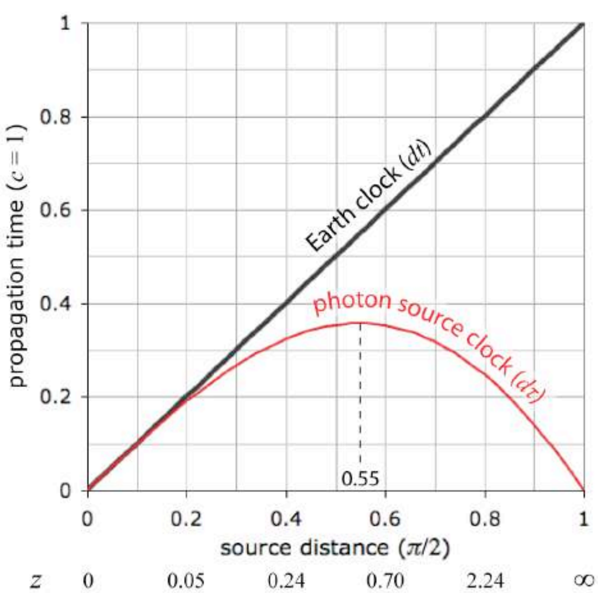
A March 2005 press release by the European Southern Observatory (ESO) describes yet another corroborating discovery by Christopher R. Mullis *et al*.[63]

> Combining observations with ESO's Very Large Telescope and ESA's XMM-Newton X-ray observatory, astronomers have discovered the most distant, very massive structure in the Universe known so far.
>
> It is a remote cluster of galaxies that is found to weigh as much as several thousand galaxies like our own Milky Way and is located no less than 9,000 million light-years away.
>
> The VLT images reveal that it contains reddish and elliptical, i.e. old, galaxies. Interestingly, the cluster itself appears to be in a very advanced state of development. It must therefore have formed when the Universe was less than one third of its present age.
>
> The discovery of such a complex and mature structure so early in the history of the Universe is highly surprising. Indeed, until recently it would even have been deemed impossible.[64]

Astronomer Laura Ferrarese made the following comment in a January 2003 issue of *Nature*.

> It has been pointed out that at a redshift of 5 we are [supposed to be] looking back in time to when the age of the Universe (about 1 billion years) was approximately equal to the dynamical timescale of a typical galaxy — roughly speaking, the stellar orbital time, or the time it takes a galaxy to communicate with itself through its own gravitational potential. Thus, the very existence of quasars at such high redshifts is a challenge to models of structure formation.[65]

One of the most fundamental concepts in astronomy and astrophysics is *lookback time*. Depending on its measured redshift, light observed today on Earth arriving from a distant galaxy was emitted at the source hundreds of millions or billions of years ago relative to a terrestrial clock. Due to the finite speed of light, the farther we look out in space with a telescope on Earth, the farther we look back in time as measured by a local ideal clock. The Big Bang paradigm naïvely interprets this lookback time as intrinsic rather than relativistic. The propagation time of a photon as measured relative to an Earth clock allegedly corresponds to the aging of the Universe as a whole, as if the Cosmos were an object existing in time. However, relativity implies that time is a strictly local property *internal* to the Universe, which is a hierarchical collection of spatially and temporally distinct processes identified as objects (e.g., galaxies). Per Eq. (9.1), the following graph is a simple but profound model of geometric relativistic cosmic time.



The x-axis of this graph is the cosmological latitude (ζ) representing a linear distance. The x-values represent fractions of ($R \cdot \pi/2$). The red curve is a plot of the relationship

$$\frac{dt}{d\tau} = z + 1 = \sec\zeta \quad \rightarrow \quad d\tau = \cos\zeta \, dt$$

According to the Earth clock, the photon propagation time (dt) is linear with distance; this is conventional "lookback time." Time elapsed on the source clock ($d\tau$) relative to the Earth clock is a function of the distance to the source (red curve). This curve ($d\tau/dt$) indicates the relative rate at which distant galaxies age as compared to galaxies in the more 'local' cosmic region ~($z < 0.05$).

Figure 14.1 | Propagation time of a photon. With increasing distance, an ideal clock ticks at an ever decreasing rate relative to an Earth clock. The source ages slower relative to the Earth and the photon propagates in less time according to the remote clock from the perspective of Earth. Strangely, at our cosmological redshift horizon, "time stands still" relative to a reference Earth clock.

The abscissa of Fig. (14.1), indicating photon source distance, correlates to the map of the finite boundaryless Cosmos shown in Fig. (9.2). The maximum distance on the scale represents the distance to our cosmological redshift horizon, or one quarter of the cosmic circumference. The ordinate represents time as a distance (*ct*). The black line at 45 degrees represents conventional lookback time according to a terrestrial clock correlated to source distance. The maximum time corresponds to the maximum distance a photon can travel in the Cosmos before all of its energy is dissipated due to the cosmological redshift. This has no bearing on the maximum possible age of an object in the Universe. The red curve models symmetric cosmic relativistic time dilation. From the perspective of an astronomer on Earth, ideal clocks of increasing distance from the Earth measure proper time at a slower relative rate; light arriving from a distant galaxy takes more time to propagate according to the observatory clock than the perceived 'slow' clock at the photon source. For example, in the case of a galaxy at 0.7 on the distance scale ($z \approx 1.2$), while the Milky Way has aged *n* years from the time the photon was emitted to the time it was observed, the source galaxy has aged only about 3*n*/7 years. At the extreme limit of cosmological redshift, proper time is linearly independent from local time. "There is a place where time stands still."[66] An arbitrary large amount of local time may correspond to an arbitrarily small amount of time in the vicinity of the relative cosmological horizon. Moreover, the effect is symmetric; according to an observer at our relative cosmological horizon, it is our clocks that are measuring relativistic cosmic time at an arbitrarily slow rate relative to the local clock. This being the case, it is impossible to associate the property of age to the Universe as a whole, for no universal reference clock exists with which to make such a measurement.

There is no measurable absolute cosmic time and therefore no intrinsic age to any region of the Universe. However, each assembled (hierarchical) physical object, from a single atom synthesized in a supernova to a supercluster of galaxies, is a *process* having an intrinsic *proper age* that can be measured to some degree of accuracy by a local ideal clock. For objects involving strong gravitational fields or significant rotational velocity, the choice of the location of the reference clock clearly affects measurement of the object's age. Recent statements appearing in the literature concerning alleged observations of the "young universe" are naïve interpretations of lookback time based on the anachronistic Newtonian concept of absolute time, which was incorporated in the cosmic time parameter (*t*) of the Robertson–Walker metric. This metric, which describes the homogenous, isotropic Friedman-Lemaître-Robertson-Walker (FLRW) expanding universe, fails to recognize Minkowski's legacy of geometric relativistic time. The metric also fails to specify a topology, but rather leaves this as a free parameter. This metric is an example of a canonical mathematical model that incorporates a simplistic, anachronistic and naïve subjective view of absolute cosmic time.

$$ds^2 = c^2dt^2 - R^2(t)\left[dr^2 + S_k^2(r)\left(d\theta^2 + \sin^2\theta d\phi^2\right)\right] \quad \begin{array}{rcl} S_{+1}(r) & = & \sin(r) \\ S_{-1}(r) & = & \sinh(r) \\ S_0(r) & = & r \end{array} \tag{14.1}$$

The Big Bang paradigm does not allow any galaxies, let alone bright and fully-formed (i.e., *old*) galaxies to be observed at $z \sim 10$, but geometric relativistic cosmic time allows for galaxies of all kinds to be observed at any redshift and the decrease in apparent luminosity between a standard candle observed at $z = 2$ and at higher observable redshifts is due almost exclusively to time dilation. Observations of high-redshift objects enabled by recent technical innovations suggest that there is no intrinsic age difference between the local universe and the high-redshift universe. Astrophysical objects (i.e., processes) of various ages, from the very ancient to the newly emergent, coexist in all regions of the Universe.

> We report the first likely spectroscopic confirmation of a *z* 10.0 galaxy from our ongoing search for distant galaxies with ISAAC/VLT. Galaxy candidates at $z >\sim 7$ are selected from ultra-deep JHKs images in the core of gravitational lensing clusters for which deep optical imaging is also available, including HST data. The object reported here, found behind Abell 1835, exhibits a faint emission line detected in the J band, leading to $z = 10.0$ when identified as Ly-a, in excellent agreement with the photometric redshift determination. Redshifts $z < 7$ are very unlikely for various reasons we discuss. The object is located on the critical lines corresponding to $z = 9$ to 11.[67]

Objections to claims such as the above, including reliable observation of what are clearly large mature galaxies at very high redshift (e.g., HUDF-JD2) can no longer be based on cosmological arguments.[68,69]

15. COSMIC MICROWAVE BACKGROUND RADIATION

In the late 1940s and in the 1950s when the Big Bang concept was still considered a tenuous theory, George Gamow and his graduate student collaborators, Ralph Alpher and Robert Herman, made a historic prediction. They posited that if there had indeed been a hot Big Bang followed by an expansion of the Universe, then some heat from the explosion that had cooled with the expansion must remain. In his 1952 book, *The Creation of the Universe*, Gamow predicted that the radiation temperature of the expanded and cooled primeval fireball would be about 50 K. Alpher and Herman had proposed a temperature of 5 K, although they stated that actual temperature measurements would be higher due to the contribution of thermal energy produced by stars in addition to the calculated residual primordial heat.[70, 71, 72, 73]

In 1965, Arno Penzias and Robert Wilson of the Bell Telephone Laboratories made the following observation, which was published in the *Astrophysical Journal*. This is the entire abstract of their paper. Emphasis on the word *possible* has been added.

> Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value of about 3.5 K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and free from seasonal variations (July, 1964 - April, 1965). A *possible* explanation for the observed excess noise temperature is the one given by Dicke, Peebles, Roll, and Wilkinson (1965) in a companion letter in this issue.[74]

The following passage is from the paper by the Princeton University team of Dicke, Peebles, Roll and Wilkinson to which Penzias and Wilson referred. It is this famous paper and its four-decade legacy that has given physicists at Princeton a large personal stake in continued support of the Big Bang theory.

> Could the universe have been filled with blackbody radiation from this possible high-temperature state? If so, it is important to notice that as the universe expands the cosmological redshift would serve to adiabatically cool the radiation, while preserving the thermal character. The radiation temperature would vary inversely as the expansion parameter (radius) of the universe…
>
> While all the data are not in hand we propose to present here the possible conclusions to be drawn if we tentatively assume that the measurements of Penzias and Wilson (1965) do indicate blackbody radiation at 3.5º K. We also assume that the universe can be considered to be isotropic and uniform, and that the present energy density in gravitational radiation is a small part of the whole. Wheeler (1958) has remarked that gravitational radiation could be important.
>
> For the purpose of obtaining definite numerical results, we take the present Hubble redshift age to be 10^{10} years.[75]

The coincidence between the discovery of the cosmic microwave background (CMB) and the search for a predicted ubiquitous cooled remnant of a primordial explosion assumed to have started the Universe was not considered to be a coincidence. For all intents and purposes, the discovery was quickly accepted as the definitive proof of the Big Bang; Penzias and Wilson shared the 1978 Nobel Prize in physics for their discovery. What nobody suspected in 1965 was that Willem de Sitter had been right; the cosmological redshift was a clock rate effect, not a motion effect. As it is now accurately explained as the geometric relationship between local time coordinates in a finite boundaryless spacetime universe, the assumption of a general recession of the galaxies is eradicated at a stroke and with it the fundamental premise for an expanding universe. There is then no reason to presuppose that the CMB is the cooled heat from a primordial state; the only alternative is that it must be the result of a ubiquitous real-time radiation emission.

The assumption of a Big Bang event a finite time ago leads to the second assumption that photons produced by this source event long ago and far away must exist. However, the isotropy of the background portion of the microwave radiation that is detected leads to the horizon problem. Considering the finite speed of light, how is it possible for causally disconnected regions of the Universe to have the same temperature? Inflation was invented to solve this problem. The inflation theory alleges that the Universe grew by a factor of $\sim 10^{50}$ in $\sim 10^{-32}$ second at ultra superluminal ($>>c$) speed.[76] This is an *ad hoc* solution to the problem employing an implausible unphysical phenomenon in order to rescue the paradigm of a suddenly created universe from its inconsistencies with scientific principles. In contrast, the concept of geometric cosmic time is fundamental science based on quite simple and irrefutable mathematical and physical principles.

In November 1989, NASA launched the Cosmic Background Explorer (COBE) spacecraft.[77] Its far infrared (IR) absolute spectrophotometer (FIRAS) instrument determined that the CMB has a nearly perfect blackbody spectrum with a temperature of 2.73 kelvin. Over a decade later, the Wilkinson Microwave Anisotropy Probe (WMAP), named after science team member Prof. Wilkinson of Princeton, was launched into orbit on 30 June 2001 from the Kennedy Space Center and inserted into the second Lagrange Point (L2) about a million miles beyond Earth on the Solar-Terrestrial radial.[78] Its accomplished mission was to make the first detailed full-sky map of the microwave background radiation with 13' angular resolution, or about 33 times better resolution than COBE. There is no doubt that the making of this map was a significant technical achievement and the team must be applauded for their historic accomplishments. However, they must also be chastened for the content of the WMAP website. Instead of exhibiting proper scientific decorum by communicating sober observational facts and humbly suggesting one particular scientific interpretation of them, the website seems to literally preach a "revealed truth." One is confronted with subjectively manipulated observational data and statements implying no room for doubt. It apparently never occurred to anyone on the team that the scientific goal of correctly interpreting the real meaning of the empirical data gathered by the WMAP instruments might remain to be achieved.

From the original WMAP website under the ironic title, "Some Theories Win, Some Lose," we learned about the so-called "winning" theories.[79] The emphasis in the last bullet point has been added.

- Universe is 13.7 billion years old, with a margin of error of close to 1%.
- First stars ignited 200 million years after the Big Bang.
- Light in WMAP picture is from 379,000 years after the Big Bang.
- Content of the Universe:
  - 4% Atoms, 23% Cold Dark Matter, 73% Dark Energy.
  - The data places new constraints on the Dark Energy. It seems more like a "cosmological constant" than a negative-pressure energy field called "quintessence." But quintessence is not ruled out.
  - Fast moving neutrinos do not play any major role in the evolution of structure in the universe. They would have prevented the early clumping of gas in the universe, delaying the emergence of the first stars, in conflict with the new WMAP data.
- Expansion rate (Hubble constant) value: H_o= 71 (km/sec)/Mpc (with a margin of error of about 5%)
- New evidence for Inflation (in polarized signal)
- For the theory that fits our data, the Universe will expand forever. (*The nature of the dark energy is still a mystery. If it changes with time, or if other unknown and unexpected things happen in the universe, this conclusion could change*.)

The new WMAP website includes the following statement from a 7 March 2008 press release.

> Prior to the release of the new five-year data, WMAP already had made a pair of landmark finds. In 2003, the probe's determination that there is a large percentage of dark energy in the universe erased remaining doubts about dark energy's very existence. That same year, WMAP also pinpointed the 13.7 billion year age of the universe.[80]

The above pontifical claims supporting the Big Bang theory do not hold up to scientific scrutiny, which can be proven easily by empirical observations guided by a corrected theoretical foundation. If the CMB is produced in real-time, rather than having been sourced in a primordial event, then conservation of energy implies that the production of the CMB is fed by a real-time phenomenon in which microwave radiation is emitted in a ubiquitous process of energy transformation. This process has already been identified through analysis of the WMAP data.

It is often quoted that observation of the cosmic microwave background radiation established the hot Big Bang paradigm beyond reasonable doubt and provided firm observational evidence for an evolving universe with a well-defined beginning. What this reveals is that the cosmological redshift was not itself considered proof of an expanding universe beyond reasonable doubt. In other words, the redshift was appropriately considered to be subject to a possible alternative explanation. The common perception that the redshift and the CMB are corroborating independent proofs of the Big Bang is false; the conventional interpretation of the CMB is in fact predicated on the idea of an expanding universe. Because of this, no alternative explanation for the CMB has ever really been considered as a possibility, yet the following is a brief cogent quote from an article in the January 2005 issue of *Physics World* referencing work published in the 26 November 2004 *Physical Review Letters*.[81] These comments seem to have been summarily discounted by the vast majority of the relevant academic community.

> The cosmic microwave background is often called the echo of the Big Bang, but recent research suggests that some of its features might have their origins much closer to home. Although most cosmologists think that the tiny variations in the temperature of the background are related to quantum fluctuations in the early universe, Glenn Starkman and colleagues at CERN and Case Western Reserve University in the US have now found evidence that some of these variations might have their roots in processes occurring in the solar system. If correct, the new work would require major revisions to the standard model of cosmology. … "Each of these correlations could just be an accident," says Starkman. "But we are piling up accident on accident. Maybe it is not an accident and, in fact, there is some new physics going on."[82]

A hint as to what is going on is found in the following series of WMAP images.

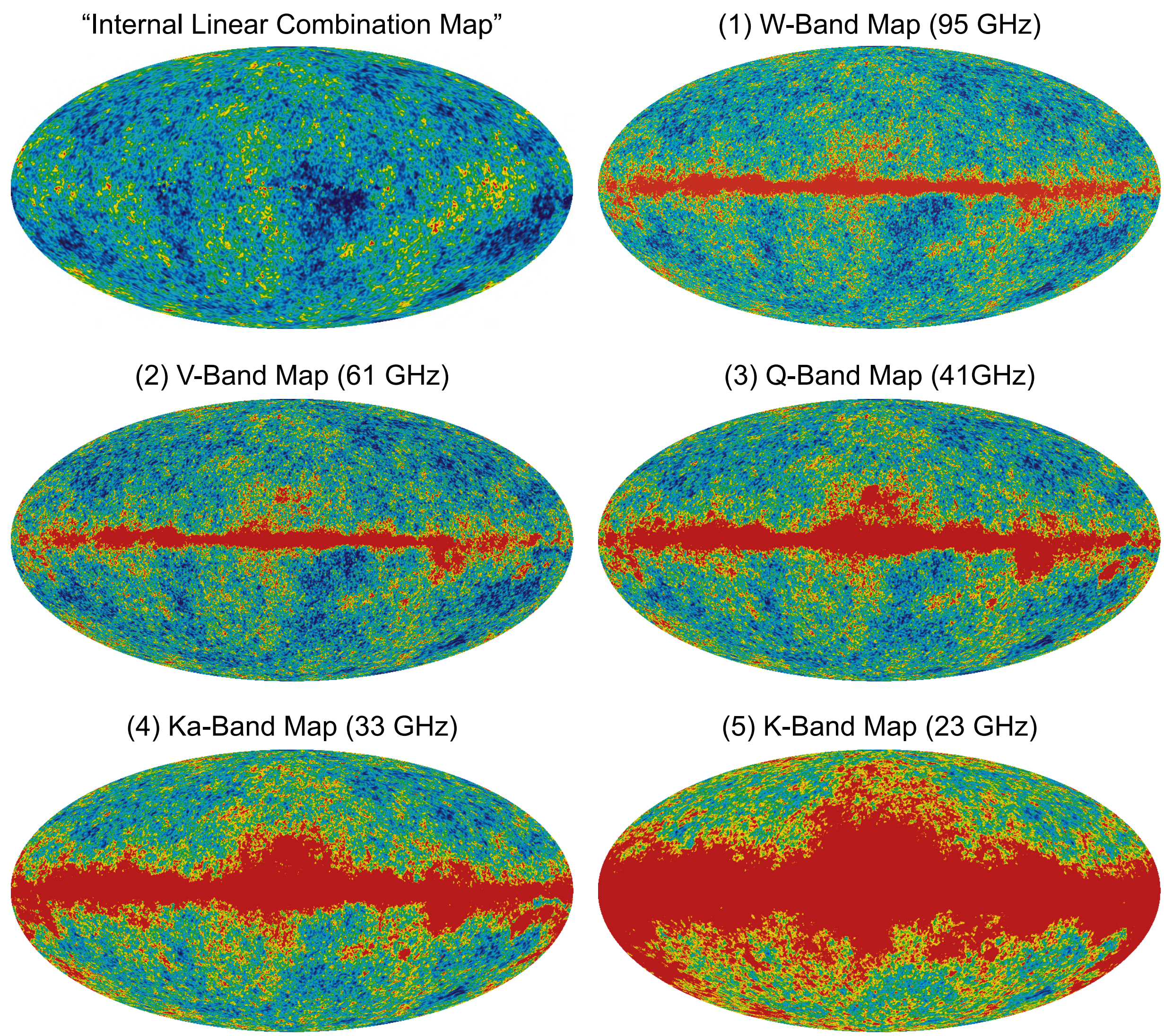


Figure 15.1 | WMAP full-sky temperature maps (linear scale from -200 to +200 μK).
Courtesy WMAP Science Team.

The touted results of the WMAP mission were summarized for the popular press in a single processed digital image described as follows (emphasis added).

> The Internal Linear Combination Map is a weighted linear combination of the five WMAP frequency maps. The weights are computed using criteria which *minimize the Galactic foreground contribution* to the sky signal. The resultant map provides a low-contamination image of the CMB anisotropy.[83]

In other words, the much publicized map is a convenient fabrication created by removing essential data. The label of "contamination" for empirical data is very likely to be a subjective assessment. Removal of empirical data that inconveniently does not fit the theory one is trying to prove is bad science at best. Each of the five authentic source maps in Fig. (15.1) is an equal-area Mollweide projection that depicts the entire celestial sphere as an oval with the central meridian corresponding to the plane of the Milky Way. The maps exhibit the same linear temperature scale from -200 to 200 μK ($\pm 2\times10^{-4}$ K). The red color represents the "warmer" regions while the blue color represents the "cooler" regions as compared to the median CMB temperature in blue-green. The Galaxy is evidently a significant source of microwave radiation, including excess emission *whose source could not be identified*.

> The cause of observed inner galaxy excess microwave emission is assumed to be synchrotron emission from highly relativistic electron-positron pairs produced by dark matter particle annihilation as more conventional sources have been ruled out.[84,85]

The above quote is from a paper by Douglas Finkbeiner, a Hubble Fellow at Princeton and an assistant professor at Harvard's Center for Astrophysics. This is a far-reaching assumption and yet another example of modern "epicycles" (i.e., an unphysical *ad hoc* invention attempting to describe observed phenomena). In light of the revelation that the cosmological redshift does not imply an expansion from a primordial explosion, the implications of the empirical observations are clear: *The unknown astrophysical source of the excess Galactic microwave radiation is the same as for the cosmic microwave background radiation*. The distinction drawn between the microwave background, whose source was assumed to be known, and the portions of the microwave foreground openly acknowledged to be of unknown origin is arbitrary. While the nearly isotropic microwave background and the microwave foreground can be distinguished so that the latter can be removed, there is a phenomenological connection between them. Moreover, the microwave foreground is not limited to the Galactic source but also has an apparent Solar System origin that was too subtle to be noted and removed from the initial WMAP data release.

> — astrophysicists have found that the plane of the solar system threads itself through hot and cold spots in the cosmic microwave background, suggesting that some of the variations in the latter are not caused by events that took place in the early universe.[86]

The critical question one must ask is, "What does the Solar System have in common with the galaxy?" Both the Solar System and the galaxy are dynamical gravitational systems involving *rotational motion*. The Sun represents approximately 99.9% of Solar System mass and the solar equatorial plane is inclined about 7 degrees to the Ecliptic plane. Let us assume that, according to some relativistic gravitational phenomenon (to be described later), the Sun's equatorial plane is associated with an excess microwave radiation temperature, just as is evident for the plane of our Galactic disk according to the empirical temperature maps in Fig. (15.1). Then, as the Earth pursues its annual rotation around the Sun in the Ecliptic, it must literally "thread itself through hot and cold spots." Moreover, it would generally appear that the regions of the sky on opposite sides of the Ecliptic plane would have different temperatures.

> Also, in 2003 Hans Kristian Eriksen of the University of Oslo and his co-workers presented more results that hinted at alignments. They divided the sky into all possible pairs of hemispheres and looked at the relative intensity of the fluctuations on the opposite halves of the sky. What they found contradicted the standard inflationary cosmology—the hemispheres often had very different amounts of power. But what was most surprising was that the pair of hemispheres that were the most different were the ones lying above and below the Ecliptic, the plane of the earth's orbit around the sun. This result was the first sign that the CMB fluctuations, which were supposed to be cosmological in origin, with some contamination by emission in our own galaxy, have a solar system signal in them—that is, a type of observational artifact.[87]

If our Sun is a local source of microwave radiation in this manner, then every star in our galaxy provides a similar microwave radiation source. Moreover, every galaxy produces the same real-time microwave emission shown in Fig. (15.1), which was subjectively eliminated from the Internal Linear Combination Map because it is inconsistent with the Big Bang paradigm. It follows that the cosmic microwave background should appear to be warmer for regions of the sky associated with high concentrations of galaxies and lower for large cosmic voids where there is a paucity of galaxies. This is precisely what is observed by our instruments. However, in the context of the Big Bang paradigm, the warm spots have been interpreted to be caused by inverse Compton scattering of assumed background CMB photons (i.e., the Sunyaev–Zel'dovich effect). This is similar to interpreting the cosmological redshift as indicative of a recession velocity; the astrophysical observation is accurate but the scientific explanation is wrong. The cooler spots have been interpreted as being due to the integrated Sachs-Wolfe effect (uneven CMB spectrum attributed to gravitational redshift), which is yet another example of modern 'epicycle theory.' Certainly the huge "WMAP cold spot" cannot be explained by this phenomenon.

The field of view of the *Hubble Ultra Deep Field* (HUDF) image is about 10^{-7} of the sky. Within this image, there appear to be about 10^4 discrete galaxies, so the HUDF suggests that there are on the order of 10^{11} distinct galaxies in the observable universe. Abstractly representing the total observable universe, the circle in Fig. (15.2) has an area of about 8000 square millimeters as printed. Ignoring fractal effects within about $z = 0.2$, a total population of 10^{11} implies 12.5 million galaxies per square millimeter within the area of the gray circle. Recall that with no expansion there is no intrinsic difference between the nearby universe and the high-redshift universe. Each galaxy is a source of copious microwave radiation, as is conspicuous for the Milky Way in Fig. (15.1). It is not difficult to visualize that the observed cosmic microwave background radiation has nothing whatsoever to do with the purported Big Bang, which reliable evidence now suggests never occurred; the CMB has been produced continuously, arguably for an eternity, and the spatially finite Universe is an ideal blackbody.

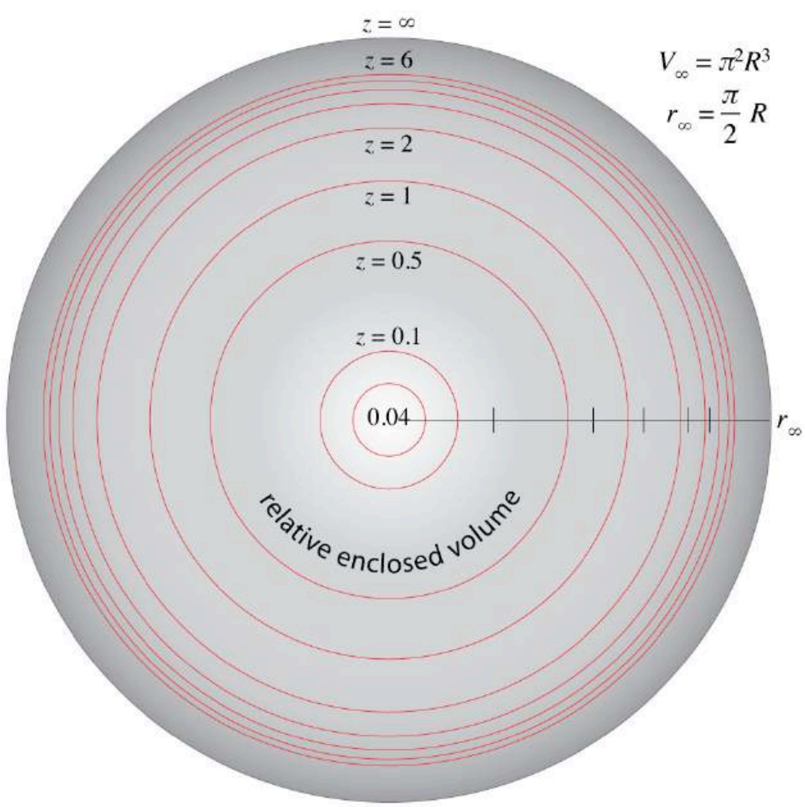


Figure 15.2 | Area plot of Eq. (10.9). Relative radial distance tick marks are at (z = 0.01; 0.5; 1; 2; 3).

The dominant paradigm generally controls what most people see (i.e., their interpretation of perception). For centuries before Copernicus, Galileo and Kepler, astronomers observed the seasonal motion of the Sun on the horizon, the circular rotation of the stars and the more subtle retrograde motion of the "wandering" planets. These observations did not lead them to understand the simple kinematics of the Solar System. Instead, they continued to defend the intellectually primitive and illogical dominant paradigm with religious fervor. The same thing has happened in recent decades in the context of the Big Bang theory. All of the observational evidence for a correct scientific understanding of nature is available, but the intellectual and political momentum of the Big Bang theory in academia has heretofore prevented the broad realization that the theory is not only false, but utterly inconsistent with the known rational laws of physics. History has proven repeatedly that the common human condition is not just being incorrect, but the pernicious combination of false confidence, persuasive authority and extreme error in thinking, which is prevalent in religion and politics, but not entirely absent from science.

If, according to conventional wisdom, one assumes that the cosmic microwave background radiation is sourced from a cosmic creation event long ago and far away, one would never conceive of including a dynamical analysis of the microwave background with the idea that not all of it is sourced from far away. To date, the ubiquitous microwave radiation has only been analyzed in the context of spatial variation (anisotropy), with no thought whatsoever given to variation over time. However, the apparent Solar System signal discovered by research groups studying the WMAP data is quite certainly indicative of a dynamical signal modulation associated with the orbital motion of the Earth.

If energy in the form of microwave radiation is produced by dynamical gravitational systems in real time, then we must surely observe the phenomenon of energy transformation that yields the microwave background, although no causal connection between the two was ever previously suspected. There is only one possible source of the energy and this is loss of rotational kinetic energy in the form of axial spin as well as orbital gravitational potential. It will be shown that the principles of relativity imply that all spinning self-gravitating bodies must experience a secular loss of angular momentum. Similarly, even in the absence of mechanical drag, all orbits must decay due to the same relativistic effect of the gravitational field, which is associated with the fundamental concept of temporal geometry applied to accelerated reference frames. Therefore, planets slowly migrate towards their host star, which in particular cases may be counteracted by stellar angular momentum transfer, causing oscillation of the orbital radius and cyclical planetary climate change.[88] Similarly, binary stars must exhibit orbital period oscillations.[89] Conservation of energy implies that the energy dissipated by dynamical gravitational systems due to this relativistic effect, most evidently as the secular spin-down of pulsars, must manifest in some other form.[90] The observation of the ubiquitous cosmic background radiation, which can no longer be attributed to a primordial cosmic explosion, suggests that all dynamical gravitational systems lose energy, emitted as electromagnetic radiation. Moreover, the maximum brightness (i.e., temperature) of this radiation must occur in the equatorial plane of rotating systems where the tangential velocity is a maximum.

If we cannot assume a primordial source of the CMB, then an analysis of astrophysical energy budgets must reveal its real-time source. As we know more about the Earth and the Moon than any other astrophysical system, this is a good place to start. The secular acceleration of the Moon, whereby the mean distance to the Moon is observed to be increasing by 3.8 *cm*/*yr* in the current epoch, is a well-known phenomenon, which has been accurately measured by lunar laser ranging (LLR).[91] A trivial calculation of gravitational force times distance (3.8 *m*/*cy*) reveals that the energy cost of this motion over a century is

$$W = F \cdot d = \frac{GM_E M_M}{a_M^2} \cdot 3.8 \approx 7.5 \times 10^{20}\ \text{J/cy} \qquad (15.1)$$

According to conventional wisdom, the Moon is being boosted in its orbit due to angular momentum transfer from the Earth. If this is correct, then over a century, the Earth loses about 7.5×10^{20} joules of rotational kinetic energy in order to account for the LLR observations. There is, however, another possible explanation to consider. Imagine that a heretofore unmodeled relativistic gravitational effect causes a secular dissipation of orbital energy. As the Moon is gravitationally bound to the Sun to a greater degree than to the Earth, the Earth-Moon system is more like a co-orbiting double-planet system than a satellite orbiting a host planet. If the gravitational interaction with the Sun dominates over the Earth-Moon interaction, then this presently hypothetical effect (described and explained in a later chapter) will tend to cause a decay of both of their solar orbits that dominates over the same effect between the two co-orbiting bodies. As the Earth and Moon are separated by an average distance of about 384,000 *km* and on average one is closer to the Sun than the other, it is reasonable to suspect a differential decay rate of both bodies with respect to the Sun that very slowly increases the mean Earth-Moon distance.

The known geologic and biologic history of the Earth precludes the idea that the Earth-Moon barycenter has undergone an unceasing secular decay of its solar orbital radius. However, there is good evidence of cyclical planetary climate change over hundreds of millions of years between brief extreme periods of an essentially frozen “snowball Earth” and an “ultra-warm greenhouse” world.[92, 93] It is then reasonable to suspect an oscillation of the Earth-Moon system’s mean distance from the Sun over geologic time periods. An energy dissipation phenomenon that causes secular orbit decay counteracted by solar effects (e.g., solar wind and angular momentum transfer) would cause just such an oscillation.

If the conventional explanation for the secular acceleration of the Moon (tidal dissipation) is correct, then the energy dissipation rate correlated with the observed spin-down rate of the Earth should closely match the energy requirement calculated in Eq. (15.1).

According to the NASA *Earth Fact Sheet*, the Earth’s moment of inertia is

$$I = 0.3308\left(5.9736\times10^{24}\,kg\right)\left(6.3781\times10^{6}\,m\right)^{2} = 8.0387\times10^{37}\ kg\ m^{2} \qquad (15.2)$$

Relative to an inertial frame, the Earth’s axial rotation rate in the current epoch is

$$\omega_1 = \frac{2\pi}{86164.1\ \text{sec}} \qquad (15.3)$$

Over a century, the work (W) done to increase the average distance between the Earth and the Moon by 3.8 meters should accurately correspond to a decrease in Earth’s angular velocity.

$$\omega_2 = \sqrt{\omega_1^2 - \frac{2W}{I}} \qquad (15.4)$$

If the Earth were losing rotational kinetic energy to match the secular gain in the Moon’s orbital energy, the resulting increase in length-of-day (lod) over a century would be about 0.15 millisecond.

$$\Delta\text{lod} = \frac{2\pi}{\omega_2} - \frac{2\pi}{\omega_1} \approx 1.5\times10^{-4}\ \text{sec} \qquad (15.5)$$

However, from astronomical records dating back several millennia, the long-term increase in the mean length-of-day has been established to be about 2.3 milliseconds per century and data limited to the last 200 years of astronomical observations (1798–1998) implies that the mean length-of-day increase over that period was about 1.5 milliseconds per century.[94, 95] As the secular acceleration of the Moon requires only a small fraction of the rotational energy dissipated by the Earth, it is conventionally assumed that the remainder (more than 3 terawatts or over 6 milliwatts per square meter of the geoid) dissipates as heat due to tidal friction, primarily occurring in a turbulent bottom boundary layer in shallow seas. Though an unlikely explanation, this was the best model previously available. However, it is now proposed that terrestrial spin-down is due primarily to a previously unsuspected relativistic phenomenon, which will be introduced in Chapter 16, and that the energy radiated from the Earth correlated with its spin-down manifests primarily in the microwave region of the spectrum. While a detailed theory of the mechanism remains to be worked out, this suspected relationship between gravity and electromagnetism is subject to empirical verification, inclusive of the prediction in Fig. (15.3). The empirical observation of the CMB and the absence of a primordial source (Big Bang) lead to the conclusion that it is a ubiquitous real-time emission correlated in part with the phenomenon of astrophysical spin-down as well as orbit decay.

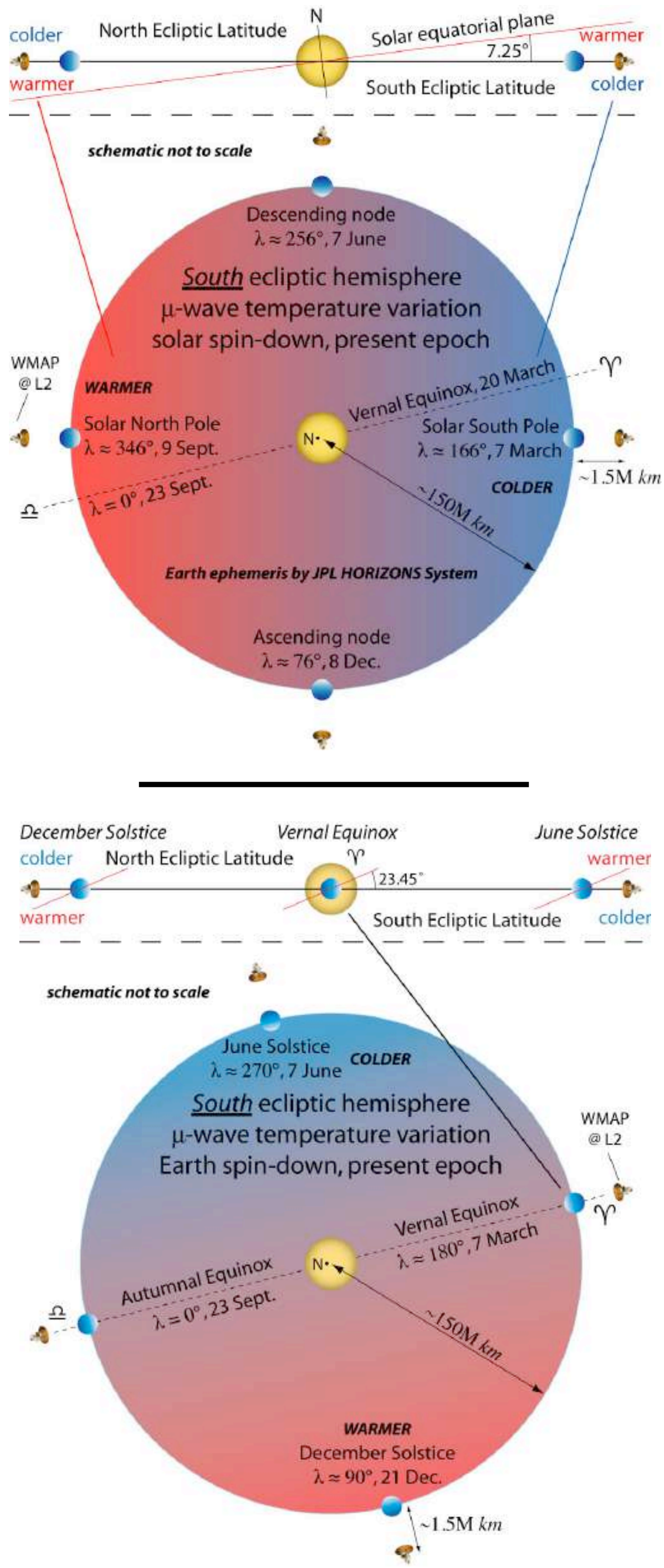


Figure 15.3 | Predicted *μ*-wave temperature variation calendars. These are the two expected dynamical signatures observing from L2 (e.g., Planck spacecraft) towards the South Ecliptic latitude. Separate out-of-phase annual sinusoids are correlated to solar and terrestrial spin-down.

16. AN OVERSIGHT IN THE FOUNDATION OF GENERAL RELATIVITY

It will be shown that the metric theory put forward by Einstein yields only a subset of all empirical implications arising from a complete synthesis of special relativity with accelerated reference frames. This exposition provides only an introduction to this subject, yet enough information will be provided to demonstrate conclusively to a suitably broad audience that the general theory of relativity incorporates a conceptual flaw. This flaw originated with a simple logical error made at the very beginning of Einstein's effort to apply the principles of special relativity to the phenomenon of gravity.

By definition, the path of light establishes a geodesic between two points in vacuum, for there is no shorter distance between those points than that measured along this path of minimum action:

> All length-measurements in physics constitute practical geometry in this sense, so, too, do geodetic and astronomical length measurements, if one utilizes the empirical law that light is propagated in a straight line, and indeed in a straight line in the sense of practical geometry.[96]

Consider the polar coordinate system of inertial frame *K* (i.e., ideally free of any acceleration) shown in Fig. (16.1a). If we imagine that a standard measuring-rod is employed to measure the radius of *K*, it is imperative that this rod be carefully placed end-over-end along the shortest possible distance between the origin and the periphery (i.e., along a radial geodesic). Per Einstein's foregoing quotation, this geodesic is defined by the radial path of light, which in practice may be traced by a radial laser placed at the origin (blue beam). Let the direction of the blue laser designate the 0º azimuth angular reference coordinate of *K*. Let the number of standard rods measured over the radius along this geodesic be exactly *n* so that we may state that the radius of the inertial reference frame *K* is *n* standard units.

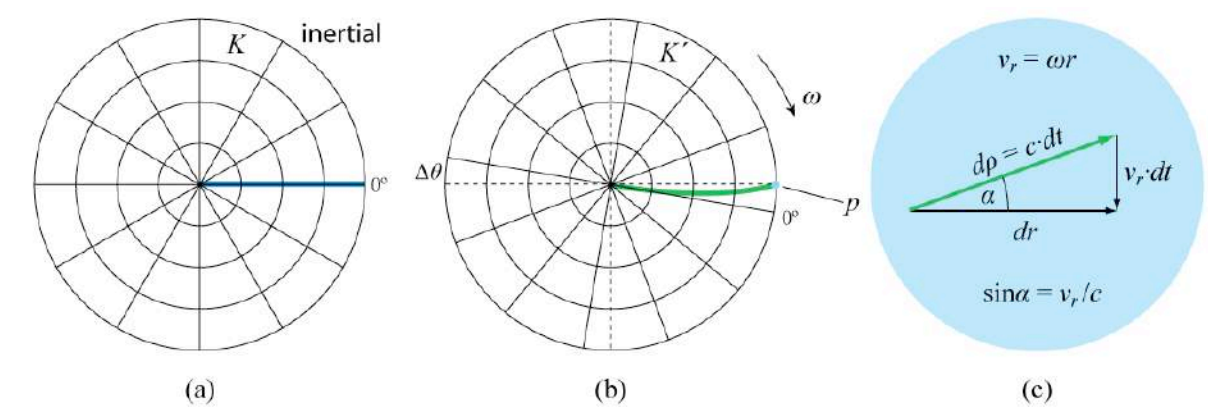


Figure 16.1 | The radial *geodesic* is defined by the path of a *physical* coherent light beam.

At the origin of *K*, let a green laser be fixed to a rotating stage with angular period *P*. Thus, every *P* seconds the green laser momentarily points in the same direction as the blue laser. The direction in which this laser points, as fixed in the co-rotating coordinate system, is designated as its 0º azimuth. It should be clear that this rotating coordinate system is a mathematical abstraction representing a virtual rotating reference frame *K′*. Consequently, the coordinate 0º reference radial of *K′* sweeps out a complete circle of 2π radians in *P* seconds and this mathematical fact is completely independent of any physical law. Contrariwise, due to the finite speed of light, photons emanating from the green laser require some amount of time to propagate. In this time, the rotating Euclidean polar coordinate system of *K′* will have advanced by some angular displacement $\Delta\theta$. It is clear that at coordinate radius *n* as defined in *K*, the green laser's photons will not strike the 0º reference radial of *K′*. Relative to the *K′* coordinate system, the coherent beam of photons traveling at the limiting speed *c* must *curve* in accord with the local tangential velocity of *K′*. For illustrative purposes, this curve is exaggerated in Fig. (16.1b). The geometry of this curve ρ (*rho*), is defined by the physical principles of the special theory of relativity. In contrast, the linear coordinate radius *r* is defined exclusively by kinematics. The local curvature of a coherent radial light beam relative to a radial of the rotating coordinate system of *K′* arises due to the physical principle that the speed of light is finite and constant for all observers, regardless of their motion. It follows that the tangential velocity (v) of a rotating observer at any point p along the curved light path ρ in K' has no effect on the measured speed of the radial photons emitted by the co-rotating green laser. Consequently, one may construct the simple spatial vector diagram shown in Fig. (16.1c), which establishes the precise geometric relationship between dr and $d\rho$.

Let us imagine an ideally co-rotating observer in K' who wishes to measure the distance from the origin of the rotating reference frame K' to some peripheral point p. If a standard measuring-rod is employed to measure the radius of K', it is again imperative that this rod be carefully placed end-over-end along a radial geodesic, which according to the laws of physics is physically defined by a radial coherent light beam *as it is experienced to exist by the ideally co-rotating observer in K'*. This light beam is represented by the green curve in Fig. (16.1b), which represents the straightest possible line and the shortest distance through space, as space is experienced to exist and as it is measured in the rotating reference frame.

It is evident that for each point p in K' there are two distinct radial coordinates: the *coordinate* radius r and the distinct *physical* radius ρ. Because light cannot propagate collinear with the geometric definition of the coordinate radius r in the rotating frame, this radius is an unphysical abstraction in that frame; it is strictly a mathematical coordinate that references the corresponding physical radial coordinate as it is defined in the stationary inertial frame. The laws of physics dictate that a geometric distinction exists between the coordinate radius r and the physical radius ρ for a rotating reference frame K' [Fig. (16.1b)], yet no such distinction exists for a similar inertial reference frame K [Fig. (16.1a)].

Let an observer in an inertial frame K measure the radial distance from the origin of K to a peripheral point p as n units of a standard measuring-rod, where ($n >> 1$). Let K now incur a rotational velocity and let the observer then remeasure the radial distance from the origin of the rotating frame K' to the same peripheral point p as n' units of the standard measuring-rod. According to the principles of relativity, it is necessarily the case that n' is greater than n; the geodesic path in the accelerated frame, which is curved relative to the coordinate radius, accommodates a greater number of measuring-rods. The geometric meaning of the word "radius" as it refers to the physical measurement of a spatial interval is not identical for an inertial frame and for a rotating frame. Thus, a fundamental physical effect incurred due to centripetal acceleration is the relativistic dilation of the physical radius corresponding to a point at a fixed coordinate radius. This implies a measured "excess radius" for a rotating frame as compared to the same inertial frame. The local differential relationship between the physical radius ρ and the coordinate radius r is precisely defined in terms of the local characteristic tangential velocity $v_r = \omega r$. Note that if there is no rotation ($v_r \equiv 0$), Eq. (16.2) reduces to the trivial equality applicable to the inertial frame.

$$\frac{d\rho}{dr} = \frac{1}{\cos\alpha} = \frac{1}{\sqrt{1-\sin^2\alpha}} = \frac{1}{\sqrt{1-\frac{v_r^2}{c^2}}} \tag{16.1}$$

$$d\rho^2 = \left(1-\frac{v_r^2}{c^2}\right)^{-1} dr^2 \tag{16.2}$$

According to the historical record, it is readily apparent that Albert Einstein never appreciated this subtle consequence of the principles of relativity. This is because his focus was clearly on the algebra of the Lorentz transformation equations, specifically suggesting the idea that a relative velocity is required to produce a relativistic length contraction in the context of a rotating reference frame. Since a velocity is exclusively associated with the tangential coordinate, Einstein wrongly assumed that no relativistic effects of a geometric nature applied to the radial coordinate of a rotating frame of reference, but this has been demonstrated to have been a serious oversight. When we look at the intrinsic curve of the green laser light beam relative to the K' coordinate system in Fig. (16.1b), which has a geometry that is precisely defined by the simple vector diagram in Fig. (16.1c), we are quite literally visualizing the most fundamental and accurate definition of "curved spacetime." It differs from the conventional definition in that it represents the transformation of time into space according to a physically intuitive and simply described geometry.

Historically, the rotating coordinate system K' in Fig. (16.1b) was imagined to be a rotating "rigid disk." This likely stemmed from a 1909 paper published by Max Born in which he discussed the relativistic treatment of rigid bodies.[97] Subsequently, Einstein's close friend and colleague, Paul Ehrenfest, put forward the idea that Born's relativistic local rigidity criterion implied that a rotating disk's circumference must incur a relativistic effect due to tangential velocity, while its radius will incur no such effect.[98] It is readily apparent that special relativity requires a standard measuring rod along the periphery of a rotating frame to contract relative to the inertial frame due to its tangential velocity. Consequently, Einstein argued that the conventional Euclidean ratio between radius and circumference does not hold for a rotating reference frame. Although this conclusion was correct, Einstein's methodology was flawed; he failed to see how the Equivalence Principle must lead immediately to valid quantitative geometric relationships applicable to a real gravitational field. In the context of the Equivalence Principle, a rotating frame of reference, while limited to 2-dimensional space, is an almost perfect analogy to a real gravitational field, assuming a static symmetric field (i.e., the Schwarzschild assumptions).

For some years prior to Ehrenfest's paper, a young Einstein (he turned 30 that year) tried and failed to find a synthesis between special relativity and gravity. Ehrenfest's flawed argument clearly electrified him, resulting in a line of thinking described in his popular book on relativity in the section entitled "Behavior of clocks and Measuring-Rods on a Rotating Body of Reference."

> If the observer applies his standard measuring-rod (a rod which is short as compared to the radius of the disc) tangentially to the edge of the [rotating] disc, then, as judged from the Galileian system [inertial frame K], the length of this rod will be less than 1, since, according to Section 12, moving bodies suffer a shortening in the direction of the motion. On the other hand, the measuring-rod will not experience a shortening in length, as judged from K, if it is applied to the disc in the direction of the radius. If, then, the observer first measures the circumference of the disc with his measuring-rod and then the diameter of the disc, on dividing the one by the other, he will not obtain as quotient the familiar $\pi = 3.14\ldots$, but a larger number, whereas of course for a disc that is at rest with respect to K, this operation would yield π exactly. This proves that the propositions of Euclidean geometry cannot hold exactly on the rotating disc, nor in general in a gravitational field, at least if we attribute the length 1 to the rod in all positions and in every orientation.[99]

He points out in a footnote that the laws of special relativity hold exclusively for the inertial system K.

> Throughout this consideration we have to use the Galileian (non-rotating) system K as reference body, since we may only assume the validity of the results of the special theory of relativity relative to K (relative to K' a gravitational field prevails).[100]

The historical record makes it clear that the analysis of a rotating rigid disk in the context of special relativity played a pivotal role in the development of general relativity. Early on in the pursuit of the theory, in a letter to Arnold Sommerfeld dated 29 September 1909, Einstein writes:

> The treatment of the uniformly rotating rigid body seems to me to be very important because of an extension of the relativity principle to uniformly rotating systems by trains of thought which I attempted to pursue for uniformly accelerated translation…[101]

In "Part 3" of his 1916 *Annalen der Physik* paper on general relativity, Einstein writes about a system of coordinates K' in uniform rotation relative to an inertial reference frame K:

> …we envisage the whole process of measuring [in K'] from the "stationary" system K, and take into consideration that the measuring-rod applied to the periphery undergoes a Lorentzian contraction, while the one applied along the radius does not. Hence Euclidean geometry does not apply to K'.[102]

In a 1921 lecture to the Prussian Academy of Sciences entitled "Geometry and Experience," Einstein made it clear that *the decisive step* leading to the method employed to develop his system of equations describing gravitation was Ehrenfest's (flawed) interpretation of the rotating disk.

> In a system of reference rotating relatively to an inertial system, the laws of disposition of rigid bodies do not correspond to the rules of Euclidean geometry on account of the Lorentz contraction; thus if we admit non-inertial systems on an equal footing, we must abandon Euclidean geometry. Without the above interpretation the decisive step in the transition to generally covariant equations would certainly not have been taken.[103]

Ehrenfest's original analysis of a rotating rigid disk in the context of special relativity clearly motivated Einstein's thought process, leading to his eventual conception of general relativity. What Einstein was searching for in the years 1907 to 1909 was a way to tackle the synthesis between special relativity and acceleration (i.e., *gravitation*). Ehrenfest's imagined rotating rigid physical disk (an accelerated reference frame that exhibits relativistic effects that can also be interpreted in the context of special relativity) offered a panacea. This is because the Equivalence Principle implies that what is generally true for a rotating centripetally accelerated observer is also true for an observer experiencing the radial acceleration of a gravitational field. The radial relativistic effects of the gravitational field (i.e., *excess radius*) are effectively duplicated for the inertially accelerated rotating frame of reference, but Einstein failed to notice this in 1909 or any time thereafter. The superficial principle that Einstein adopted based on an erroneous analysis of the rotating frame analogy to gravity was the idea of non-Euclidean spatial geometry. The essential idea that Einstein failed to appreciate was the transmutation of time into space for the rotating 'disk' and indeed all accelerated frames of reference, including a gravitational field.

Using a suitable instrument such as a gyroscope over some interval of time, a centripetally accelerated rotating observer can determine that the acceleration experienced is an inertial acceleration. However, if measurement is restricted to a single moment, then this measurement cannot distinguish between inertial and gravitational acceleration. Accordingly, although in fact moving as perceived by inertial observers and by a local instrument over time, the rotating observer is entitled to the opinion that no such motion exists and to interpret the measured acceleration as the effect of a peculiar kind of "gravitational field." Thus, the Equivalence Principle allows a rotating frame of reference K' with its associated system of coordinates to function as an accurate analog to a real gravitational field. In the words of Einstein,

> But, according to the principle of equivalence, K' may also be considered as a system at rest, with respect to which there is a gravitational field… We therefore arrive at the result: the gravitational field influences and even determines the metrical laws of the spacetime continuum.[104]

Willem de Sitter had more to say on the matter.

> In Einstein's theory of general relativity, there is no essential difference between gravitation and inertia. The combined effect of the two is described by the fundamental tensor $g_{\mu\nu}$, and how much of it is to be called inertia and how much gravitation is entirely arbitrary. We might abolish one of the two words, and call the whole by one name only. Nevertheless, it is convenient to continue to make a difference. Part of the $g_{\mu\nu}$ can be directly traced to the effect of known material bodies, and the common usage is to call this part "gravitation" and the rest "inertia."[105]

Correctly employed in the context of a rotating frame of reference, the Equivalence Principle is magnificent in its ability to produce a penetrating understanding of the gravitational field. A rotating observer who, according to the Equivalence Principle, is entitled to interpret the experience of inertial acceleration as a kind of "gravitational field," is equally entitled to identify the locally measured "gravitational acceleration" at an eccentric point p with a characteristic "escape velocity" energy value associated with that point. The concept of escape velocity indirectly refers to a kinetic energy equivalent to the local gravitational potential energy. In the case of a rotating frame of reference, conservation of energy implies that this characteristic velocity, which is essentially an abstract mathematical property associated with a coordinate radius r, is identical in magnitude to the real physical tangential velocity at radius r measured by an inertial observer. If this is not immediately clear, then it can be shown explicitly by integrating the centripetal acceleration over an arbitrary coordinate radius r. The work done on a particle of arbitrary mass m ideally translated from the disk center to radial coordinate r must always equal the particle's kinetic energy of rotation due to its tangential velocity v_r at r. In the non-relativistic regime, where m is taken to be a constant,

$$\int F \cdot dr = m\int \frac{(\omega r)^2}{r} dr = m\omega^2 \int r\, dr = \frac{1}{2} m\omega^2 r^2 = \frac{1}{2} m v_r^2 \tag{16.3}$$

Eq. (16.3) and the Equivalence Principle imply that the role of the tangential velocity (v_r) in Eq. (16.2) is indistinguishable from the role of characteristic escape velocity ($v_r \equiv v_{esc}$). Then this expression for $d\rho^2$, which was derived exclusively in reference to a rotating frame of reference, can be written as Eq. (16.4).

$$d\rho^2 = \left(1 - \frac{v_{esc}^2}{c^2}\right)^{-1} dr^2 \tag{16.4}$$

In the case of inertial acceleration due to rotation,

$$v_{esc} = \omega r \tag{16.5}$$

and in the case of real gravitational acceleration due to a source mass M,

$$v_{esc} = \sqrt{\frac{2GM}{r}} \tag{16.6}$$

Upon substituting the latter definition, Eq. (16.4) takes on a familiar form found in standard textbooks of general relativity relating the physical radius of a gravitational field (ρ) to its coordinate radius (r).

$$d\rho^2 = \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 \tag{16.7}$$

The derivation of Eq. (16.7) from Eq. (16.2) is clearly a direct consequence of the Equivalence Principle and confirms that Einstein made a significant mistake in accepting Ehrenfest's assumption that no spatial relativistic effect occurs in the direction of the radius for a rotating frame of reference. This should have been obvious, for there can be no radial relativistic *temporal* effect without a corresponding *spatial* effect.

Recall Minkowski's assertion that spacetime is composed of an "infinite number of spaces." This claim is made manifest in the case of a rotating frame of reference because the neighborhood of each unique point over a geodesic interval ρ constitutes a distinct space with each space being distinguished by a unique value of the characteristic angle α as defined in Fig. (16.1c). This is also the angle between the local proper time coordinate and the time coordinate of an inertial observer at $r = 0$. Naturally, each of these distinct spaces is associated with a geometrically unique local time coordinate.

The term "proper time" commonly employed in relativistic physics is a kind of malapropism referring to Henri Poincaré's term "propre temps." In the French, the literal meaning of "votre propre temps" is "your own time."[106] Then *proper time* refers to the time indicated by an ideal clock in the rest frame of any particular observer whose relativistic perspective is being considered. In a rotating frame of reference, the time t at the radial coordinate $r = 0$ corresponds to the proper time of an ideal inertial observer O who experiences no centripetal acceleration. As this observer has the unique inertial perspective for all points on K', the time t designates "coordinate time" in like manner to the "coordinate radius," which designates the physical radial coordinate as measured in inertial space. The time at some eccentric point at a coordinate radius r in K', designated τ_r, corresponds to the proper time of a local ideally co-rotating observer O' who measures a centripetal acceleration at that location. According to O, the only *observable* applicable to O' is the measured tangential velocity v_r. Consequently, the inertial observer O is entitled to apply the principles of special relativity to this observation and to conclude that the rate of proper time for O' is less than the rate of local proper time according to Eq. (16.8).

$$\frac{dt}{d\tau_r} = \frac{1}{\sqrt{1 - \frac{v_r^2}{c^2}}} \tag{16.8}$$

Again, recognizing the identity ($v_{esc} \equiv v_r$) and rearranging the terms to produce an expression for local proper time (τ) in terms of the coordinate time (t) puts this equation in similar form to Eq. (16.4).

$$d\tau^2 = \left(1 - \frac{v_{esc}^2}{c^2}\right) dt^2 \tag{16.9}$$

Upon substituting the gravitational definition of escape velocity, Eq. (16.9) takes on a familiar form found in standard textbooks of general relativity relating the local proper time in a gravitational field (τ) to the coordinate time (t).

$$d\tau^2 = \left(1 - \frac{2GM}{rc^2}\right)dt^2 \tag{16.10}$$

Consider now an observer experiencing ideal radial free-fall in a gravitational field. Consequently, the angular parameters (θ, φ) are constant and can be ignored. With the exception of arbitrarily small gravitational tidal forces, this free-falling observer can make no local measurements that indicate absolute motion; there is nothing internal to a locally Lorentzian free-falling reference frame to indicate a state of acceleration relative to a gravitational source mass. Consequently, the space-time metric for the inertial free-falling observer corresponds to the Minkowski metric in terms of local measurable coordinates.

$$ds^2 = -c^2 d\tau^2 + d\rho^2 \tag{16.11}$$

Equations (16.7) and (16.10) correlate these local proper space and time coordinates to the convenient reference coordinates of the gravitational field (i.e., the coordinate radius and the coordinate time). Substitution yields the first two terms of the familiar Schwarzschild metric for an ideal static symmetric gravitational field. Per the concept of temporal geometry developed in the previous chapters, one is not entitled to assume that the local time coordinate of the metric is independent of angular coordinates (θ, φ).

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right)c^2 dt^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 \tag{16.12}$$

Max Born, Paul Ehrenfest, Albert Einstein and numerous theoretical physicists who followed them made the fundamental mistake of imagining K' to be a kind of a physical object (i.e., a "rigid disk") instead of a purely abstract mathematical object (i.e., a virtual disk) that can be used to model the laws of mathematical physics. Is not a polar coordinate system by its very mathematical nature perfectly 'rigid'? Then, as shown in Fig. (16.2), the periphery of the abstract coordinate system may spin with a virtual tangential velocity (i.e., not an actual physical velocity) of the speed of light (c).

As quoted in his book, *The Meaning of Relativity*, the following is a reiteration of young Einstein's erroneous analysis of the rotating frame of reference, which eventually led him to his ingeniously conceived yet seriously flawed concept of "spacetime curvature."

> Imagine a circle drawn about the origin in the $x'y'$ plane of K', and a diameter of this circle. Imagine, further, that we have given a large number of rigid rods, all equal to each other. We suppose these laid in series along the periphery and the diameter of the circle, at rest relatively to K'. If U is the number of these rods along the periphery, D the number along the diameter, then, if K' does not rotate relatively to K, we shall have $U/D = \pi$. But if K' rotates we get a different result. Suppose that at definite time t, of K we determine the ends of all the rods. With respect to K all the rods upon the periphery experience the Lorentz contraction, but the rods upon the diameter do not experience the contraction (along their lengths!). It therefore follows that $U/D > \pi$.[107]

Herein there are two fallacies. The first is that the geometric meaning of *physical radius* is identical for the distinct reference frames K and K'. This significant logical error has already been discussed in detail. The second fallacy is that the contraction of measuring rods along the periphery of K' implies an *increase* in the effective circumference of the reference frame. Quite the contrary, it is clear that the physical interpretation of the coordinate transformation implies a relativistic *contraction* of the circumference according to Eq. (16.13).

$$C'(r) = 2\pi r\sqrt{1 - \frac{v_r^2}{c^2}} \tag{16.13}$$

Normalizing the speed of light ($c = 1$), angular velocity ($\omega = 1$) and maximum radius ($R = 1$) yields the effective radius of circumference (r') as a function of the coordinate r, which is graphed in Fig. (16.3).

$$\frac{C'(r)}{2\pi} = r'(r) = r\sqrt{1-r^2} \tag{16.14}$$

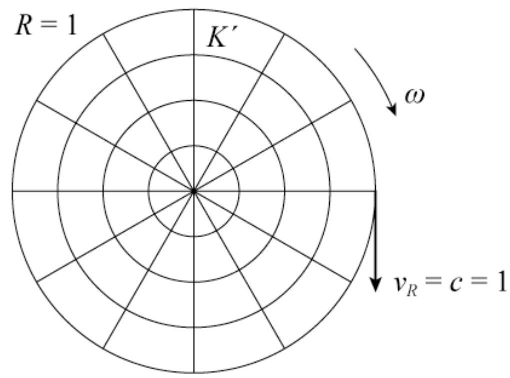


Figure 16.2 | The coordinate system K' as a *mathematical* object. The peripheral tangential velocity at maximum radius ($R = 1$) is the normalized limiting speed c. Applying the relativistic length contraction formula to the circumference (C), this perimeter is reduced to a point (i.e., a pole).

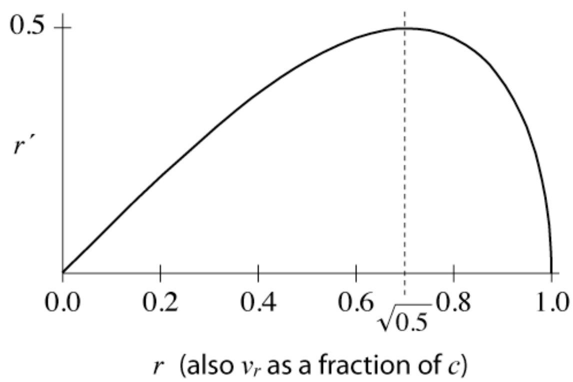


Figure 16.3 | Graph of Eq. (16.14).

It becomes clear that due to the phenomenon of "spacetime curvature" induced by acceleration whereby "time becomes space," the coordinate $r = 1$ is a pole, similar to the coordinate $r = 0$. The outer circle of Fig. (16.2) collapses to a single point according to the mathematics. The part of our mind that evaluates reality according to visual logic tends to reject the idea that the perimeter of K' corresponds to a single point. It would then seem that the entire virtual disk must collapse to a single point because we think of the perimeter as enclosing an interior 2-dimensional *space*. However, the virtual disk in Fig. (16.2) is actually a 2-dimensional mapping of a 3-dimensional subset of *spacetime* restricted to an x-y plane of 3-space. Per the existence of the "infinite number of spaces" revealed by Minkowski, it proves to be the case that the neighborhood of each point on K' represents a distinct space with a distinct time coordinate. The physical picture is that the rotating virtual disk represents a kind of spatial wormhole (with radius r') through the time dimension of the inertial observer (i.e., "time becomes space"). The same physical and geometric principles must hold for a real gravitational field according to the Equivalence Principle, although the radial orientation of the relativistic effect is reversed (i.e., it is in the inbound direction).

There is another way to show that the coordinate $r = 1$ in Fig. (16.2) collapses to a single point, which is more physically intuitive than Eq. (16.14). Consider the fact that the tangential velocity of a rotating observer as measured by an inertial observer and also as measured in the rotating frame according to a gyroscope is equal to the circumference of the rotation divided by the time required for one revolution.

$$v = \frac{C}{dt} \qquad v' = \frac{C'}{d\tau} \tag{16.15}$$

As the relative velocity of an ideal clock (from the perspective of the inertial observer) or the equivalent escape velocity (from the perspective of the rotating observer) approaches the speed of light, the absolute rate of the rotating clock relative to an inertial clock approaches zero. In order for the measured characteristic velocity to asymptotically approach the speed of light in such a way that both observers agree on its magnitude, the measured circumference of rotation in the rotating frame must approach zero (i.e., a point) in correspondence with the relative clock rate. The physical circumference in the accelerated frame ($C' = 2\pi r'$) *must* contract relative to the coordinate circumference ($C = 2\pi r$).

$$v \equiv v' \quad \rightarrow \quad \frac{C}{C'} = \frac{dt}{d\tau} = \frac{1}{\sqrt{1 - \frac{v_{esc}^2}{c^2}}} \tag{16.16}$$

In the context of spacetime and the idea that relativity implies that "time becomes space," the virtual disk in Fig. (16.2) can be visualized as a 3-dimensional surface having a cylindrical symmetry around the inertial frame's time axis (t), rather than a 2-dimensional surface with a circular symmetry around the inertial frame's z-axis. The latter model is a simplistic interpretation lacking mathematical sophistication. Relative to the inertial clock, the measured rate of an ideal clock slows as a function of the coordinate radius of K', so it should be clear that with increasing coordinate radius in K', we are going *back in time* relative to the inertial time coordinate. Consequently, the time axis in Fig. (16.4) must have a negative sign.

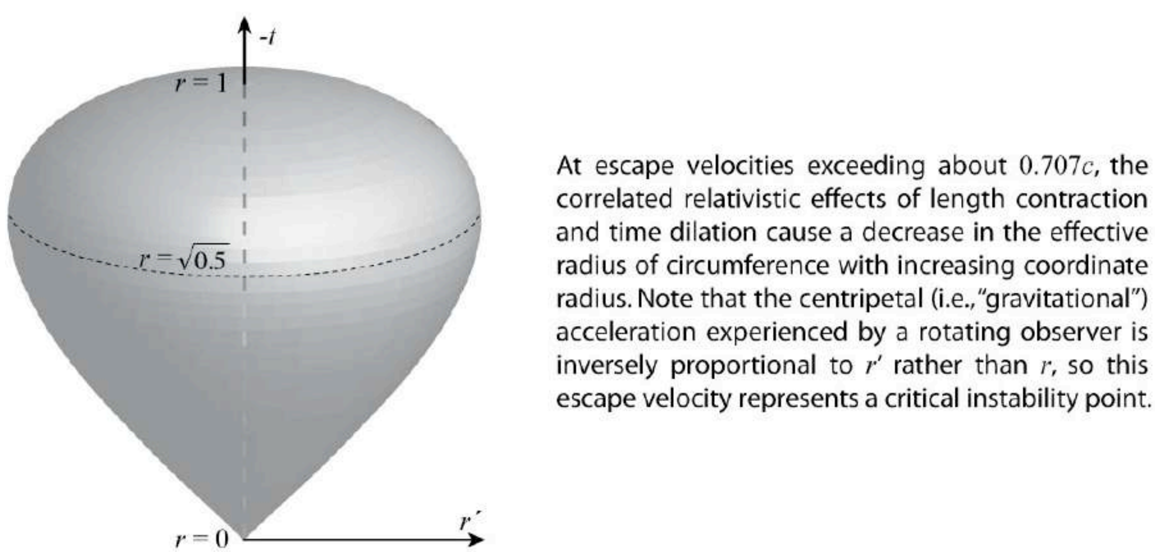


Figure 16.4 | The virtual 2-D disk of Fig. (16.2) represented as a 3-D surface in spacetime. The curvature of the physical radius ρ relative to the coordinate radius r represents the conversion of K-frame time into K'-frame space. While each subsequent concentric differential circle of increasing radius in K' is mathematically and visually coplanar in inertial space, according to the principles of relativity these circles are not concentric (i.e., coplanar) in *spacetime*. Rather, the increasing velocity of each successive circular differential element of K' implies a further displacement of each of these successive rings in the negative direction of the inertial time coordinate. "Time becomes space."

17. A NEW LOOK AT THE GRAVITATIONAL BENDING OF LIGHT

The empirical prediction that brought Einstein rapid fame in November 1919 concerned the bending of light by a gravitational field according to his published 1916 formula, Eq. (17.1).[108,109] It predicts a deviation of about 1.75" of arc for light grazing the surface of the Sun where *b* is the "impact parameter" or radius of closest approach to the centroid of the source mass (in this case *b* is the solar radius). This was a correction to an erroneous earlier prediction of half this value that Einstein made in 1911.[110]

$$\alpha = \frac{\kappa M}{2\pi\Delta} = \frac{4GM}{bc^2} \tag{17.1}$$

Although it makes an accurate prediction in the weak field, this equation is known to be a kind of mathematical hack, for it is not a general formula applicable to the phenomenon. As Eq. (17.1) fails to be meaningful in the strong field limit (yielding a value of two radians at the Schwarzschild radius), this weak-field formula is an accurate but naïve approximation to a general gravitational lensing formula, which Einstein never put forward. The correct completely general formula may be derived directly from first principles, pure geometry and symmetry considerations.

As shown with illustrative exaggeration in Fig. (17.1), an ultrahigh eccentricity hyperbolic trajectory is geometrically equivalent to bending a linear trajectory through a very small angle. The asymptotes of a hyperbolic trajectory of eccentricity *e* intersect at the angle *α* quantified by Eq. (17.2). This is a *definition* arising from pure geometry. As both the inbound and outbound asymptotes represent linear trajectories, the original inbound linear trajectory is effectively "bent" through this precise angle.

$$\alpha = 2\sin^{-1}\frac{1}{e} \tag{17.2}$$

Due to the small-angle approximation ($\sin x \approx x$), Einstein's empirically verified 1915 formula can be written in this new form. For the typically weak astrophysical fields for which this formula is known to be exclusively applicable, there are no measurable consequences.[111]

$$\alpha = 2\sin^{-1}\left(\frac{2GM}{bc^2}\right) \tag{17.3}$$

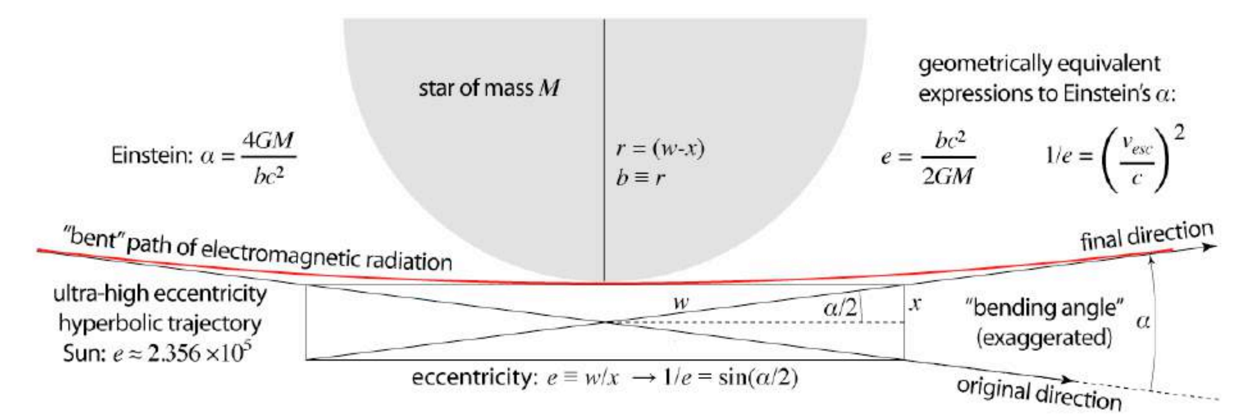


Figure 17.1 | Gravitational light bending modeled by a hyperbolic trajectory. The foundations of astrodynamics require orbital trajectories to follow conic sections. The applicable conic section is dependent exclusively on the relationship between the velocity of the orbiting particle and the maximum gravitational escape velocity incurred during the orbit. A hyperbolic escape trajectory is implied when the orbital velocity exceeds this escape velocity. Because the speed of a photon is typically much greater than escape velocity ($c >> v_{esc}$), this is the implied trajectory for radiation.

Combining Eq. (17.2), which is simply a geometric identity, and Eq. (17.3) yields the eccentricity of the hyperbolic trajectory of electromagnetic radiation in a weak gravitational field. Then the inverse of this characteristic eccentricity is the square of the ratio of the escape velocity at b to the speed of light.

$$e = \frac{bc^2}{2GM} \quad \rightarrow \quad \frac{1}{e} = \frac{v_{esc}^2}{c^2} \tag{17.4}$$

Einstein's light bending formula is naïve in two ways. First, it does not provide a general solution and second, it does not realistically model the phenomenon as a smooth process acting over the entire photon trajectory, which must be the case. With no reference to the mass of an orbiting particle, the geometric foundations of astrodynamics specify that when the periapsis velocity of a particle is equal to the local gravitational escape velocity, the trajectory is parabolic. A parabolic trajectory (e = 1) implies parallel asymptotes, which means that the angle through which the trajectory is bent is exactly *pi* radians (180º). Although Eq. (17.4) is effectively identical to conventional relativity in the weak field, it is consistent with the geometric foundations of astrodynamics in the strong field limit and inconsistent with the predictions of the Einstein field equations. It can be readily demonstrated that the strong field limit prediction yielded by the field equations is incorrect because Eq. (17.4) is consistent with first principles [Fig. (17.2), right].

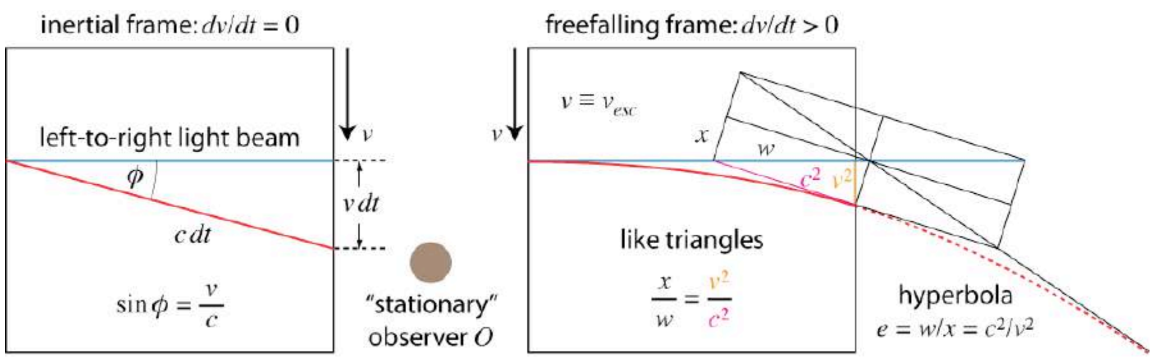


Figure 17.2 | The curved trajectory of light derived from first principles. The "stationary" observer (O) is independently applied to both cases. *Left*: O feels no acceleration. In special relativity, O experiences a horizontal light beam as experienced in the uniformly 'moving' inertial frame to translate with speed c at a fixed angle *phi*. The relativistic effects are symmetrical. *Right*: O feels acceleration (i.e., the local surface gravity associated with v_{esc}). O experiences a horizontal light beam as experienced in the radially free-falling inertial frame to curve. The *asymmetry* of relativistic effects (time dilation and length contraction) requires O to apply a unilateral *second* factor of v/c to the sine ratio of v/c that appears in the symmetric SR case. The applicable velocity of the free-falling frame (originating at 'infinity') is the local escape velocity of the gravitational field measured by O.

The kinematics of the virtual "light clock" in the left frame of Fig. (17.2) lead to the simple derivation of relativistic time dilation in SR. The kinematics shown on the right lead to the conclusion that the bending of light in a gravitational field corresponds to a hyperbolic photon trajectory of known eccentricity. Both are based on incontrovertible first principles. At any moment in time (i.e., speed v), the unaccelerated observer in the free-falling frame (*right*) is entitled to invoke special relativity in reference to the 'stationary' observer's accelerated frame of reference (O); however, this is not reciprocal. Observer O experiences gravitational acceleration and so cannot invoke special relativity, so the measurement of relativistic time dilation and length contraction effects are asymmetrical; from the point of view of O, ideal clocks in the free-falling frame run fast and radial standard measuring rods are longer relative to local ideal references. Free-falling from infinity, the velocity of the 'moving' frame is identical to the gravitational escape velocity locally measured by O. The total curvature of the light beam evaluated at that point represents exactly half of the total curvature of a grazing trajectory due to the symmetry of the outbound trajectory to the inbound trajectory. Failing to account for geometric time, general relativity incurs modeling errors of increasing magnitude as the escape velocity approaches the speed of light.

THANK YOU

I greatly appreciate that you have invested your valuable time in these ideas. Those having talent in mathematical physics should be able to carry them forward. Others may make an important contribution by promoting criticism. If you have enjoyed reading the book, I encourage you to periodically visit www.sensibleuniverse.com, where there will be new information and opportunities for visitors as the website develops. In particular, I look forward to soliciting and posting professional criticism of this dissertation by leading authorities in the physical sciences.

A. SDSS RECOGNITION

Critical portions of this book have relied on the data acquired by the Sloan Digital Sky Survey (SDSS).

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The SDSS is managed by the Astrophysical Research Consortium for the Participating Institutions. The Participating Institutions are the American Museum of Natural History, Astrophysical Institute Potsdam, University of Basel, Cambridge University, Case Western Reserve University, University of Chicago, Drexel University, Fermilab, the Institute for Advanced Study, the Japan Participation Group, Johns Hopkins University, the Joint Institute for Nuclear Astrophysics, the Kavli Institute for Particle Astrophysics and Cosmology, the Korean Scientist Group, the Chinese Academy of Sciences (LAMOST), Los Alamos National Laboratory, the Max Planck Institute for Astronomy (MPIA), the Max Planck Institute for Astrophysics (MPA), New Mexico State University, Ohio State University, University of Pittsburgh, University of Portsmouth, Princeton University, the United States Naval Observatory and the University of Washington.

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C. TRIBUTE TO HERMANN MINKOWSKI

The mathematical education of the young physicist [Einstein] was not very solid, which I am in a good position to evaluate since he obtained it from me in Zürich some time ago. – H. Minkowski

Hermann Minkowski (1864–1909)

Preface to *Raum und Zeit* [*Space and Time*] (1908)

The talk on "Space and Time," which Hermann Minkowski gave at the Convention of German Scientists and Doctors in Cologne, is the last of his ingenious creations. Unfortunately, it was not destined for him *to finish the more detailed development of his audacious concept* of a mechanics in which time is integrated with the three dimensions of space. Equally esteemed for his personal and professional qualities, the author was torn away from his loved ones and friends at the height of his life and creativity by a tragic fate on 12 January.

The understanding and enthusiastic interest that his talk had awakened filled Minkowski with inner content and he desired to make his interpretation available to a wider circle through a special published edition of his lecture notes. It is with a painful duty of piety and friendship that the editor's bookshop von B. G. Teubner and the undersigned do herewith fulfill the last wish of the deceased.

Halle an der Saale, Germany

20 February 1909

A. Gutzmer

– Translated and adapted from the German with the kind assistance of Dr. Martin Lades. –

Obituary by David Hilbert

Since my student years Minkowski was my best, most dependable friend who supported me with all the depth and loyalty that was so characteristic of him. Our science, which we loved above all else, brought us together; it seemed to us a garden full of flowers. In it, we enjoyed looking for hidden pathways and discovered many a new perspective that appealed to our sense of beauty, and when one of us showed it to the other and we marveled over it together, our joy was complete. He was for me a rare gift from heaven and I must be grateful to have possessed that gift for so long. Now death has suddenly torn him from our midst. *However, what death cannot take away is his noble image in our hearts and the knowledge that his spirit in us continues to be active.*[289]

D. ADDRESS BY DAVID HILBERT

David Hilbert (1862–1943) was an outstanding 20th-century mathematician. He grew up in Königsberg, where he also attended the University of Königsberg with his close friend, Hermann Minkowski. He spent the majority of his career as the Chair of Mathematics at Göttingen and made efforts to ensure that Minkowski was a member of the department. After Minkowski's sudden and unexpected death caused by appendicitis in January 1909, it is likely that Hilbert had priority access to Minkowski's papers. It is conceivable that Hilbert's 1909 idea of the infinite-dimensional "Hilbert Space" was in part motivated by unpublished creative work originally conceived by Minkowski.

Königsberg, Fall 1930

> The tool implementing the mediation between theory and practice, between thought and observation, is mathematics. Mathematics builds the connecting bridges and is constantly enhancing their capabilities. Therefore it happens that our entire contemporary culture, in so far as it rests on intellectual penetration and utilization of nature, finds its foundations in mathematics.
>
> Already some time ago Galileo said, "Only one who has learned the language and signs in which nature speaks to us can understand nature."
>
> This language however is mathematics, and these signs are the figures of mathematics.
>
> Kant remarked, "I maintain that, in any particular natural science, genuine scientific content can be found only in so far as mathematics is contained therein."
>
> In fact we do not have command of a scientific theory until we have peeled away and fully revealed the mathematical kernel. Without mathematics, modern astronomy and physics would be impossible. The theoretical parts of these sciences almost dissolve into branches of mathematics. Mathematics owes its prestige, to the extent that it has any among the general public, to these sciences along with their numerous broader applications. Although all mathematicians have denied it, the applications serve as the measure of worth of mathematics.
>
> Gauss speaks of the magical attraction that made number theory the favorite science of the first mathematician — not to mention the inexhaustible richness of number theory, which far surpasses that of any other field of mathematics.
>
> Kronecker compares number theorists with the lotus-eaters, who, once they started eating this food, could not let go of it.
>
> The great mathematician Poincaré once sharply disagreed with Tolstoy's declaration that the proposition "science for the sake of science" would be silly.
>
> The achievements of industry for example would not have seen the light of the world if only applied people had existed and if uninterested fools had failed to promote these achievements.
>
> The honor of the human spirit, so said the famous Königsberg mathematician Jacobi, is the only goal of all science. We ought not believe those who today, with a philosophical air and reflective tone, prophesy the decline of culture, and are pleased with themselves in their own ignorance. For us there is no ignorance, especially not, in my opinion, for the natural sciences.
>
> Instead of this silly ignorance, on the contrary let our fate be:
>
> **"We must know, we will know."**

Translation by Amelia and Joe Ball.

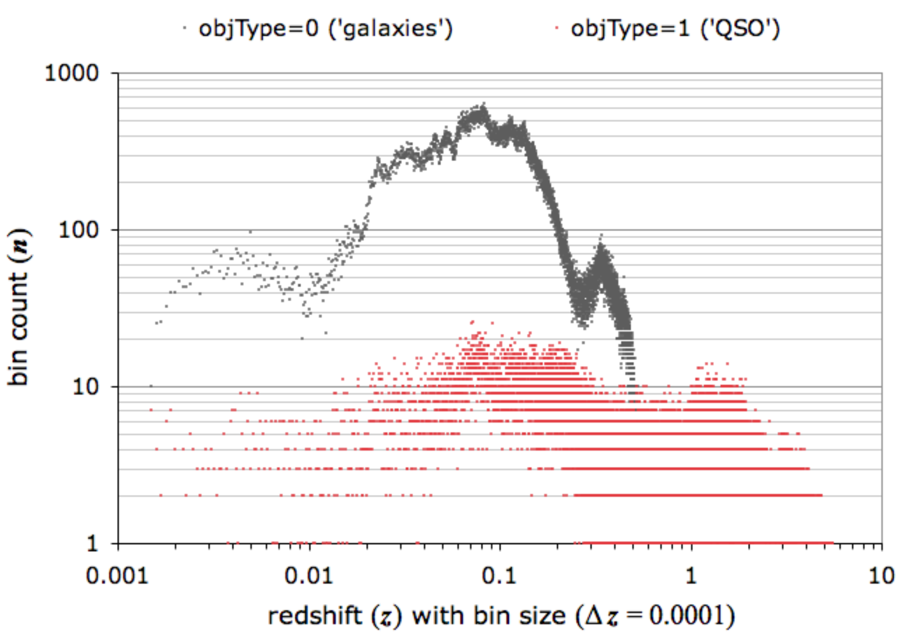
Thanks to Ruth Williams of UC San Diego for posting this translation online.

E. SDSS DR7 SPECTROSCOPIC DATA

Preamble: relational database (e.g., SDSS SkyServer) fundamentals

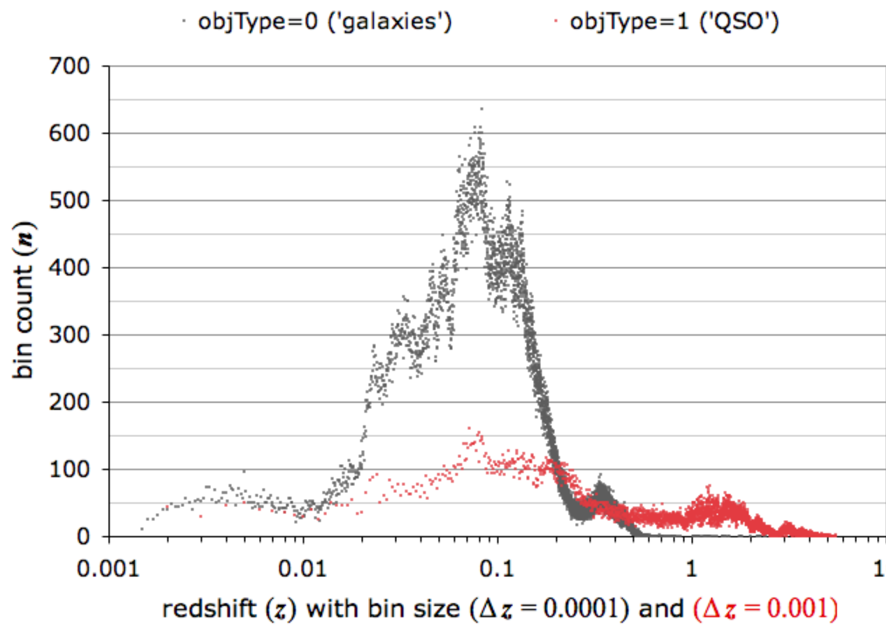
A relational database is organized in *tables*. Each table is organized in *columns*, which are the attributes of the entity described by the table. For example, a table Person may include columns for FirstName and Gender, among others. A database column is uniquely identified by prefixing it with its table name in the form *table.column*. A *row* of data in a table represents an instantiation of the entity described by the table (e.g., a row in a table called Person represents a unique individual and includes known column values). Tables may be related to one another by containing a unique (key) value from another table. For example, the Citizenship column of Person would normally contain a reference to a Country table. A database *view* is a prepared selection of data meeting certain criteria. For example, a NorthAmerica view of Person would exclusively display citizens of Canada, the United States and Mexico. **[end of preamble]**

The SDSS PhotoObj view, which contains the attributes of SDSS photometric (image) objects, contains over 453 million rows. Select photometric objects were distinguished by ObjType (object type) as part of the automated spectroscopy target selection process (see "3. Quasars" at http://pdfref.com/m1/aE.01.htm). The SpecObj view contains about 10^6 rows, each describing a distinct object targeted for spectroscopy. The value of the SpecObj.objType column designates the initial tentative object type by examination of photometric data. Of ~1.05 million rows in the SpecObj view, about 76% are objType=0 ('GALAXY') and about 15% are objType=1 ('QSO'). Because a quasi-stellar object (quasar) is identified by its distinct spectral characteristics, it was not certain that an objType=1 target was actually a QSO in advance of spectroscopic measurement. Thus, while targets designated 'QSO' through assignment of objType=1 had a high likelihood of being correctly identified in advance, some of these targets would inevitably not fall under this specific spectral classification following measurement.[290,291] Accordingly, the red objType=1 bins in the following graphs include objects that are not real QSO according to their spectral properties. Yet, the objType=1 targets are broadly classified as sharing observed physical properties that are distinct from objType=0 targets. Because all objType=1 SDSS targets are QSO targets but may not be actual QSO, these objects can be broadly classified as photometric "point source objects" or "PSO," meaning that these targets typically appear point-like or that they otherwise incorporate an object of this description.



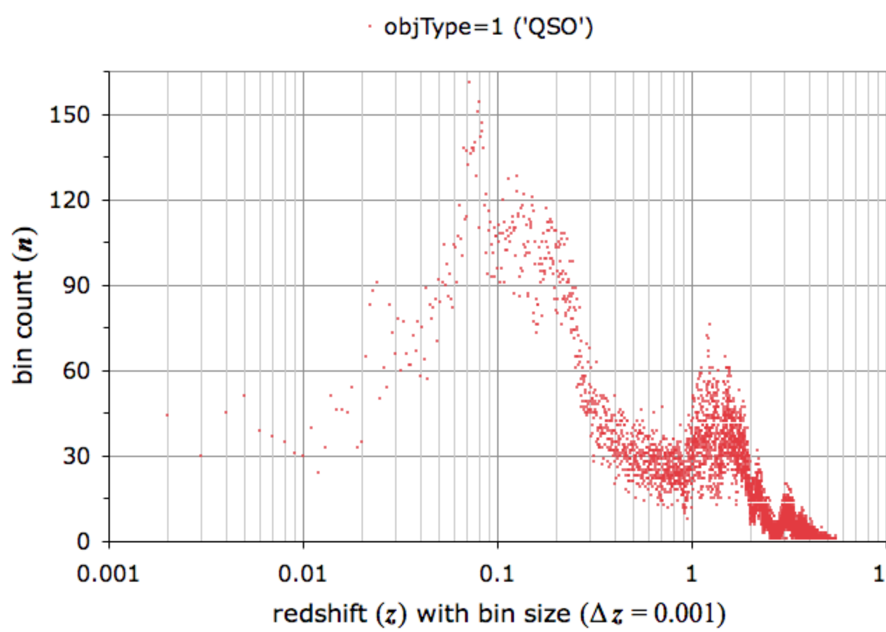
E.1

The above graph shows high-quality measured redshifts (SpecObj.zStatus=3, 4, 6, 7 or 9) for these two object types. It is clear that the 'QSO' (objType=1) bin population is generally a small fraction of the galaxy population for ($z < 0.2$). The prominent secondary maximum in the galaxy data (gray) is caused by the inclusion of the Luminous Red Galaxies (LRG) Survey redshifts in SpecObj. The LRGs are not identified by a simple database parameter so, for the purpose of keeping the query brief and easily understood, they are not excluded. While this graph provides a good understanding of the relative density in redshift-space of the two object types, the relative population trend with redshift for objType=1 targets is not obvious. This is remedied in the following graph of the same data. The bin size (in redshift space) of the 'QSO' (i.e., PSO) in red is now an order of magnitude larger ($\Delta z = 0.001$) than that of the 'GALAXY' bins in gray ($\Delta z = 0.0001$).



E.2

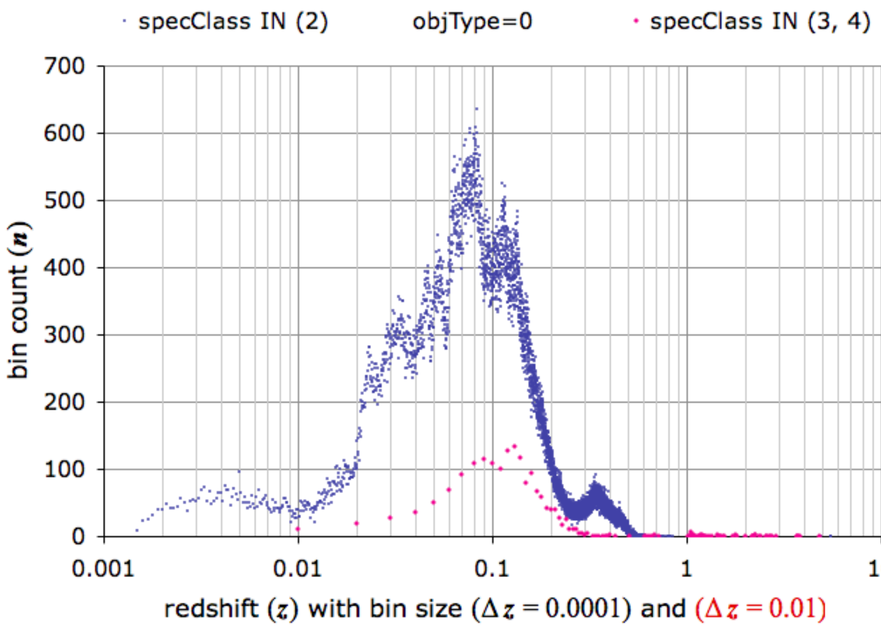
In E.3, isolating the 'QSO' and reducing the y-axis magnitude provides better detail. Both E.2 and E.3 plot the same data set in red (SpecObj.objType=1 ignoring SpecObj.zWarning flags). The latter graph clearly reveals three distinct maxima in this set of SDSS objects at $z \approx 0.1$; $z \approx 1.5$; $z \approx 3$.



E.3

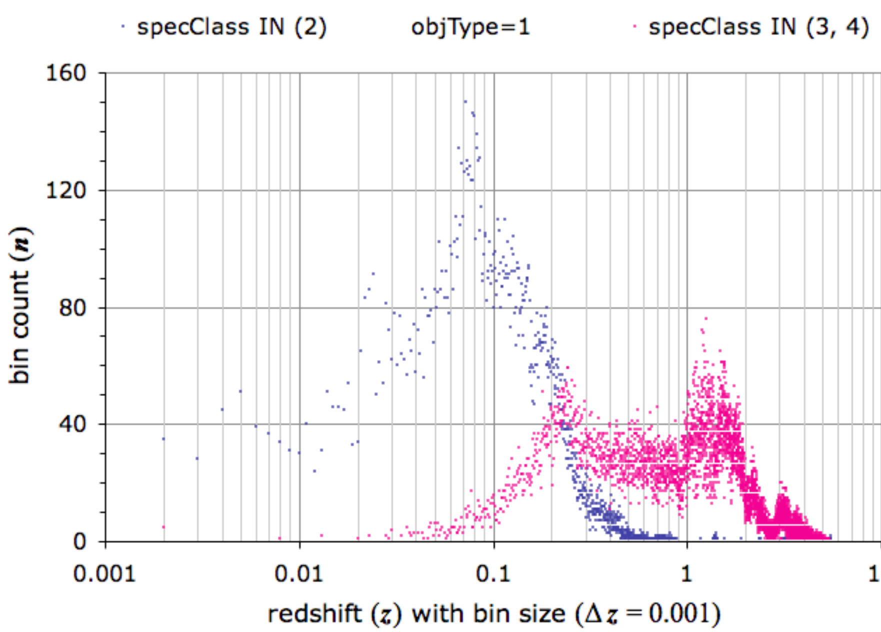
Following secondary observation and spectral analysis of targeted galaxies, SDSS assigned each target to a SpecClass, which differentiated between objects exhibiting the defined spectral characteristics of a

QSO and other targets (about 89%) that do not meet this criteria. A distinction was made between typical QSO spectra (specClass=3) and high redshift QSO spectra (specClass=4). Very few of the objects designated as objType=0 targets prior to spectroscopic analysis exhibited spectra associated with QSO (just 0.25%). The QSO bins shown in pink in the following graph have a bin size 100 times larger in redshift space than the bins for the other galaxies shown in blue (SpecObj.specClass=2). This implies that pink QSO bins of equal size to the blue galaxy bins would have on average 1% of the bin count shown in the graph (i.e., there would be 100 times more red bins than shown and most would be empty). It is notable that both curves exhibit the same $z \approx 0.1$ peak and the post peak ($z \approx 0.15$) surge in bin counts.



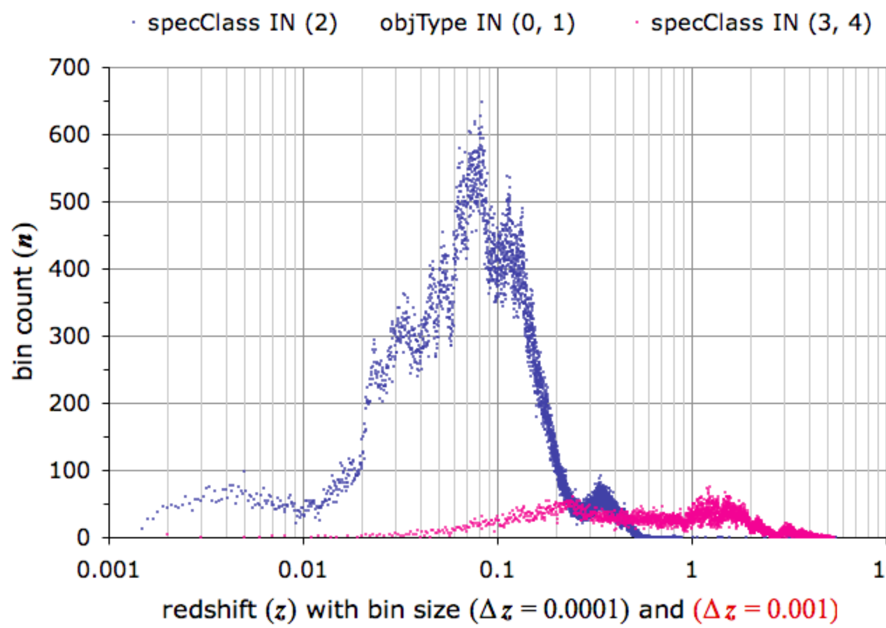
E.4

In contrast, a significant number (22,165 or about 20.6%) of the $z \geq 0.001$ targets that were identified as objType=1 ('QSO') prior to spectroscopic analysis were later identified in the database as having the spectral characteristics of a galaxy (specClass=2), rather than a QSO. These are shown below in blue.

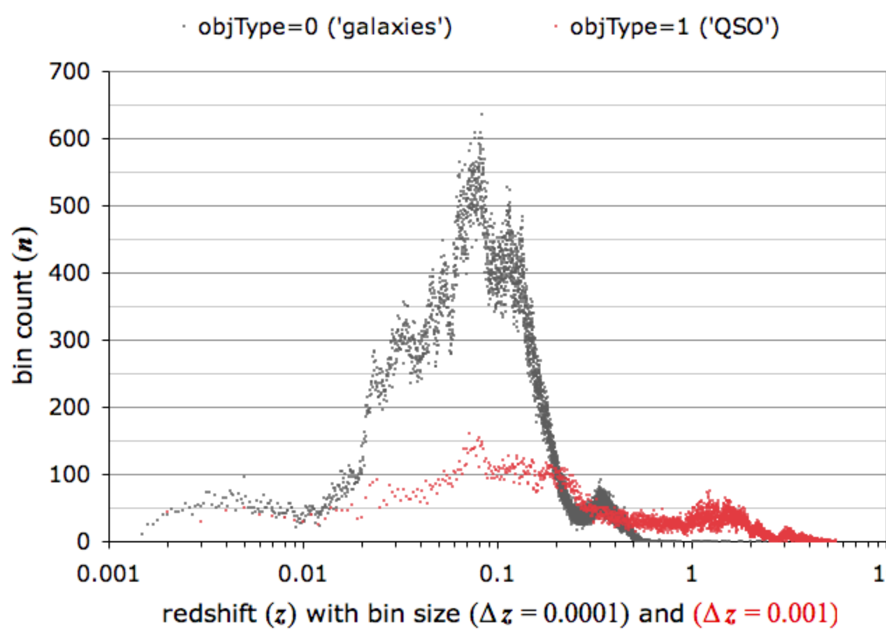


E.5

The following graph shows the specObj data for both photometric object types (objType=0 and 1) separated into objects with measured spectra identified as that of QSO in pink and other galaxies in blue. For convenient immediate comparison, the next graph (identical to the second graph in this appendix) shows the specObj data separated into objType without regard to spectral class.

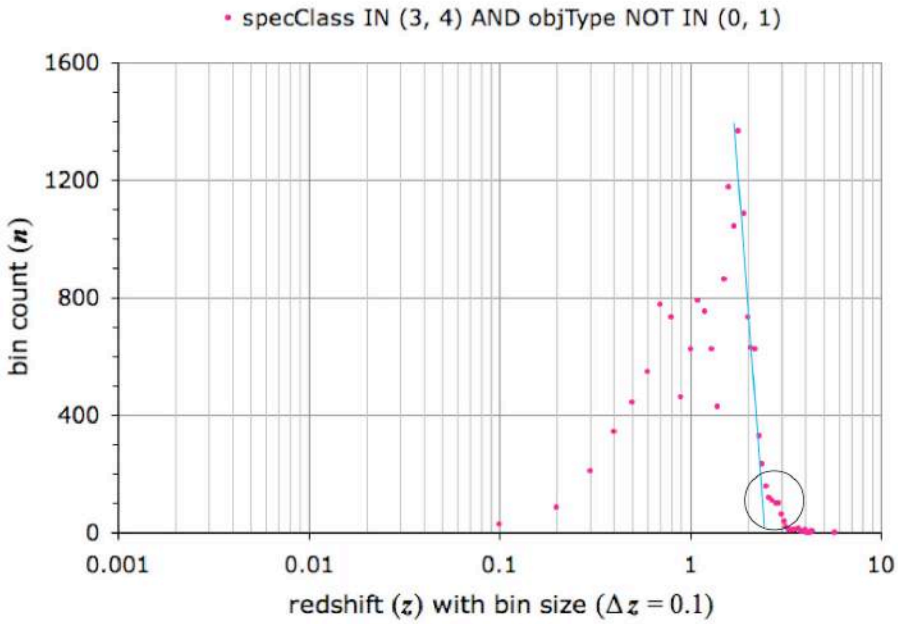


E.6



E.7

Only 317 objects represented in the latter graph are not represented in the former. That is, only 317 objects of (objType=0 or 1) were not identified as being of (specClass=2, 3 or 4). On the other hand, a significant fraction of objects (about 19%) identified by their spectrum as QSO (specClass=3 or 4) were not identified as being either a photometric 'QSO' or 'GALAXY' (objType=1 or 0). The majority of these objects (76% of 19,386) were classified as objType=16 ("SERENDIPITY_BLUE") with another 9.1% classified as objType=17 ("SERENDIPITY_FIRST"). "Serendipity" implies an open category of target whose selection criteria could change (see http://pdfref.com/m1/aE.02.htm). The small minority of targets selected for spectroscopy that were not pre-classified through photometric analysis as (objType=0 or 1) are graphed below. Although it is quite subtle in this relatively small data set, a secondary maximum (circled) is evident at about $z = 3$. This empirical feature in the high redshift data from the SDSS survey is far more obvious in the E.3 and E.5 graphs.



E.8

The following quotations are taken from the SDSS FAQs (Frequently Asked Questions):

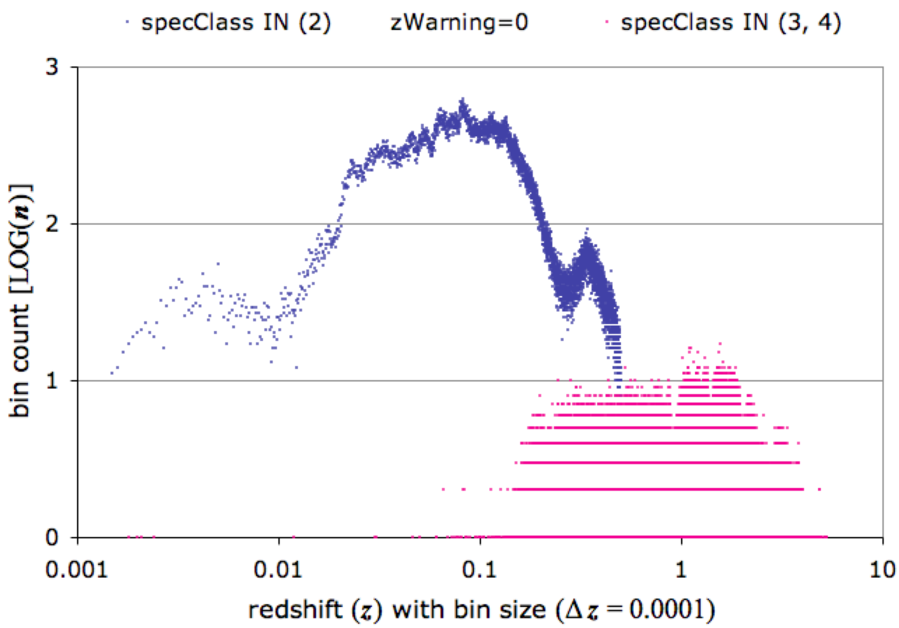
> In image data, you will see data called **objType**, which usually says STAR or GALAXY. In spectral data, you will see data called **specClass**, which can say STAR, GALAXY, QSO, or HIZ_QSO. objType is based only on the images, while specClass is based on spectra. When the two disagree, use specClass.[292]

> The **objType** parameter in SpecObj and other tables is set when the objects are targeted for spectroscopy, when the spectroscopic plates are prepared. The **specClass** parameter is set by the spectroscopic pipeline after the spectrum is observed. For science, you should use the specClass attribute. The objType field is included for studies of the targeting algorithm.[293]

What these official statements make clear is that prior conventional scientific analysis of SDSS data did not employ SpecObj.objType as a selection criteria. Moreover, various warning flags further limited the empirical data that was subject to research.

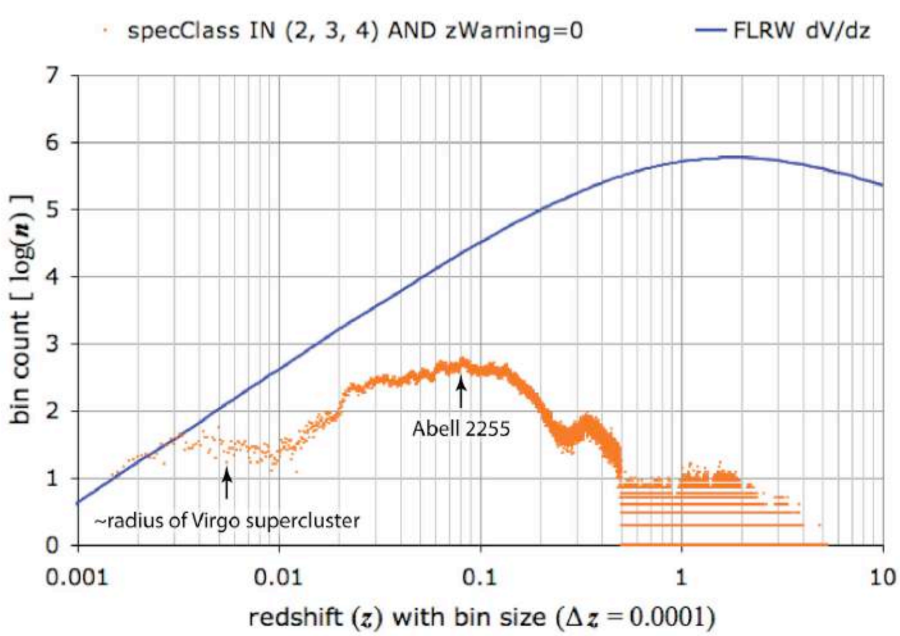
The ultimate purpose of an extended galaxy redshift survey such as SDSS is to provide an accurate map of the Cosmos for the purpose of yielding empirical evidence for a correct holistic cosmological model. For example, in ancient times a correct understanding of our planet was not achieved until maps extended far enough for people to realize the approximately correct geometry and proportions of the planet, even if the majority of it was as yet unmapped. SDSS has achieved this goal, but this momentous achievement in the history of astronomy remained obscured because the data was examined using conventional ideas in the context of the dominant standard cosmological model and its many limiting assumptions.

The following graph (E.9) shows what is effectively the 'officially approved' SDSS spectroscopic data set ($z \geq 0.0015$) for scientific analysis. Without regard to photometric objType, the data is limited to the same high-quality spectroscopic measurements as shown in the previous graphs with the added restriction that all targets associated with one or more warning flags (69,688 objects) have been purged. There are 5,017 (specClass=2) bins in purple containing 711,359 galaxies with an average of 142 galaxies per bin and 26,574 (specClass=3 or 4) bins in pink containing 77,031 QSO with an average of three QSO per bin.



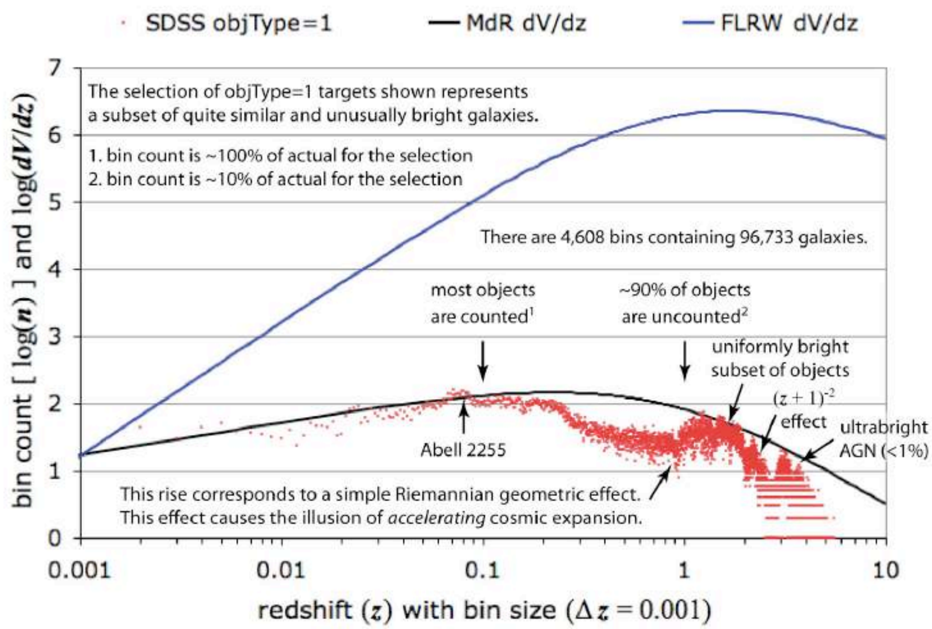
E.9

The following graph combines the two distinct data sets shown in the previous graph into a single empirical histogram 'curve' in red that is compared to the canonical dV/dz (volume rate of change) curve. "FLRW" refers to the Friedmann-Lemaître-Robertson-Walker cosmological model. The demarcation in the data at $z = 0.5$ is clearly artificial. Basic visual inspection of SDSS images implies that a significant percentage of the actual population of survey-selected bright galaxies in clusters observed below redshift $z = 0.1$ are included in the spectroscopic data. For example, Fig. (2.6) shows Abell 2255 at ($z = 0.08$). Any galaxy luminosity function that is not consistent with this observational fact cannot be correct. Moreover, this observation implies that, below $z = 0.1$, the histogram showing the empirical galaxy population growth rate with redshift should not diverge appreciably from an accurate theoretical dV/dz curve. The magnitude of the divergence between observation and theory shown in this graph suggests that a very different dV/dz model is required to explain the observed SDSS galaxy counts.

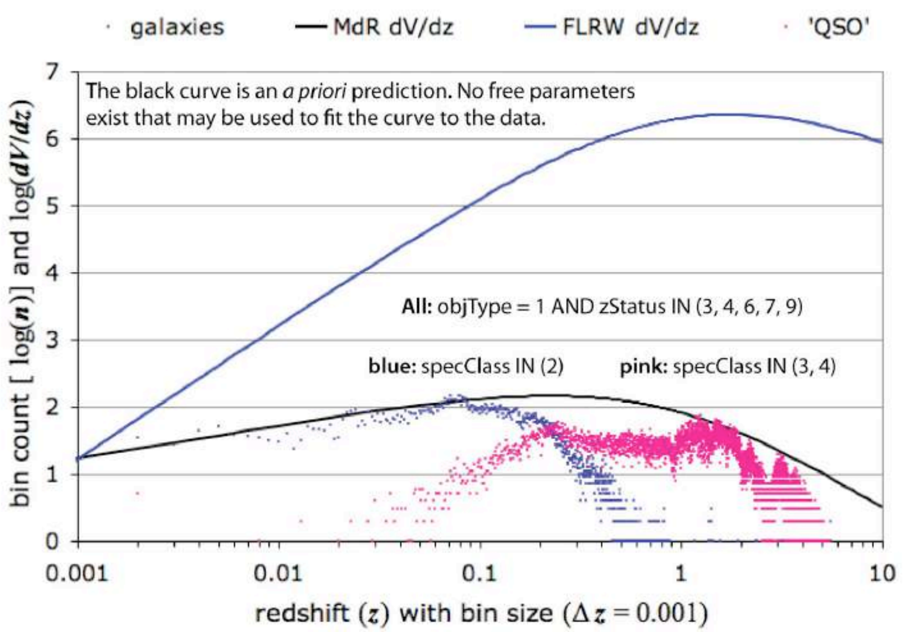


E.10

[The algorithm](#) to identify objType=1 targets produced a selection of about 100,000 bright galaxies with similar physical properties across the entire range of redshift.[294] Such a subset can be expected to accurately reflect trends in the total population. An *a priori* synthesis of original ideas put forward by Minkowski, de Sitter and Riemann (MdR), which complemented Einstein's relativity theory, describes the cosmological redshift as a temporal relativistic effect that increases with distance. This quantitative theory incorporates *no free parameters* and yields the theoretical *dV*/*dz* curve shown in black, below. The latter graph (E.12) shows the identical SDSS objType=1 targets shown in E.11 bifurcated by their distinct SDSS spectral classifications. The empirical galaxy population trends reflected by the redshift-population histogram for galaxies at both high ($z > 1$) and low ($z < 0.1$) redshifts are accurately predicted, assuming a roughly homogeneous distribution of these objects.



E.11



E.12

F. 1929 HUBBLE DIAGRAM

Hubble's famous graph, upon which his claim of an expanding universe was based, was published in the March 1929 issue of *Proceedings of the National Academy of Sciences of the United States of America* and is reproduced below. The vertical axis labeled "VELOCITY" (Doppler equivalent) is expressed in kilometers per second, although this is not obvious according to the labeled units. The modern consensus value of H_0 superimposed in blue for comparison to Hubble's graph references D. Spergel *et al*. (2007).[283] Based on WMAP cosmic microwave background data, they claim the smallest error bars to date for a 'measurement' of H_0 (73.2 +3.1/-3.2 *km*/*s*/M*pc*). The thickness of the blue line in this annotated graph represents an error of ±4.8 *km*/*s*/M*pc*, so the precision they claim would require a thinner line. The non-linear MdR model annotated in red is a far more reliable representation of empirical reality [see Fig. (12.3)].

Hubble's interpretation of the astrophysical data was obviously unjustified. The linear redshift-distance relationship that he claimed in 1929 can be considered a complete fabrication, rather than imagining it to have been a scientifically valid claim that was simply based on bad data. Consequently, the modern interpretation of the data (a linear redshift-distance relationship) is itself a fabrication patterned on what was at best a conclusion (in 1929) unsupported by the empirical data and at worst an unethical fabrication based on the *a priori* theoretical idea of an expanding universe furnished in 1925 by Georges Lemaître. The Catholic priest's idea that the entire physical world originated in a single moment of creation was motivated by a desire to give scientific credence to the Hebrew biblical creation myth; his 1921 essay, *God's First Three Declarations* (translated from the original French) makes this clear. This same ancient creation myth was responsible for the long-held belief in Western academia that the geologic history of the Earth and indeed the history of the entire Cosmos did not exceed a time span of about 6,000 years and that all biological life on Earth originated simultaneously in a single coordinated act of creation. Apparently, the same creation myth incorporated in the *Old Testament* is at least in part responsible for the recent prevalent belief in Western academia that the history of the entire Universe does not exceed a time span of about 14 billion years and that the Milky Way Galaxy originated simultaneously with virtually all other observed galaxies in a single coordinated cosmic creation event.

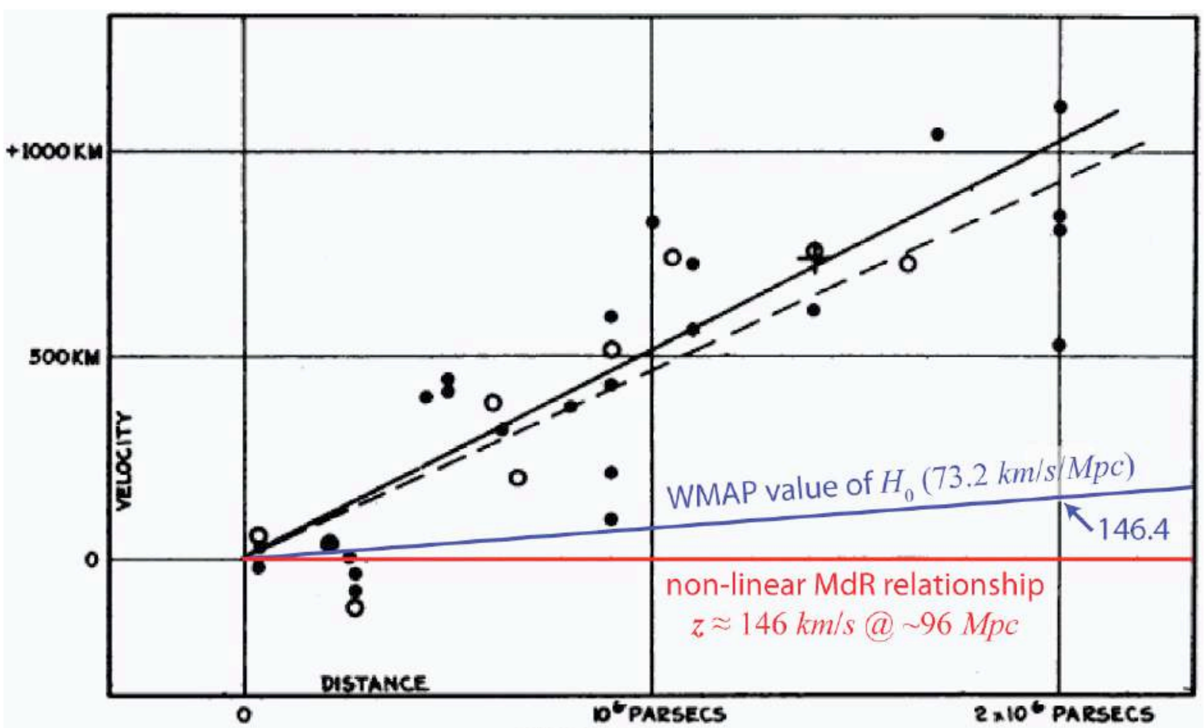


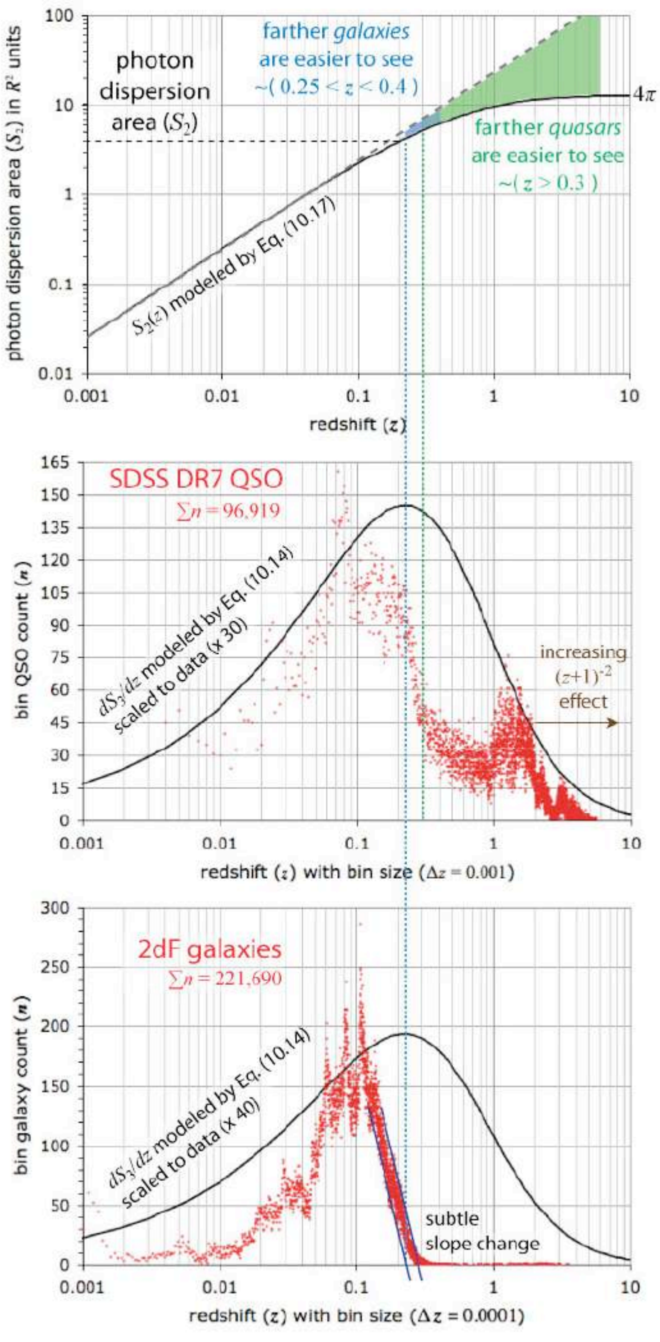
FIGURE 1

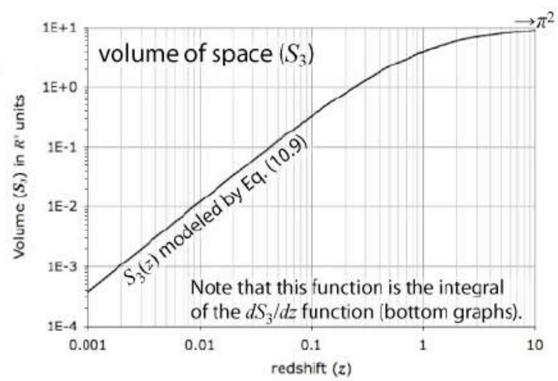
Velocity-Distance Relation among Extra-Galactic Nebulae.

G. SDSS GALAXY AND QSO HISTOGRAM SECONDARY MAXIMA

The top left graph is a modified Fig. (10.5). Exponential decrease in apparent brightness of a standard candle with redshift, due to photon dispersion, starts to taper off approaching the peak of the dS_3/dz curve. The decreasing slope of $S_2(z)$ causes a smaller percentage of objects to drop out of the growing bin population for $z > 0.2$ in this region of observed uniform galaxy space density. This causes the secondary maxima seen in both the SDSS DR7 galaxy and QSO histograms.

QSO have a unique radiation signature and due to their higher absolute luminosity they can be seen at much larger distances than the majority of conventional galaxies. Consequently, both the decline in the primary maximum and the peak of the secondary maximum in the QSO histogram are shifted to the right as compared to the conventional galaxy histogram. I thank Andrew J. S. Hamilton for critical suggestions.





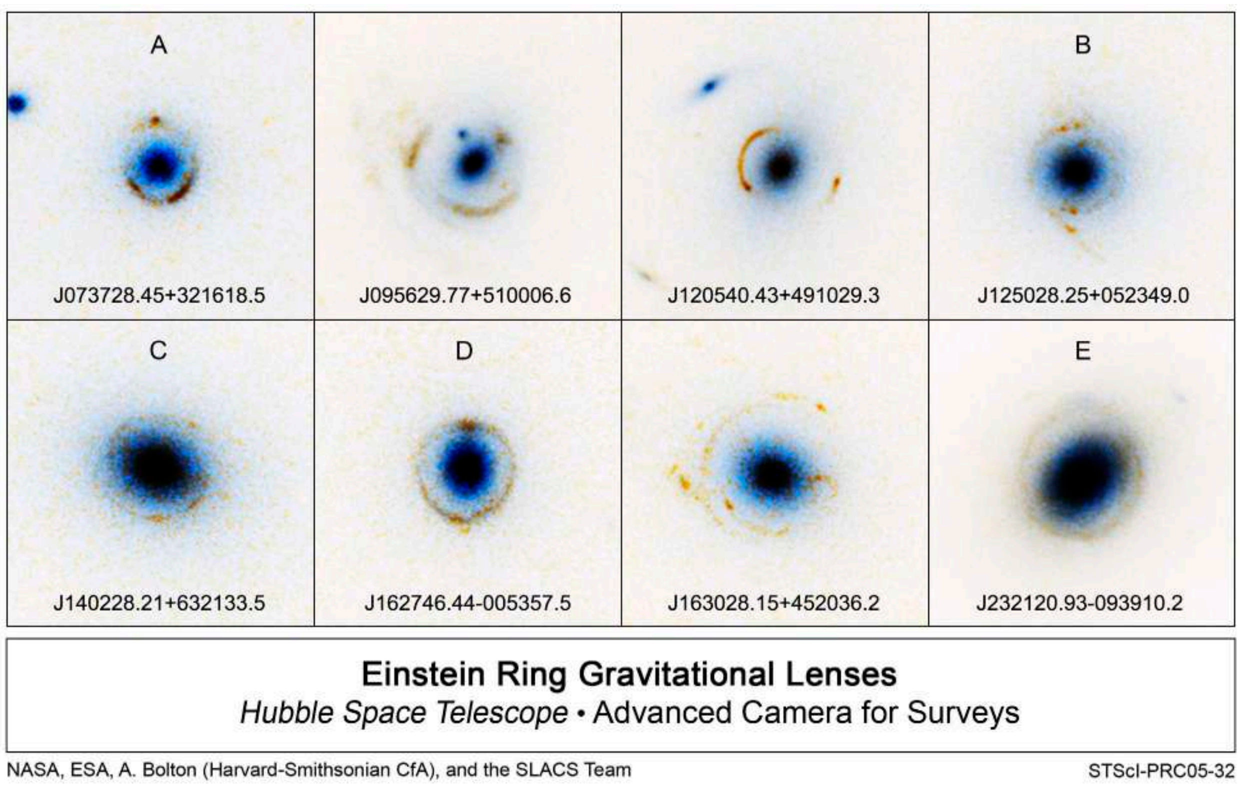
Consider the circumference (C) of a circle of constant latitude on Earth as a function of radial distance from the North Pole [$C(r)$]. Over the first hundred miles from the pole, this function grows much faster than over the last hundred miles to the Equator. Flattening of the photon dispersion area function [$S_2(z)$] at high redshift (see top left graph) occurs for similar geometric reasons.

For ($z > 0.2$), the growth rate of the volume of space (S_3) relative to the enclosing surface (S_2) increases as compared to a nearly Euclidean geometry at lower redshift. Distance increase yields slower decrease in apparent luminosity. Consequently, fewer objects drop out of the sample with increasing z and bin count rises. Few galaxies are bright enough to be seen by the 2dF survey telescope beyond (z = 0.4). However, the brightest of the SDSS QSO are as easily seen at high z as at low z, so the QSO histogram closely follows the dV/dz curve both at low redshift and at high redshift. Deviation of the QSO histogram from the model is caused by the lower luminosity QSO dropping out of the sample.

H. REVISED GRAVITATIONAL LENS MASS MEASUREMENTS

An Einstein ring is a special case of gravitational lensing that occurs when the lensed source object is directly behind the gravitational lens from the perspective of the observer. From Fig. (11.2) the impact parameter (b) can be determined in terms of the redshift of the lens and the order-of-magnitude estimate for the cosmic radius, which from Eq. (11.10) is $R \sim 10^9\ ly$ ($\sim 10^{25}\ m$). The $\sin\zeta$ term in the equation for b gains expression in terms of z in reference to Eq. (10.7). As θ_E is measured directly and b may be accurately estimated in reference to R, one may estimate the Einstein ring's diameter ($D_E = 2b$) as well as the mass of the lensing object (M_L) within the accuracy of ($\theta_E \times R$). The distance to the background light source is not relevant to the calculation. The table, below, expresses M_L in 10^{11} solar mass units.

$$\theta_E = \frac{4GM_L}{bc^2} \qquad b = \left[\theta_E\left(z_L+1\right)\right]R\sin\zeta \quad \rightarrow \quad M_L = \frac{\theta_E^2 c^2\left(z_L+1\right)}{4G}\left[R\left(1-\frac{1}{\left(z_L+1\right)^2}\right)^{\frac{1}{2}}\right] \tag{H.1}$$



Observational data (θ_E, z_L) references Adam S. Bolton *et al.* (2005).[296]

System	θ_E (10^{-5} *rad*)	z_L	d_L (*Gly*)	b (10^5 *ly*)	M_L ($10^{11}\ M_\odot$)
A	**1.047±0.063**	**0.3223**	0.71	0.40–0.45	1.4–1.8
B	**0.853±0.034**	**0.2318**	0.62	0.35–0.37	0.82–0.96
C	**1.294±0.039**	**0.2046**	0.59	0.54–0.58	1.8–2.0
D	**1.008±0.039**	**0.2076**	0.60	0.42–0.45	1.1–1.3
E	**1.900±0.024**	**0.0819**	0.39	1.06–1.09	2.5–2.6

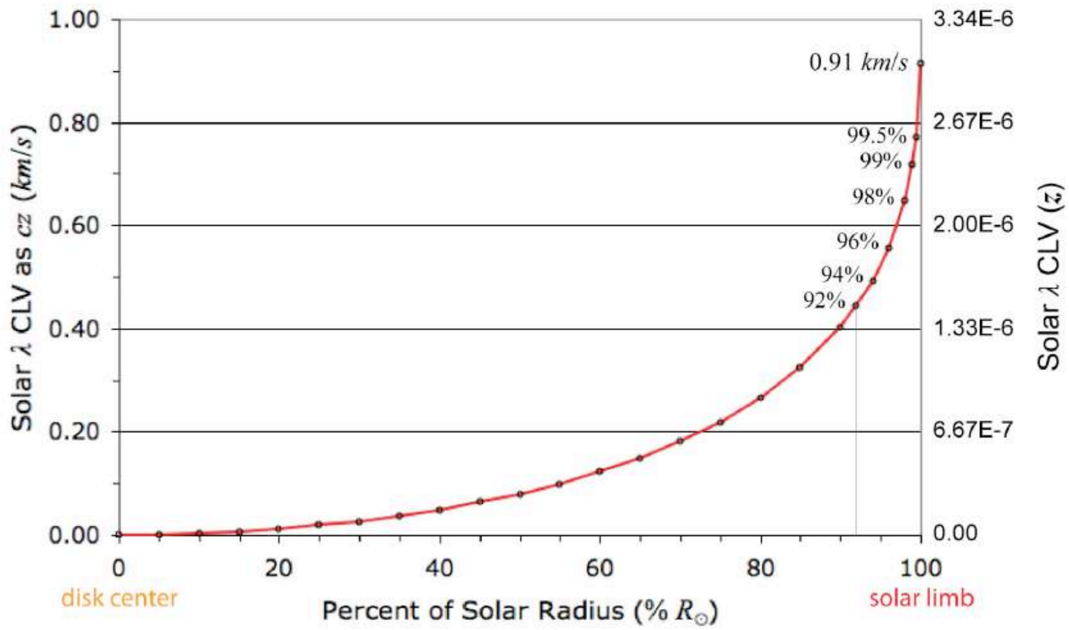
I. RESERVED (KEPLER MISSION)

J. SUMMARY OF TRANSVERSE GRAVITATIONAL REDSHIFT (*TGR*) PREDICTIONS

To deal with opposition to innovation in science, "Beat them down with the evidence." – Dave Finley

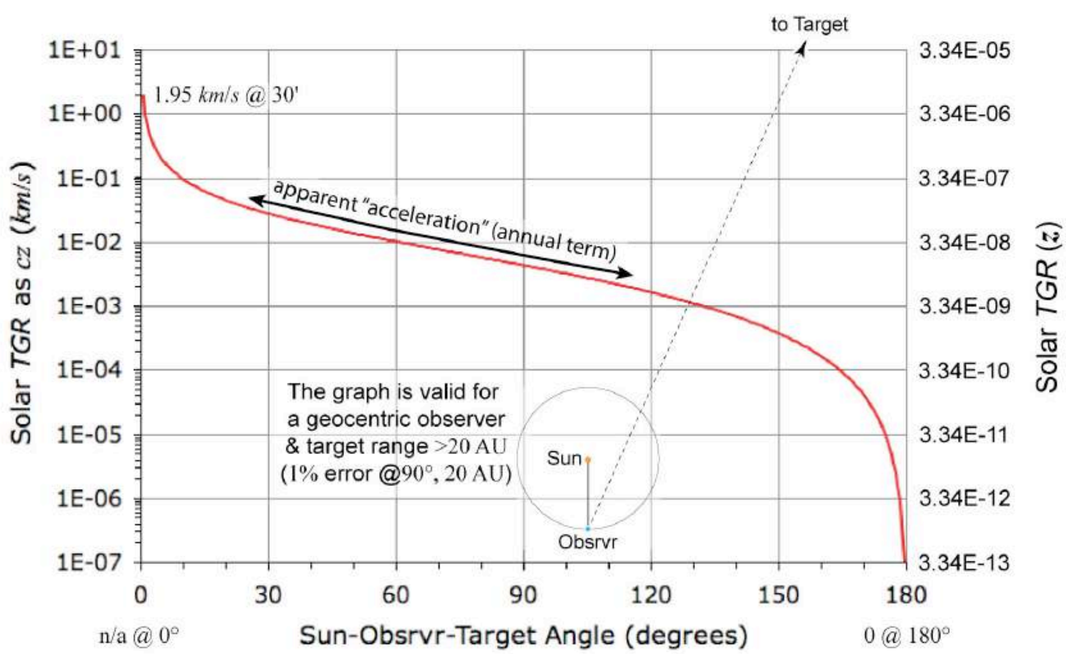
1. Center-to-limb variation (CLV) of the solar wavelength

The *TGR* for spectroscopy of sunlight sampled through a slit as a function of distance from the center of the solar disk (shown below) is *added* to the solar Einstein gravitational redshift of ~0.64 *km*/*s*.



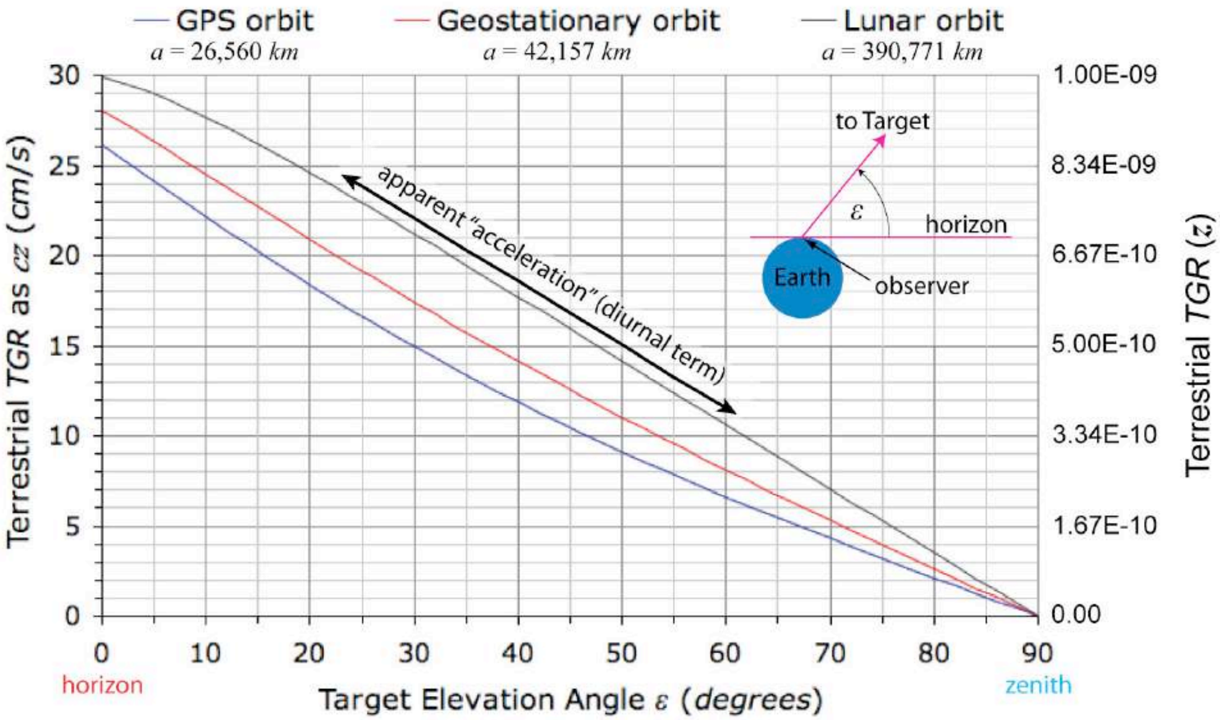
2. Solar *TGR*

Redshift of a distant signal (e.g., a star or deep space probe telemetry) caused by the solar gravitational field as a function of the Sun-Observer-Target angle. Canonical processing of raw Doppler data will remove this or any similar *TGR* residual as "*impossible*" or at least greatly reduce its reported magnitude.

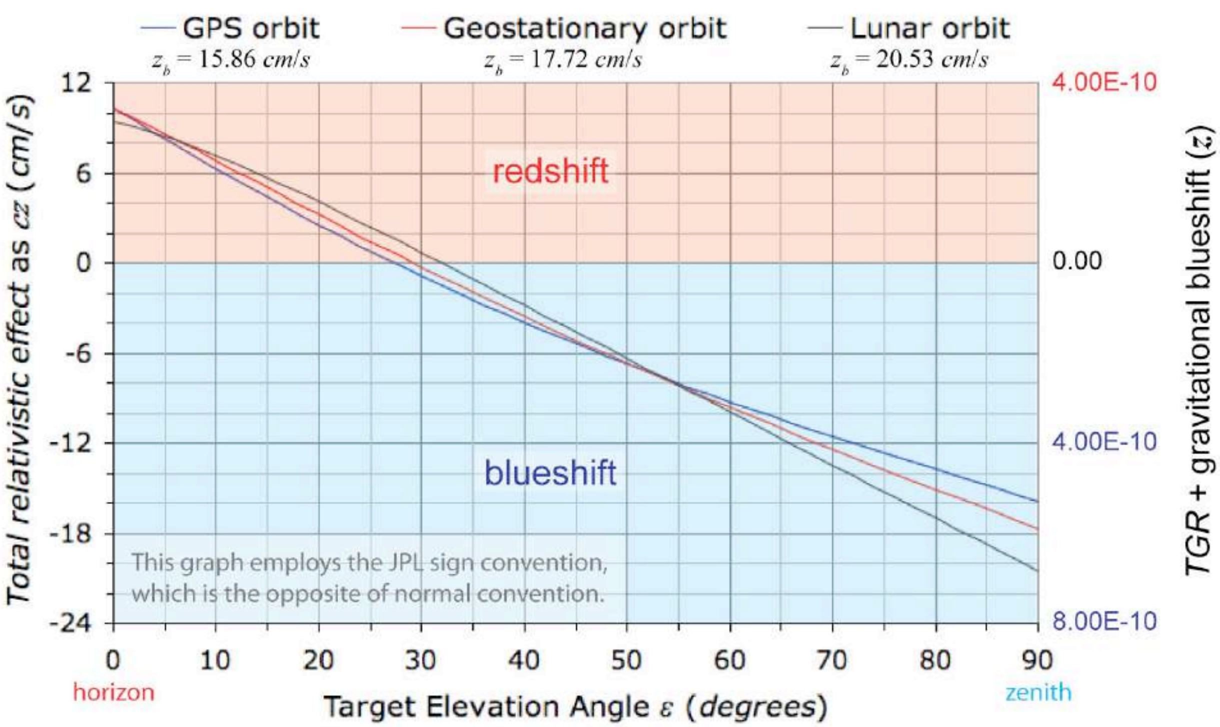


3. Terrestrial *TGR*

The following graph shows the *TGR* effect due to Earth's gravitational field as a function of target elevation angle for GPS satellites, geostationary satellites and the lunar orbit. The curve for a radiation source at arbitrary distance from Earth is identical to the lunar orbit curve shown in gray.

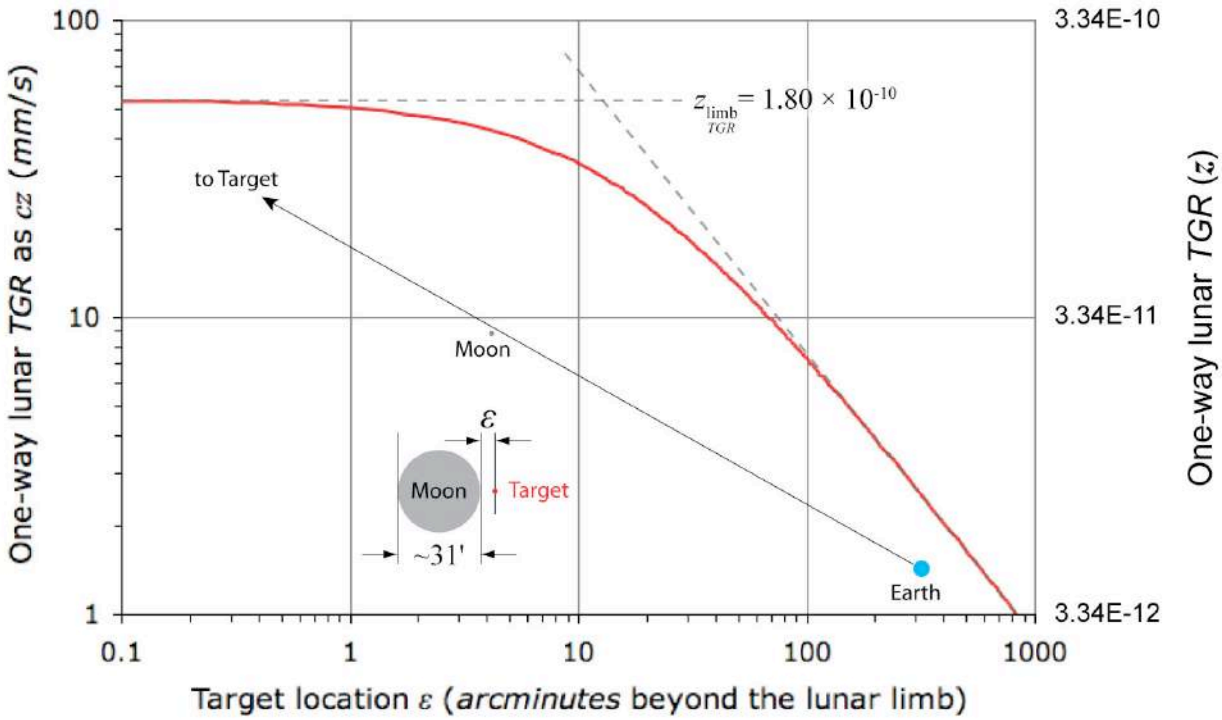


The following graph sums the altitude-dependent Einstein gravitational blueshift and the *TGR* effect.



4. Lunar *TGR*

The following graph shows the *TGR* effect due to the Moon's gravitational field as a function of target location relative to the lunar limb. For $\varepsilon < 10'$, the curve shown is accurate for a target with a range of about twice the Earth–Moon distance. For $\varepsilon > 100'$, the curve shown is accurate for a target with a range at least ten times the Earth–Moon distance. Note that a two-way transponded Doppler tracking signal incurs the *TGR* effect on both legs of the journey, thereby doubling the magnitude graphed below.



5. Stellar limb effect *TGR*

Electromagnetic radiation observed to originate from the limb of any star having mass *M* and radius *R* will incur a redshift in excess of the Einstein gravitational redshift of

$$z = \sec\left(1.198\sqrt{\frac{2GM}{Rc^2}}\right) - 1 \tag{J.1}$$

This effect causes a systematic excess redshift of starlight that is particularly noticeable for white dwarf stars and the center-to-limb variation (CLV) of the stellar wavelength associated with the effect causes line broadening of starlight that becomes more pronounced as the surface gravity of the star increases.

6. A proposed experiment

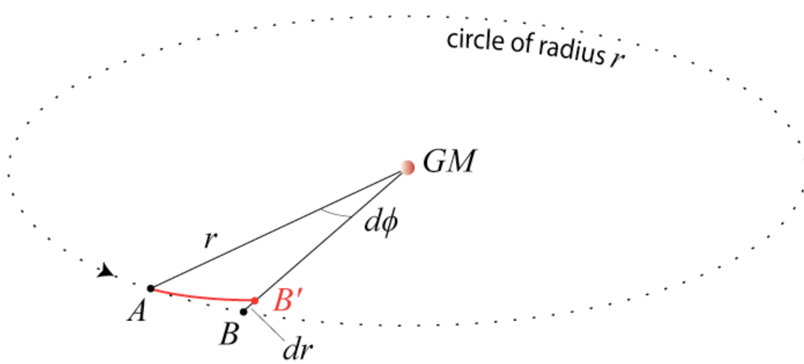
The predicted magnitude of terrestrial *TGR* (see graphs under *Terrestrial TGR*, above) can be tested using a geostationary satellite transmitting clock "ticks" from an ultrastable oscillator with a known frequency. The frequency of this clock as observed on the ground will be a function of the satellite's elevation angle. The satellite's range is essentially fixed, so there are no relativistic velocity effects, and while atmospheric effects may delay the clock signal, they do not alter the received frequency of sequential clock pulses. When the satellite is observed at 30° elevation from a ground station, *TGR* is predicted to counteract gravitational blueshift; the observer's local laboratory clock will not run slower than the satellite clock as predicted by general relativity. Observed at 50° elevation, the satellite clock will gain ~17 *µsec*/day relative to the ground clock and when observed at 10° elevation, it will appear to lose ~17 *µsec*/day.

K. *TGR*, CELESTIAL MECHANICS AND GRAVITATIONAL RADIATION

According to relativistic mechanics, the trajectory of a free-falling object is that for which the proper time of its rest frame is a maximum relative to a stationary clock. Conventionally, this requires striking a balance between increasing the gravitational potential energy of the clock, which causes it to speed up, and increasing the kinetic energy of the clock, which causes it to slow down. At low velocities (<< *c*) and *assuming that relative velocity and gravitational potential are the only phenomenon affecting clock rate*, this principle is identical to the Lagrange formulation of mechanics, whereby the free-fall trajectory of a material body is a path minimizing the action (i.e., the time integral of the Lagrangian). In turn, this is consistent with the orbital energy conservation equation of celestial mechanics relating velocity (v), orbital radius (r) and the semi-major axis (a) whereby the sum of the kinetic and potential energy of a satellite is constant.

$$v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right) \tag{K.1}$$

This conventional concept of energy conservation is inconsistent with the phenomenon of gravitational radiation, whereby dynamical gravitational systems experience a secular loss of total energy, which is radiated away from the system in some form. It follows that if the fundamental principle behind the relativistic equations of motion is correct (i.e., that the proper time of a free-falling clock is maximized), then something in addition to relative velocity and gravitational potential must affect ideal clock rate. It is this third relativistic effect that must act as the fundamental mechanism behind gravitational radiation.

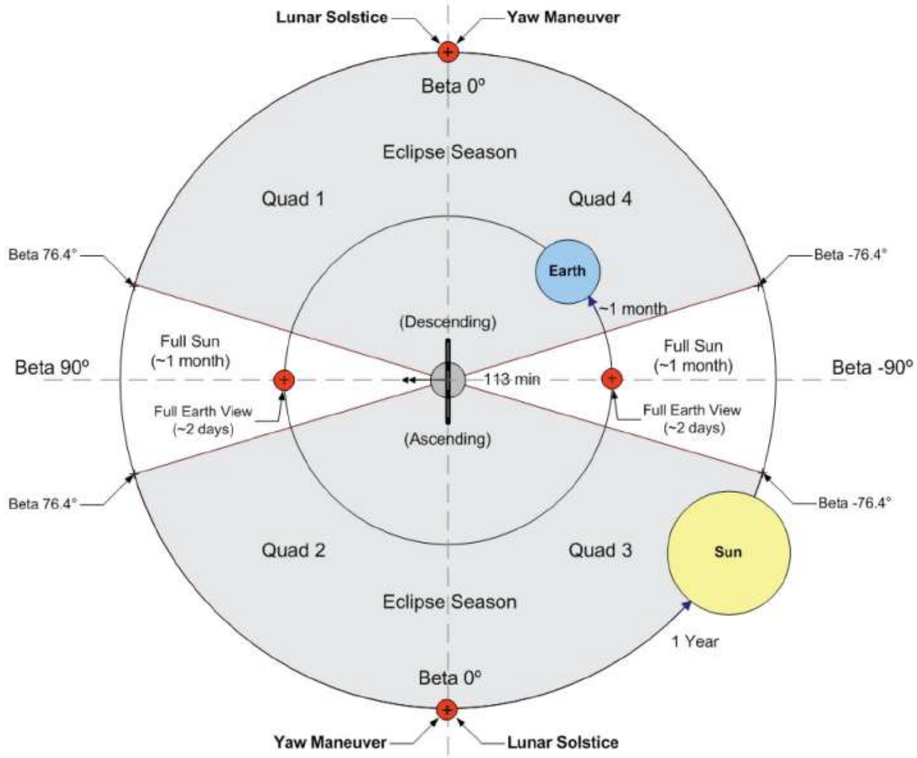


If the velocity of a material body at A would imply an ideal circular orbit of radius r according to Newtonian celestial mechanics, then inclusion of the *TGR* effect implies that the body would lose some small amount of total energy over the path A–B. Consequently, it could never arrive at B, but would rather arrive at point B', where its gravitational potential energy is slightly less, its kinetic energy slightly more and its orbital period slightly less than was the case at point A.

Recall that the goal of the mathematical 'balancing act' of the relativistic equations of motion is to achieve maximum net rate of a moving clock relative to a stationary clock over a fixed interval. The *TGR* effect is similar to increased velocity in that it causes the traveling clock to slow down. Due to the angular dependency of the *TGR* effect, reducing the orbital period correlates to reducing the amount of time it retards the clock, which adds time on the clock over a completed orbit. However, by reducing the orbital period, the kinetic energy is increased and the gravitational potential energy decreased, which both subtract time recorded by the clock over the same period. Accounting for the *TGR* effect, it must be the case that a subtle secular acceleration, which is correlated with the emission of gravitational radiation, achieves maximum orbiting clock rate. This is an outstanding mathematical problem of great importance.

Gravitational radiation carries energy away from the source dynamical gravitational system, has no rest mass and must be quantized with a wavelength of h/p. Consequently, it is immediately clear that this radiation manifests as electromagnetic radiation and not in some other unique form.

L. LRO MISSION DETAILS



Schematic from Craig Tooley, "The Moon-Centered LRO Universe," *LRO Spacecraft & Objectives*, *2006* AIAA-Houston Annual Technical Symposium, (19 May 2006), p. 14; http://pdfref.com/m1/aL.01.htm

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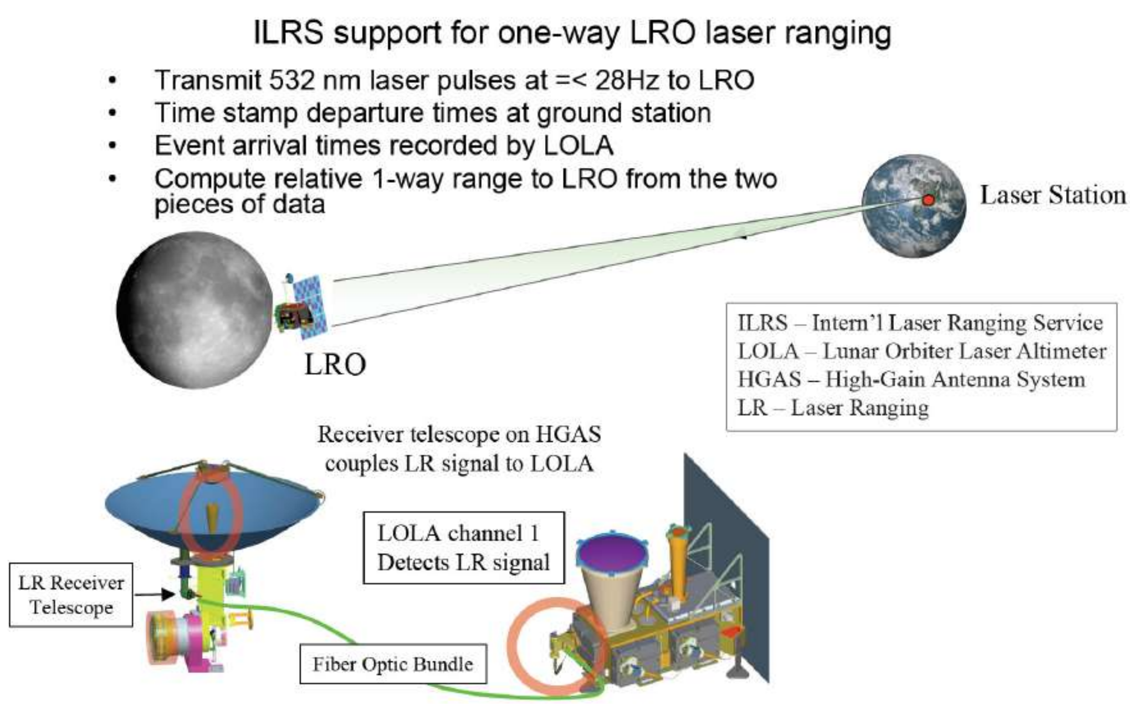

Adapted from Jan McGarry, *LRO Laser Ranging Overview*, (Sept. 2007); http://pdfref.com/m1/aL.02.htm

EPILOGUE QUOTATIONS

It is our responsibility as scientists, knowing the great progress and value of a satisfactory philosophy of ignorance, the great progress that is the fruit of freedom of thought, to proclaim the value of this freedom, to teach how doubt is not to be feared but welcomed and discussed, and to demand this freedom as our duty to all coming generations.

– Richard P. Feynman, *The Value of Science* (1955)

Δ

I know that most men — not only those considered clever, but even those who really are clever and capable of understanding the most difficult scientific, mathematical or philosophic problems, can seldom discern even the simplest and most obvious truth if it be such as obliges them to admit the falsity of conclusions they have formed, perhaps with great difficulty — conclusions of which they are proud, which they have taught to others, and on which they have built their lives.

– Leo Tolstoy, *What is Art?* (1896)

Δ

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances. To this purpose, the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

– Isaac Newton, "Rules of Reasoning in Philosophy, Rule I.," *Principia, Book III* (1687)

Δ

We may always depend on it that algebra, which cannot be translated into good English and sound common sense, is bad algebra.

– William K. Clifford, *Common Sense in the Exact Sciences* (1885)

Δ

Advances are made by answering questions. Discoveries are made by questioning answers.

– Bernard Haisch, astrophysicist (c. 2000)

Δ

When I was starting out in mathematics, it seemed very important to prove a big theorem. Now, with more experience, I understand that it is *new notions* that are more important, for example, Alan Turing's new notion of computability, which I shall discuss today.

– Yuri Ivanovich Manin, *Talk on Computability*, Northwestern University (c. 1995)

Δ

★ . . . The doctrine that the world was created is ill-advised, and should be rejected. If God created the world, where was He before the Creation? . . . Know that the world is uncreated, as time itself is, without beginning and end.

– Jinasena, *Mahapurana* (India, 9th century)

Δ

★ Every cluster of galaxies, every star, every atom had a beginning, but the Universe, itself, did not.

– Sir Fred Hoyle (1915 – 2001)

Δ

Creation is ongoing. – Lakota proverb

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This monograph presents new ideas in physics and cosmology based on improvements in the physical concept and mathematical model of relativistic time. The observed redshift of distant galaxies is shown to be a relativistic temporal effect rather than the widely accepted idea of cosmic expansion. This effect also models the observed slope increase in the supernovae redshift-magnitude curve, previously interpreted as the unlikely phenomenon of accelerating cosmic expansion allegedly caused by 'dark energy.' New theory describes and quantifies numerous previously unexplained empirical observations, such as the center-to-limb variation of the solar wavelength and the marked excess redshift of white dwarf stars, as a relativistic effect of the gravitational field. The modeling and empirical verification of this phenomenon represents a significant amendment to canonical theory. Additionally, advances have been made in the understanding of quantum mechanics and relativistic energy leading to new perspectives on the related nature of the nuclear binding force and the quantum source of the gravitational field, which can be empirically verified.

Because *time* is fundamental to many aspects of physics, a new and more accurate mathematical model and underlying concept of time is far-reaching. The broad scope of the new ideas presented in this book will have a rapid and profound effect on researchers in numerous fields, including:

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