Dilemmas in Cosmology – the Universe's Fate

Dean Spieth
November 2017

Introduction

Hubble's "law" is almost universally accepted as proof that the universe is expanding, and states that the speed of the expansion is increasing proportional to distance from our Milky Way. Hubble's "constant" has changed from estimates of approximately 500 km/s/Mpc based on brightest star observations of "close" galaxies by Hubble (1929) to the present day value of about 73 km/s/Mpc based on more accurate distance measurements of Type IA supernovae from distant galaxies [Freedman and Madore (2010)].

If distant galaxies are receding from us at a rate whose velocity increases proportional to distance, then their acceleration must also increase proportional to distance, requiring a "force" field that increases with distance. This will be discussed later, and has led to various hypotheses involving dark energy causing this expansion. All known force fields, except for one special case, decrease with distance from its source. These issues cause serious dilemmas with current cosmology theories.

Only a century has elapsed since the discovery that many nebulae were also galaxies and that distant galaxies had redshifts. The theory of relativity is slightly over a hundred years old. There have since been many assumptions and theories regarding how the equations of general relativity can be simplified to predict various models of the universe, after Einstein published his general theory. But are these assumptions, required to solve the equations of general relativity, valid?

The Cosmological Principle

The assumption, or belief, that the universe is homogeneous and isotropic, which forms the basis of simplifying Einstein's general relativity equations as well as the basis of most cosmology theories, is questionable. One should not a priori assume the universe is homogenous, which in this context means the universe appears the same from any galaxy. It therefore assumes the velocity of a distant galaxy observed from Earth, normalized by distance, will be the same as that observed from another galaxy. Instead, one should discover a physics theory that can reproduce Hubble's law, not hypothesize mysterious dark energy theories and unverifiable assumptions.

The belief of an isotropic universe arises from the appearance that there are stars and galaxies in every direction. But, in reality, the stars are not uniformly distributed in the Milky Way, or within spiral galaxies. Planets are not uniformly distributed around stars. The distributions of galaxies and clusters of galaxies are likewise not uniformly distributed, although they exist in every direction outside the plane of the Milky Way. One should not necessarily assume the universe is homogeneous and isotropic.

If the cosmological principle is invalid, it does not invalidate the other aspects of general relativity, but refutes most attempts to understand the origin and future of the universe. The other aspects of general relativity are well verified, including the bending of light near a gravitational field, the prediction of the perihelion advance of Mercury, the gravitational redshift, and so forth. In fact, Einstein (1916) published his general relativity theory prior to applying it to cosmology in 1917, and then others explored different values of Einstein's cosmological constant.

Rowan-Robinson (2004) and others stated that the complex field tensor equations of general relativity simplify to the following equation with the application of the cosmological principle (which as just noted is a questionable assumption):

$$\frac{d^2R}{dt^2} = \frac{-4\pi GR}{3}\left(\frac{3p}{c^2} + \rho\right) + \frac{\Lambda R}{3} \tag{1}$$

where R is the radius of curvature of space, t time, G the universal gravitational constant, p pressure, c the speed of light, ρ density, and Λ Einstein's cosmological constant. Note that the left hand side of the equation is essentially the acceleration of the universe, and that the first term on the right hand side of the equation can be interpreted as a deceleration term that could cause a gravitational collapse, and the last term can lead to deceleration or acceleration of the universe depending on the value of the cosmological constant, as noted by Swihart (1968). As a side note, this equation appears illogical, as the pressure term (which should contribute to an expansion) and the density term (which should contribute to a gravitational collapse) have the same sign.

The cosmological constant, Λ, is a term added by Einstein to create a static universe, the predominant thinking at the time, by setting $\Lambda = 4\pi\rho G$ prior to the work of Hubble (1929). It was quite bluntly a fudge factor, which Einstein (1952) later regretted and rejected, and unfortunately is the basis for many theories of dark energy and accelerating universes today. If Λ is eliminated, equation (1) will approach zero as the density and pressure approach zero in an expanding universe. This may not be immediately obvious as R approaches infinity, but since R is related to the radius of the universe, one can rewrite the equation involving the total mass of the universe, and then R is in the denominator and the term will approach zero as R approaches infinity. The integration of this zero result then gives an expansion velocity that is a constant (with zero acceleration), which is contradictory to Hubble's law. The other Friedmann equation results in zero velocity as R approaches infinity with zero curvature constant, which is consistent with gravity slowing down the expansion, but also contradictory to Hubble's data.

Whether the cosmological principle is true or not, the possibility of many different cosmological theories exists. Various values of Λ in equation (1) can lead to expanding, static, or contracting universes. These have been discussed in numerous books, including Motz and Duveen (1966), Swihart (1968), Unsold and Baschek (1983), etc. More elaborate derivations are presented by Berry (1976) and Rowan-Robinson (2004) using undergraduate level mathematics, and by Weinberg (1972) using complex tensor mathematics; yet these derivations also depend on applying the cosmological principle and the fictitious cosmological constant.

Lessons from Gas Dynamics and Supernovae

When there is a gas expansion in space, whether from an explosion, or from a rocket engine, it is well known that the gas velocity approaches a constant value (relative to the origin of the explosion) known as the gas limiting velocity, described in textbooks such as Shapiro (1953). The limiting velocity depends on the initial conditions of the explosion, or combustion, and the final atomic and molecular concentration of the expanding gases. The initial explosion is generally quite complicated, as chemical and radiative nonequilibrium develops quickly as the gases expand into vacuum, but eventually the expansion becomes quite simple and approaches free molecular flow with a limiting velocity. If the surrounding space is not actually empty, the gases can later slow down, due to gravitational effects, collisions with surrounding atoms and molecules, or influenced by electric and magnetic fields if the gases are ionized.

This is similar to a supernova explosion. Its velocity cannot exceed that given by simple kinetic energy theory, proportional to the square root of the supernova's initial energy divided by its mass. It cannot continue to accelerate, and in fact decelerates after reaching its maximum velocity due to collisions with interstellar matter. Calculations by Chiad and Hassani (2015) discuss that a supernova's velocity can increase to >10,000 km/s but then decreases over time, with comparisons to observed supernova events. The events are typically described as a free expansion, followed by a blast shock wave, slowing down or snowplow phase, and death.

The Big Bang

If a "Big Bang" occurred, the universe should have expanded like a spherical shell of matter, with a leading edge faster than a trailing edge, similar to a supernova. This implies that there should be fewer galaxies looking outward from or inward toward the explosion, and more galaxies at approximately right angles to the outward expansion – this has not been observed so far to date. The microwave background radiation, observed by Penzias and Wilson (1965), has been interpreted as evidence of a "Big Bang". However, light (photons) from this explosion would advance ahead of any expanding matter and be lost in a vacuum of space - recall that matter will always travel slower than the speed of light according to Einstein's relativity theory – and it would not appear from all directions. The nearly isotropic microwave radiation observed is probably nothing more than distant matter that existed prior to the "Big Bang", or intergalactic matter that has cooled from the expansion, and is at a very cold temperature of about 3 K.

If, on the other hand, the "Big Bang" expanded into tenuous pre-existing matter, the light from the Big Bang could scatter off this pre-existing gas and dust, and appear to come back at us from all directions. There should be absorption lines from intervening intergalactic gas, more so from the direction of the "Big Bang". However, this possible remnant radiation should be blue-shifted in one direction and red-shifted in the opposite direction, which is not observed. Such backscattered radiation would more likely be so weak as to be lost in noise.

There are those that argue that Hubble's "law" is just the expansion of space itself, due to a mysterious effect called dark energy; but it might be better to say the physics is not known.

Redshifted Spectra

Spectral observations show that distant galaxies (except those in our galactic neighborhood) have spectra shifted to longer wavelengths, and has led to the interpretation that their redshift must be due to the Doppler effect. In other words, the universe is expanding more rapidly at greater distances. Gravitational redshifts are not likely to apply to galaxies, only to a few extremely dense and small objects, so gravity does not explain the observed galactic redshift behavior.

By definition, redshift z is simply the shift to wavelength λ of a spectral line divided by its nominal wavelength λ_o:

$$z = \frac{\lambda - \lambda_o}{\lambda_o} \quad (2)$$

and can be shown to also equal:

$$z = \frac{\nu_o - \nu}{\nu_o} = \frac{E_o - E}{E_o} \quad (3)$$

where ν is frequency and E energy. Note that since Hubble (1929) stated that redshift is proportional to distance, energy loss may instead be proportional to distance as later suggested by Zwicky (1929). In this instance, there may still be some residual expansion velocity that results in an expanding universe.

The relativistic Doppler shift as given by Motz and Duveen (1966) is:

$$\frac{\Delta\lambda}{\lambda_o} = \frac{1 + \mathrm{v}/c}{\sqrt{1 - \mathrm{v}^2/c^2}} - 1 \quad (4)$$

which simplifies to v/c if v<<c, where v is velocity component in the direction of the observer, and c the speed of light in a vacuum. Equation (4) allows for redshifts greater than one. The Doppler shift is of course the dominant theory today to explain redshifts of distant galaxies.

An Accelerating Universe

There is a solution for an expanding universe that results in a recessional velocity that increases proportional to distance. It also results in a universe that accelerates slightly with distance, but physics cannot currently explain this behavior.

If the universe is expanding with a velocity that increases proportional to distance (at least over a localized volume) from the center of a "Big Bang", then it will also result in the appearance that galaxies are receding from each other at a velocity proportional to distance from any observer. This can be proven using plane or spherical trigonometry by estimating an arbitrarily large distance to the center of the "Big Bang", expanding the universe according to any value of

Hubble's constant, choosing an arbitrary distance from the Milky Way, varying the observation angle of a distant galaxy with respect to the Milky Way, solving for the length and angles of a triangle so formed, and calculating the relative velocity between the two galaxies. This results in identical expansion behavior between galaxies versus distance. Note that these results can be derived without introducing general relativity.

Differentiating this velocity with respect to time results in an acceleration that increases proportional to distance, an accelerating universe derived from Hubble's law. There is no physics that can explain an accelerating universe (except for at least one effect), and leads to beliefs of dark energy that mysteriously causes the acceleration. Pressure forces should cause an acceleration that decreases with distance (becoming extremely small at current times), and gravity should cause a deceleration inversely proportional to the square of distances. Almost every known force decreases with distance from its source, not vice versa.

The Charge Repulsion Hypothesis

Electrical and magnetic forces can cause either an attraction or a repulsion of objects. And, if there is a uniform spherical distribution of charge, elementary physics textbooks show that the electric field inside the sphere increases with distance from its center, and then falls off as inverse square outside the sphere [Halliday and Resnick (1966)]. Since electrical forces are proportional to an object's charge and the electric field strength, an object's force (and hence acceleration) will increase proportional to distance from the center inside a spherical envelope of uniform charge distribution. Is it possible that galaxies, or clusters of galaxies, have a net charge (either predominately negative or positive) resulting in Hubble's law? It turns out that the number of needed excess charges (either electrons or ions) is extremely small compared to the number of atoms in a galaxy, and may be the explanation long sought after for Hubble's observations.

Halliday and Resnick (1966) show that the electric field E inside a sphere of radius R with uniformly distributed charges, at a distance r from its center, is:

$$E = \frac{Q}{4\pi\varepsilon_o}\frac{r}{R^3} \tag{5}$$

where Q is the total charge within the sphere and ε_o is the electrical permittivity constant. In applying this to the universe, r will be the distance from our Milky Way galaxy, Q the total excess charge in the universe, and R the radius of the universe. For now assume our galaxy is at the center of the universe, which is unlikely, but remember that if Hubble's law is correct, every other galaxy will appear to recede proportional to distance as observed from any one galaxy. This is true only if recessional velocity is proportional to distance.

The force F on a charge q (which is taken as the net charge of a galaxy) is simply:

$$F = qE \tag{6}$$

Also, from F = ma where m is the mass of a galaxy of interest and "a" its observed acceleration from our galaxy, the acceleration of that galaxy will be proportional to distance r:

$$a = qE/m = \frac{q}{m}\frac{Q}{4\pi\varepsilon_o}\frac{r}{R^3} \tag{7}$$

Hubble's law, derived by interpreting redshift to be a Doppler shift, or velocity of recession, v, as a function of distance r, is:

$$v = H\,r \tag{8}$$

where H is Hubble's "constant" taken to be the more modern value from Freedman and Madore (2010) of 73 km/s/Mpc, or 2.36×10^{-18}/second. Differentiating Equation (8) gives the apparent acceleration, also "mysteriously" increasing proportional to distance:

$$a = H^2\,r \tag{9}$$

which at a distance of 100 Mpc (sufficiently far from our local group of galaxies) gives:

$$a = (2.36 \times 10^{-18}/s)^2\ \ (100\ \text{Mpc} \times 3.086 \times 10^{22}\ \text{m/Mpc}) = 1.73 \times 10^{-11}\ \text{m/s}^2,$$

extremely small compared to 9.8 m/s^2, the gravity at the Earth's surface. A deceleration fudge factor was often placed in front of Equation (9) to allow gravity to slow down the expansion.

For purposes of obtaining estimates of q and Q to determine if excess galactic charge could be the cause of today's apparent universe's expansion rate, assume for the moment that each galaxy has the same net charge q, such that Q = Nq, where N is the estimated number of galaxies in our universe. Assume further that the radius of the universe corresponds to 13.7 billion light years, or 4.2 Gpc. The total spherical volume V of the universe will be 3.1×10^{11} cubic mega-parsecs. Then, using an average universe density of 4.26×10^{-29} kg/m^3, based on luminosity density estimates that ignore dark matter [Rowan-Robinson (2004)], the total mass of the universe will be 3.88×10^{50} kg. A representative mass of a galaxy, again ignoring dark matter, is m = 10^{11} solar masses or 1.989×10^{41} kg per galaxy. We can then obtain a rough number N for the number of galaxies in the universe (again neglecting dark matter which should partially cancel out in the ratio, and neglecting the many different types of galaxies):

$$\begin{aligned} N &= \text{Mass of the universe/Average mass of a galaxy} \\ &= 3.88 \times 10^{50}\ \text{kg}/\ 1.989 \times 10^{41}\ \text{kg} \\ &= 1.95 \times 10^{9}\ \text{galaxies,} \end{aligned}$$

or roughly two billion "average" galaxies in our universe. Recent estimates are over a trillion galaxies in our observable universe [Conselice et.al. (2016)], many much smaller than the average mass assumed herein; however, this will not change our overall conclusions.

Equation (7) can now be rearranged to solve for q:

$$q^2 = \frac{4\pi\varepsilon_o maR^3}{Nr} \qquad (10)$$

$= (1.11^{-10}\ \text{coul}^2/\text{nt-m}^2)(1.989^{41}\ \text{kg})(1.73^{-11}\ \text{m/s}^2)(1.3^{26}\text{m})^3/\ (1.95^9)(100\ \text{Mpc})$

$= 1.39 \times 10^{65}\ \text{coul}^2$

or $q = 3.73 \times 10^{32}$ coulombs per "average" galaxy in order to cause Hubble's expansion rate. If the net charge on each galaxy were due to electrons, each with a charge of 1.6×10^{-19} coul/e-, then there would be an excess (compared to a neutral state) of 2.33×10^{51} electrons per galaxy. Since a galaxy with a mass of 10^{11} solar masses would have $\sim 10^{68}$ atoms assuming a predominantly hydrogen composition, and likely many more accounting for dark matter, the required excess charge in a galaxy can be an exceedingly small number compared to the number of atoms in a galaxy. Therefore, it is concluded that excess charge in galaxies, assuming that most galaxies have similar charge to mass ratios, is a possible explanation for Hubble's law. Could this possible charge exist around galaxy cores?

The problem with the charge distribution hypothesis is that the charge density should increase in the early universe (if charge is conserved and follows the assumed universe's expansion rate), leading to yet higher accelerations and hence extremely high velocities at earlier times. Hubble's "constant" does not increase as we look back in time at distant galaxies. Barnes (1979) gives a similar argument that the universe would have expanded too quickly at early times, not allowing sufficient time for nucleosynthesis to occur. Also, if the conservation of charge "law" is correct, then the universe could not have developed an increasing excess charge distribution over time as the universe expands. However, it should be remembered that at one time it was thought that mass was conserved, until Einstein showed the relationship between mass and energy, $E = mc^2$.

The more likely case, if the universe's expansion is due to charge effects, is that charged matter pre-existed in the universe, and that a "Big Bang" expanded into it, as discussed in the addendum. In addition, there would be a net charge to mass ratio for each galaxy (or cluster of galaxies) of the same sign as the pre-existing matter. In this case, for an assumed universe radius of 4.2 Gpc (13.7 billion light years), $qQ = 2.72 \times 10^{74}\ \text{coul}^2$, and there would be many possibilities for q/m and Q to satisfy Equation (7) with extremely small charge densities to match Hubble's "law". Non-uniformities in the pre-existing charge distribution could then explain why the universe appears to be accelerating even higher at later times, consistent with accelerations inferred by Riess et.al. (1998). The tendency for such pre-existing charged matter to repel itself might be offset by its gravitational attraction, depending on its charge and "particle" size.

The Behavior of Light

Students have been taught that light waves, or photons, will retain their original energy (that is, wavelength and frequency), with the exception of Doppler effects or gravitational effects, as they pass through matter. The flux and irradiance of the light beam decreases exponentially as some photons are either absorbed or scattered out of the beam by intervening atoms and molecules, according to Beer's law, but the energy of the surviving photons is supposedly not affected.

But what if, over a very long time and/or distance, photons actually lose some energy – spectral lines will appear to lose energy versus time and/or distance. This hypothesis is similar to that proposed by Zwicky (1929), except an expanding universe is still allowed with slower constant or decreasing velocities versus distance. It will manifest itself as a redshift that increases with distance, just as Slipher (1915) and Hubble (1929) observed. The broadening of spectral lines due to galactic rotation will still most likely be due to the Doppler effect, but the bulk shift of the spectral lines may be more logically due to photons losing energy as shown by equation (3).

There is ample evidence that particles lose energy over time and distance. The universe is not a vacuum. Charged particles lose energy as they collide with other atoms and molecules, although it involves electrostatic fields. Neutral particles slow down, losing energy, as they encounter collisions through matter. Radioactive particles lose energy by decay processes. Photons, although considered to be without mass, are also perhaps losing energy over great times and/or distances, just not nearly as quickly as other particles. They may not have to collide with other matter to do so. The observational evidence may in fact be redshifts of distant galaxies.

The primary evidence against this tired light theory is the paper by Goldhaber et.al. (2001), that Type IA supernovae take longer to decay (due to time dilation of special relativity) at very high redshifts, implying that galactic redshifts are recessional velocities. It is possible, however, that supernovae took longer to decay in the distant past but there is no evidence to support it.

A New Cosmology

A new cosmology is needed. There are many contradictions with current cosmological theories:

1. One should not simply invoke the cosmological principle, namely that the universe is homogeneous (viewed identically by all observers on any galaxy) and isotropic (the same in all directions), just so that the general relativity equations can be simplified. The homogeneous assumption cannot be proven as it is too far to travel to or communicate with any other galaxy, and the universe does not appear isotropic from even our own solar system.

2. Even if the cosmological principle was correct, the introduction of the cosmological constant used in current cosmological theories is the biggest fudge factor in physics today (which even Einstein eventually rejected), and leads to equally fictitious concepts of dark energy. Changing the cosmological "constant" is nothing more than curve fitting to match Hubble's law or slight variations to Hubble's law.

3. It does not make sense that radiation from a "Big Bang" would appear from all directions (the cosmological principle is being rejected). There is simply not enough "gravity" to cause light from a "Big Bang" to bend around in circles and appear to come from all directions. There are those that argue the "Big Bang" happened everywhere, but that is just nonsense in an attempt to explain why the cosmic background radiation is observed in all directions. If the universe is

expanding, then it must have originated from a point in space that we cannot see, as the light from it would precede matter's expansion and be lost in space. And, as suggested earlier, the cosmic background radiation is probably just intergalactic matter or distant pre-existing matter at a very cold temperature of about 3K, not redshifted light from an initial "Big Bang".

4. The problem with the charge distribution hypothesis is that the charge density should increase in the early universe (if charge is conserved, and follows the assumed universe's expansion rate), leading to yet higher accelerations and hence extremely high velocities at earlier times. Also, if the conservation of charge "law" is correct, then the universe could not have developed an excess charge distribution over time as the universe expands in order to explain Hubble's "constant". There is still a reasonable possibility with this hypothesis if a "Big Bang" expanded into a pre-existing, fairly uniform charge distribution, which can result in Hubble's law.

5. We must also reconsider the tired light theory of Zwicky (1929) - the overall redshift is not due to velocity but rather to photons losing energy over great distances. As noted earlier, the objection to this tired light theory is that time dilation of Type IA supernovae imply that the observed redshifts are due to velocities that increase approximately proportional to distance [Goldhaber (2001)]. Could Type IA supernovae take longer to decay at earlier times, or are we again misidentifying classes of supernovae?

Summary

In summary, there are too many contradictions with any proposed theory today to put forth a credible cosmological model of the universe at this time. Additional observations and experiments are needed, and this may lead to new physics. Most cosmologists today are using simplified general relativity equations with fictitious cosmological "constants", based on beliefs of homogeneity and isotropy instead of facts based on verifiable data. It may be necessary to incorporate electromagnetic fields into the general relativity equations with excess charge distributions, i.e., a unified field theory that Einstein sought in his later years. Closed form solutions are no longer needed, with the advent of finite difference techniques and supercomputers over the past half century.

The expansion from a "Big Bang", if it occurred, should cause galaxies to approach a constant velocity based on gas dynamics and supernova theory (excepting the excess charge theory), or if there is enough dark matter or sufficient collisions with other matter, slow back down and possibly collapse. The universe either expands and cools forever, or is more or less static (unlikely), or contracts into a "Big Crunch" and disappears into a black hole, or forms oscillatory universes with infinite "Big Bangs". In the latter case, atoms would be stripped back into sub-atomic particles and energy with each catastrophic collapse, so there would not be an issue with atomic and metallic abundances continually increasing. The universe may be much older than previously thought (perhaps infinitely so).

References

Barnes, Aaron (1979), "Cosmology of a Charged Universe," ApJ, **227**, January 1, 1979, pp 1-12.

Berry, Michael (1976), *Principles of Cosmology and Gravitation*, Cambridge University Press.

Chiad, Baha T. et.al. (2015), "Determination of Velocity and Radius of Supernova Remnant after 1000 yrs of Explosion," International J. of Astronomy and Astrophysics, **5**, pp 125-132.

Conselice, Christopher J., et.al. (2016), "The Evolution of Galaxy Number Density at $z<8$ and its Implications," Astrophysical Journal (ApJ), **830**, #2, October 14, 2016.

Einstein, A. (1916), "The Foundation of the General Theory of Relativity," Annalen der Physik, **49**, #7.

Einstein, Albert (1952), *Relativity – The Special and General Theory*, 15th ed, Crown Publishers, NY, translated and copyrighted 1961.

Freedman, Wendy L. and Madore, Barry F. (2010), "The Hubble Constant," Annual Review of Astronomy and Astrophysics, **48**, pp 673-710.

Goldhaber, G. et.al. (2001), "Timescale Stretch Parameterization of Type IA Supernova B-Band Light Curves," ApJ, **558**, pp 359f.

Halliday, David and Resnick, Robert (1966), *Physics*, John Wiley & Sons, pp 695f.

Hubble, Edwin P. (1929), "A Relation Between Distance and Radial Velocity Among Extragalactic Nebulae," Proc. Natl. Acad. Sci., **15**, pp 168-173.

Motz, Lloyd and Duveen, Anneta (1966), *Essentials of Astronomy*, Wadsworth Publishing Co., Belmont, California.

Penzias, Arno A. and Wilson, Robert W. (1965), "A Measurement of Excess Antenna Temperature at 4080 Mc/s," ApJ, **142**, pp 419-421.

Riess, Adam G. et.al. (1998), "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant," Astron. J., **116**, pp 1009-1038.

Rowan-Robinson, Michael (2004), *Cosmology*, 4th ed, Clarendon Press.

Shapiro, Ascher H. (1953), *The Dynamics and Thermodynamics of Compressible Fluid Flow*, John Wiley and Sons.

Slipher, Vesto M. (1915), "Spectroscopic Observations of Nebulae," Popular Astronomy, **23**, p 21.

Swihart, Thomas L. (1968), *Astrophysics and Stellar Astronomy*, John Wiley & Sons, NY.

Unsold, Albrecht and Baschek, Bodo (1983), *The New Cosmos*, 3rd ed, Springer-Verlag, NY.

Weinberg, Steven (1972), *Gravitation and Cosmology*, John Wiley & Sons.

Zwicky, Fred (1929), "On the Red Shift of Spectral Lines through Interstellar Space," Proc. National Academy of Science, **15** (10), pp 773-779.

Addendum - A Pre-Existing Charged Particle Distribution in the Universe?

Equation (7) can be rearranged in terms of a galactic charge per unit galactic mass, q/m, and a pre-existing intergalactic charge per unit volume, Q/V:

$$a = \frac{q}{m}\frac{Q}{(4/3)\pi R^3}\frac{r}{3\varepsilon_o} = \frac{q}{m}\frac{Q}{V}\frac{r}{3\varepsilon_o} \qquad \text{(A-1)}$$

Since a galaxy's acceleration is also $a = H^2 r$ per Equation (9), Equation (A-1) becomes:

$$a/r = H^2 = (q/m)\,(Q/V)\,/3\varepsilon_o \qquad \text{(A-2)}$$

Note that a galaxy's acceleration is no longer dependent on knowing the actual radius R of a pre-existing excess charge distribution. Since Hubble's "constant" is approximately 73 km/s/Mpc, allowable combinations of q/m and Q/V can be calculated.

A high q/m of $\sim 10^{-9}$ coul/kg, or if the repulsion is due to excess electrons or protons, $\sim 6 \times 10^{9}$ e- or p+/kg, would result in excessive galaxy accelerations at earlier times due to repulsion between galaxies, i.e., an increasing Hubble constant at earlier times that is not observed. Therefore, in order to avoid an increasing Hubble constant, except at the very earliest times, q/m must be substantially smaller.

If q/m was six orders of magnitude smaller, $\sim 10^{-15}$ coul/kg ($\sim 6.25 \times 10^{3}$ e-/kg if due to electrons), then Q/V would have to be six orders of magnitude larger, $\sim 1.5 \times 10^{-31}$ coul/m^3. If due to electrons, a pre-existing excess charge distribution of $\sim 9.25 \times 10^{-13}$ e-/m^3 would be required to match Hubble's constant, an extremely small charge density. This corresponds to a mass density of $\sim 8.4 \times 10^{-43}$ kg/m^3, also extremely small compared to an average density of the universe. A similar argument holds for protons.

A pre-existing charge density cannot be too large or photons from distant galaxies would not reach our Milky Way due to electron scattering. However, the electron cross-section for Thompson scattering is $\sim 6.6 \times 10^{-29}$ m^2 (Gibson, 1973), so the mean free path for photon-electron collisions (assuming a Q/V of $\sim 10^{-12}$ e-/m^3) would be $\sim 1.5 \times 10^{40}$ m, or about 500 thousand gigaparsecs (Gpc), over a hundred trillion times larger than our observable universe. The proton cross-section for Thompson scattering is much smaller. Therefore, light attenuation would be nonexistent at these charge densities, and pre-existing electron (or proton) densities could in fact be much larger along the curve of Figures A-1 and A-2.

Something, however, must be holding the pre-existing charges in intergalactic space or they would fly apart – a small net charge density might have to reside on a larger particle so gravity can act as a counterbalance – or perhaps these charges are replenished as stars blow off plasmas into space.

One should not assume that the observable universe has to be neutral; charge imbalances occur throughout nature, between clouds on Earth as well as within the universe. One can visualize electrons being blown far away leaving a slightly positively charged observable universe.

In summary, a surprisingly simple physics theory can reproduce Hubble's law. A uniform intergalactic charge distribution existing prior to the "Big Bang", with similarly charged galaxies expanding into it, can result in a repulsive force, acceleration and velocity proportional to distance.

Gibson, Edward G. (1973), The Quiet Sun, NASA SP-303, U.S. Government Printing Office, p 261.

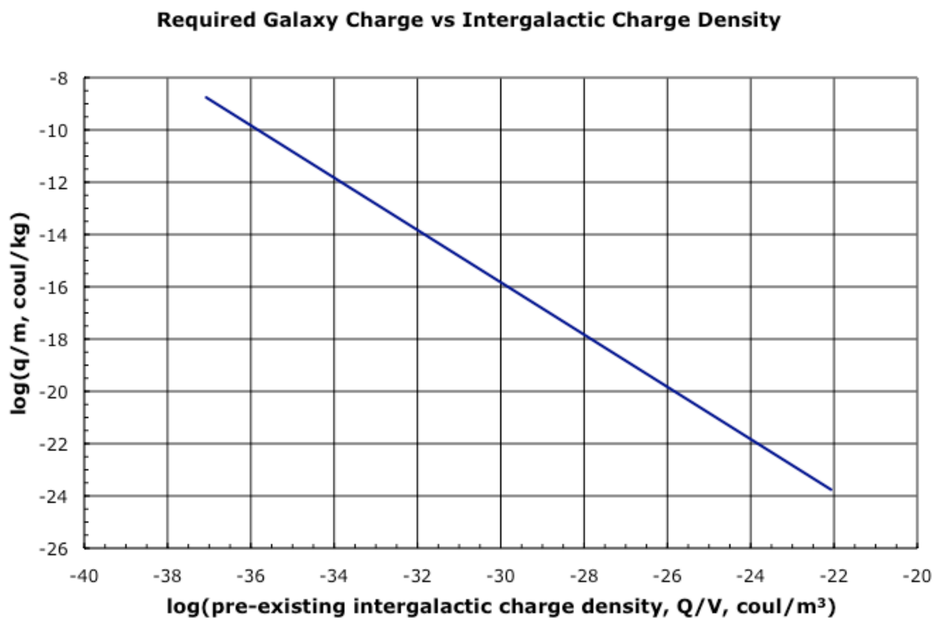

Figure A-1. Net Charge Requirements for Galaxies as Pre-Existing Charge Densities Increase

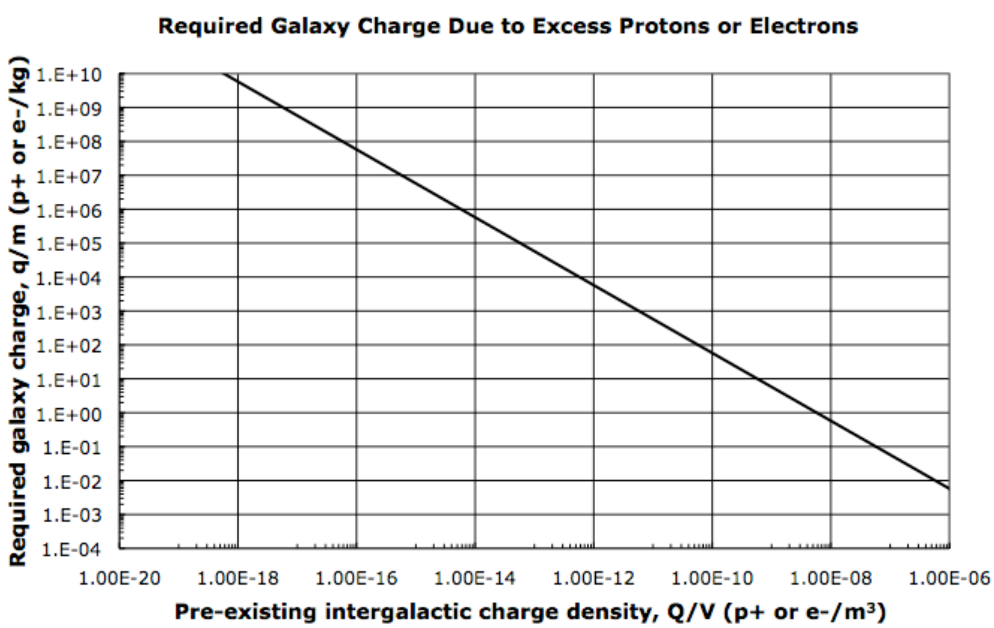

Figure A-2. Charge Requirements if Hubble's Law is Due to Excess Protons or Electrons

Since this is an addendum, not part of the original US Copyright, a few additional notes are added based upon the prior references and additional references.

Willem de Sitter was one of the first scientists to predict an expanding universe. He initially used a k=0 universe ("flat" space, i.e. Euclidean space as believed today), zero density (in the limit as the gravitational term vanishes), and a positive cosmological constant (which was a fudge factor that Einstein introduced so his equations would predict a static universe). The result was a velocity of expansion proportional to distance, eventually known as Hubble's law after Hubble (1929). After Einstein was convinced of Hubble's data, the Einstein-de Sitter (1932) model (k=0 with density but no cosmological constant) was developed predicting a decelerating universe consistent with gravitational effects, becoming the dominant model for much of the 20th century.

Lemaitre (1927) criticized de Sitter's earlier assumption of a zero density universe, and "predicted" an expanding universe that slowed down and then accelerated, eventually approaching an expansion velocity proportional to distance. He included a non-zero density, assumed a k=1 universe (a non-Euclidean, positive curvature universe like the surface of a sphere where the universe resides – not popular today). He also retained a positive cosmological constant, for which there is no physical basis even today (except perhaps for a charged particle universe). Lemaitre's "prediction" of an expanding universe was actually based on Slipher's Lowell Observatory (Flagstaff, Arizona) data of nebulae radial velocities and early data on extra-galactic distances from California observatories (including data from Hubble at Mt Wilson). In his original paper in French, a footnote mentioned two data points at 1.16 Mpc and 1 Mpc (based on now obsolete distance candles) resulting in expansion velocities of 670 and 575 km/s-Mpc. Hubble (1929) published his paper when he had 24 known galaxy distances and velocities, was unaware of Lemaitre's French paper, and presented his famous Hubble's law that velocities were proportional to distance, ~500 km/s-Mpc (today ~73 km/s-Mpc). Data scatter was large, out to what was then thought to be ~2 Mpc, so it was difficult to select one cosmological model from another - true for most of the 20th century with a much larger subsequent data base.

Duren (2012) performed an analysis of a uniform distribution of protons in the universe and concluded that it may contribute to the expansion of the universe. However, he did not attribute all of the expansion to a charged particle field and did not take the next simple step to show that it can result in an expansion velocity proportional to distance. He came up with a proton density of 10^{-17} protons/m^3, consistent with one point on Figure A-2 in this paper.

Duren, Michael (2012), The Electrically Charged Universe," arXiv:1201.6585v1, Cornell.

Einstein and de Sitter (1932), "On the Relation between the Expansion and the Mean Density of the Universe," Proceeding of the National Academy of Sciences, **18**, #3, pp 213f.

Lemaitre, Georges (1927), "A Homogeneous Universe of Constant Mass and Increasing Radius Accounting for the Radial Velocity of Extra-Galactic Nebulae," Annales de la Société Scientifique de Bruxelles, **47**, pp 49-59.