Discovery of Uniformly Expanding Universe

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Saul Perlmutter and the Brian Schmidt – Adam Riess teams reported that their Friedmann-model GR-based analysis of their supernovae magnitude-redshift data revealed a new phenomenon of "dark energy" which, it is claimed, forms 73% of the energy/matter density of the present-epoch universe, and which is linked to the further claim of an accelerating expansion of the universe. In 2011 Perlmutter, Schmidt and Riess received the Nobel Prize in Physics "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae". Here it is shown that (i) a generic model-independent analysis of this data reveals a uniformly expanding universe, (ii) their analysis actually used Newtonian gravity, and finally (iii) the data, as well as the CMB fluctuation data, does not require "dark energy" nor "dark matter", but instead reveals the phenomenon of a dynamical space, which is absent from the Friedmann model.

1 Introduction

Observational determination of the time evolution of the scale factor $a(t)$ of the universe is fundamental to understanding the dynamics of the universe. Measurement [1, 2] of supernovae magnitude-redshifts provided that critical data, and it is a simple procedure to determine $a(t)$ from that data. A secondary process is then to test different dynamical theories of the universe against that data. However this did not happen, and not for the 1st time in the history of astronomy was one predetermined theory forced into the data fitting.

The 1st example was Ptolemy's fitting of his geocentric model of the solar system to the Babylonian planetary orbit data. This then required, and correctly so, that the orbits have epicycle components. This model persisted for some 1400 years, until the heliocentric model replaced the geocentric model, and for which the epicycle phenomenon then evaporated - it was merely an artifact of the incorrect geocentric model. It now appears that a similar confusion of data and model has reappeared in analysing the supernovae data, for again a simple and manifestly inadequate model of the universe, namely Newtonian gravity (NG), has been used. A generic model-independent analysis of the data reveals that the universe is undergoing a uniform expansion, see sect.2. However use of the Newtonian gravity model has resulted in a new collection of model-induced artifacts, namely "dark energy", "dark matter", and a claim that the universe expansion is accelerating. These artifacts also disappear once we use a model that replaces Newtonian gravity.

It is usually argued that General Relativity (GR) in the form of the Friedmann equation is superior to NG, and it was the Friedmann equation that was used in analysing the supernovae data [1, 2]. However in sect.3 we derive the Friedmann equation from NG in a few simple steps. This happens because GR was constructed as a generalisation of NG, and reduces to NG in the limit of low matter densities and low speeds. Alternatively, in sect.4, we show in a few simple steps, that the dynamical 3-space theory of space and gravity yields a uniformly expanding universe, and so dispenses with the "dark energy" and "dark matter" artifacts. The implication here, and in previous analyses of the dynamics of space itself, shows that NG is a flawed model of gravity, even at the level of laboratory measurements of G, bore-hole g anomalies, galactic rotation, and so on. So the Friedmann equation is based upon a flawed theory. This is in fact a major outcome of the observations of supernova events, and needs to be understood.

2 Model Independent Analysis Reveals Uniform Expansion

The scale factor $a(t) = r(t)/r(t_0)$; ($a(t_0) \equiv 1$ by definition), where $r(t)$ are galactic separations on a sufficiently large scale, and t_0 is the present moment age of the universe. It describes the time evolution of the universe assuming a homogeneous and isotropic description. In principle it may be directly extracted from magnitude-redshift data without the use of any particular dynamical model for $a(t)$. The redshift is $z = 1/a(t) - 1$, and the Hubble function is $H(t) = \dot{a}/a$. We define $H(z)$ by changing variables from t to z. A dimensionless luminosity distance is given by (see appendix)

$$d_L(z) = (1 + z) \int_0^z \frac{H_0 dz'}{H(z')}. \tag{1}$$

$d_L(z)$ takes account of the reduced photon flux and energy loss caused by the expansion. Then the magnitude-redshift observables are computable from $a(t)$

$$\mu(z) = 5 \log_{10} d_L(z) + m, \tag{2}$$

where m is determined by the intrinsic brightness of the SNe Ia supernova. In principle this can be inverted to yield $a(t)$, without reference to any dynamical theory for $a(t)$. A simple

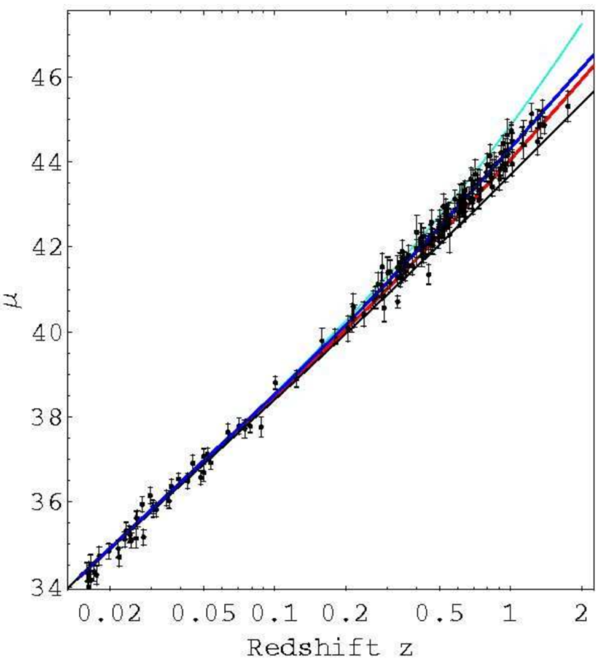

Fig. 1: Supernovae magnitude-redshift data. Upper curve (light blue) is "dark energy" only $\Omega_\Lambda = 1$. Next curve (blue) is best fit of "dark energy"-"dark-matter" $\Omega_\Lambda = 0.73$. Lowest curve (black) is "dark matter" only $\Omega_\Lambda = 0$. 2nd lowest curve (red) is generic uniformly expanding universe.

first analysis of the data tries a uniform expansion $a(t) = t/t_0$, which involves one parameter $t_0 = 1/H_0$, which sets the time scale. Fig.1 shows that this uniform expansion (shown by red plot) gives an excellent account of the data. We conclude that the supernovae magnitude-redshift data reveals a uniformly expanding universe. So why did [1, 2] report an accelerating expansion for the universe? The answer, according to the Nobel Prize briefing notes, is because "the evolution of the Universe is described by Einstein's theory of general relativity" [3]. To the contrary we argue that the data should be used to test possible theories of the universe, as in the usual scientific method, and not *a priori* demand that one theory, with *ad hoc* adjustments, be defined to be the only correct theory.

3 Newtonian Gravity Universe Model

The analysis in [1, 2] used the GR-based Friedmann equation for $a(t)$

$$\dot{a}^2 = \frac{8}{3}\pi G a(t)^2 \rho(t), \tag{3}$$

where $\rho(t)$ is the matter/energy density. However this equation follows trivially from Newtonian gravity. Consider a uniform density of matter moving radially with speed $v(r, t)$, at distance r, away from an origin. The kinetic + gravitational potential energy, with total energy E, of a test particle of mass m is given by

$$\frac{1}{2}mv^2 - \frac{GmM(r)}{r} = E, \tag{4}$$

where $M(r) = \frac{4}{3}\pi r^3 \rho$ is the mass enclosed within radius r - this follows simply from Newton's Inverse Square Law. Using $r(t) = a(t)r_0, v = \dot{r}$ and the so-called critical case $E = 0$, immediately gives (3). The reason for this simple derivation is that GR was constructed as a generalisation of NG that reduces to NG in the limit of low speeds and matter densities. So the Friedmann equation inherits all of the known failures of NG. As well the redshift z is a Doppler shift, caused by the motion of the source relative to the observer. Consider then some of the implications of (3): (i) if $\rho = 0$, i.e. no matter, then there is no expanding universe possible: $\dot{a} = 0$. This arises because (3) is about the effects of matter-matter gravitational attraction, and without matter there are no gravitational effects. (ii) (3) is not about the expansion of space, for it arises from NG in which matter moves through a Euclidean and unchanging space, (iii) (3) requires, at $t = t_0$, that

$$H_0^2 = \frac{8}{3}\pi G \rho_c, \tag{5}$$

where ρ_c is the so-called critical density. However (5) is strongly violated by the data: the observed baryonic matter density is some 20 times smaller than ρ_c, and so ρ must be padded out to satisfy (5), and (iv) (3) does not posses uniformly expanding solutions, unless $\rho \sim 1/a^2$, a form not considered in [1, 2]. To fit the data [1, 2] used the restricted *ad hoc* form

$$\rho(a) = (\frac{\Omega_M}{a^3} + \Omega_\Lambda)\rho_c, \tag{6}$$

where Ω_Λ is the "dark energy" composition parameter, and Ω_M is the "matter" composition parameter. There is no theoretical underpinning for this "dark energy". The above $H_0-\rho_c$ (5) relationship requires that $\Omega_\Lambda + \Omega_M = 1$, resulting in a two parameter model: H_0 and Ω_Λ. Fitting the data, by solving (3), and then using (1) and (2), gives $\Omega_\Lambda = 0.73$, and so $\Omega_M = 0.27$. This fitting is shown in Fig. 1. Essentially $\Omega_\Lambda = 0.73$ is the value for which NG best mimics a uniformly expanding universe, despite its inherent weakness as a model of a universe. The known baryonic matter density, corresponding to $\Omega_m = 0.05$, then requires that $\Omega_M - \Omega_m = 0.22$ be interpreted as the "dark matter" composition. However (3) has another strange feature, namely that $a(t)$, as a consequence of the "dark energy" parametrisation, possess an exponential component: neglecting Ω_M, which becomes increasingly valid into the future we get

$$a(t) \sim e^{H_0 \sqrt{\Omega_\Lambda} t}. \tag{7}$$

The Nobel Prize for Physics in 2011 was awarded for the discovery of this "accelerated expansion of the universe", despite the fact that the model-independent analysis in sect. 2 shows no such effect.

4 Dynamical Space Universe Model

A newer dynamical model of space describes the velocity of this structured space, relative to an observer using coordinate system $\mathbf{r}$ and t, by [5]

$$\nabla\cdot\left(\frac{\partial \mathbf{v}}{\partial t}+(\mathbf{v}\cdot\nabla)\mathbf{v}\right)+\frac{\alpha}{8}\left((trD)^2-tr(D^2)\right)+$$
$$+\frac{\delta^2}{8}\nabla^2\left((trD)^2-tr(D^2)\right)+...=-4\pi G\rho$$

$$\nabla\times\mathbf{v}=\mathbf{0},\quad D_{ij}=\frac{\partial v_i}{\partial x_j}. \tag{8}$$

The 1st term involves the Euler constituent acceleration, while the $\alpha-$ and $\delta-$ terms contain higher order derivative terms. This dynamical theory is conjectured to arise from a derivative expansion of a quantum foam theory of space. Laboratory, geophysical and astronomical data show that α is the fine structure constant, while δ appears to be a very small Planck-like length. Quantum theory determines the "gravitational" acceleration of quantum matter to be, as a quantum wave refraction effect,

$$\mathbf{g}=\frac{\partial \mathbf{v}}{\partial t}+(\mathbf{v}\cdot\nabla)\mathbf{v}+(\nabla\times\mathbf{v})\times\mathbf{v}_R-\frac{\mathbf{v}_R}{1-\dfrac{\mathbf{v}_R^2}{c^2}}\frac{1}{2}\frac{d}{dt}\left(\frac{\mathbf{v}_R^2}{c^2}\right)+..., \tag{9}$$

where $\mathbf{v}_R=\mathbf{v}_0-\mathbf{v}$ is the velocity of matter relative to the local space. Substituting the Hubble form $\mathbf{v}(\mathbf{r},t)=H(t)\mathbf{r}$, and then $H(t)=\dot{a}/a$, we obtain

$$4a\ddot{a}+\alpha\dot{a}^2=-\frac{16}{3}\pi Ga^2\rho. \tag{10}$$

This has a number of key features: (i) even when $\rho=0$, i.e. no matter, $a(t)\neq 0$ and monotonically increasing. This is because the space itself is a dynamical system, and the (small) amount of actual baryonic matter merely slightly slows that expansion, as the matter dissipates space. As well relation (5) no longer applies, and so there is no "critical density", (ii) the redshift z is no longer a Doppler shift; now it is caused by the expansion of the space removing energy from photons. Because of the small value of $\alpha=1/137$, the α term only plays a significant role in extremely early epochs, but only if the space is completely homogeneous*. In the limit $\rho\to 0$ and neglecting the α term, we obtain the solution $a(t)=t/t_0$. This uniformly expanding universe solution is exactly the form directly determined in sect.2 from the supernovae data. It requires neither "dark energy" nor "dark matter" – these effects have evaporated, and are clearly revealed as nothing more than artifacts of the NG model. The "accelerating expansion of the universe" in the future has also disappeared.

*Keeping the α term we obtain $a(t)=(t/t_0)^{1/(1+\alpha/4)}$

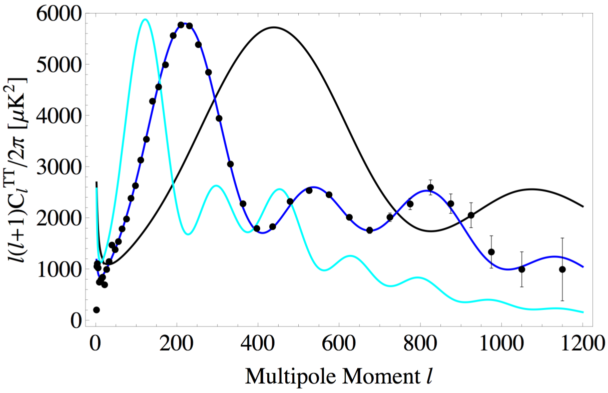

Fig. 2: CMB angular power spectrum for (i) $\Omega_\Lambda=1$ (light blue curve), (ii) = 0.73 (dark blue curve), and (iii) = 0 (black curve), confirming that the background space is uniformly expanding.

5 CMB Fluctuations

Another technique for determining the expansion rate of the universe is to use the Cosmic Microwave Background (CMB) temperature angular fluctuation spectrum. This spectrum is computed as a perturbation of the plasma relative to an assumed homogeneous background universe dynamical model. The background model used is the Friedmann equation (3). We show in Fig. 2 the angular fluctuation power spectrum from CAMB (Code for Anisotropies in the Microwave Background), [6, 7], for the same three values $\Omega_\Lambda=0$, 0.73 and 1, as also used in Fig. 1. However, as already noted in sect. 3, this homogeneous background dynamics is merely a Newtonian gravity model, with "dark energy" and "dark matter" used to pad out the critical density and mimic a uniform expansion. The Newtonian model and the dynamical 3-space model give the same age for the universe, 13.7 Gyr, as they both describe the same uniform expansion rate, with the minor variations in the Newtonian model expansion rate cancelling out. However they give different decoupling times, 0.38 Myr for the Newtonian model and 1.4 Myr for the dynamical 3-space. So it is important to note that the decoupling time is very model dependent.

6 Conclusions

The supernovae magnitude-redshift data is of great significance to cosmology. It reveals, using a model-independent analysis, that the universe is undergoing a uniform expansion. This represents a major challenge to theories of the universe, particularly as GR does not have such solutions. We have also noted that GR, via the Friedmann equation, is nothing more than Newtonian gravity applied to the gravitational force between matter, essentially with galaxies as that matter. To mimic the uniform expansion the canonical value $\Omega_\Lambda=0.73$ emerges by fitting the NG model to either the data, or more revealingly, by fitting to the dynamical 3-space theory. However the *ad hoc* introduction of the "dark energy" parameter results in a spurious accelerating expansion. These spurious effects, "dark energy", "dark matter", and "accelerating expansion", are reminiscent of Ptolemy's epicycles when an incorrect model of the solar system was forced to fit the data, rather than using the data to test different models of the solar system. This recurring failure to use the scientific method resulted, in both cases, in deeply wrong theories being embellished and promoted as orthodoxy, with astronomers now committing major resources to "explaining" these new epicycles. The dynamical 3-space theory has been extensively tested, from bore hole g anomalies, to supermassive black holes and cosmic filaments. It gives a uniformly expanding universe without the introduction of any *ad hoc* parameters, and disagrees in general with Newtonian gravity, even in the low matter density, low speed limits, while nevertheless reproducing the NG restricted successes within the solar system. Introducing "dark matter" and "dark energy" amounts to the belief that Newton had correctly and completely described space and gravity some 300 years ago, requiring only the identification of new matter/energy. The supernova data is informing us that this is not so [8]. The use of the *ad hoc* parametrisation in (6) is not sufficiently general to give an unbiased fitting procedure, forcing an exponential growth term which is not present in the data.

7 Acknowledgments

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8 Appendix: Luminosity Distance

To extract $a(t)$ we need to describe the relationship between the cosmological observables: the apparent energy-flux magnitudes and redshifts, and in a model independent manner. We use the dynamical space formalism, although the result, in (1) & (15), is generic and was used in [1, 2]. First we take account of the reduction in photon count caused by the expanding 3-space, as well as the accompanying reduction in photon energy. To that end we first determine the distance travelled by the light from a supernova event before detection. Using a choice of embedding-space coordinate system, with $r = 0$ at the location of a supernova event at time t_1, the speed of light relative to this embedding space frame is $c + v(r(t;t_1), t)$, i.e. c wrt the space itself, where $r(t;t_1)$ is the photon embedding-space distance from the source. Then the distance travelled by the light at time t, after emission at time t_1, is determined implicitly by

$$r(t;t_1) = \int_{t_1}^{t} dt'(c + v(r(t';t_1), t'), \tag{11}$$

which has the solution, on using $v(r,t) = H(t)r$,

$$r(t;t_1) = ca(t) \int_{t_1}^{t} \frac{dt'}{a(t')}. \tag{12}$$

This distance gives directly the surface area $4\pi r(t;t_1)^2$ of the expanding sphere and so the decreasing photon count per unit area on that surface. With $t \to t_0$ (and then dropping t_0 in the notation), $a(t_0) = 1$ and $a(t_1) = 1/(1 + z(t_1))$ we obtain

$$r(z) = c \int_0^z \frac{dz'}{H(z')}. \tag{13}$$

However because of the expansion the flux of photons is reduced by the factor $1/(1 + z)$ simply because they become spaced further apart by the expansion. The photon flux is then given by $\mathcal{F}_P = \mathcal{L}_P/4\pi(1 + z)r(z)^2$ where $\mathcal{L}_P$ is the source photon-number luminosity. However usually the energy flux is measured, and the energy of each photon is reduced by the factor $1/(1 + z)$ because of the redshift. Then the energy flux is, in terms of the source energy luminosity $\mathcal{L}_E$: $\mathcal{F}_E = \mathcal{L}_E/4\pi(1 + z)^2r(z)^2 \equiv \mathcal{L}_E/4\pi r_L(z)^2$ which defines the effective energy-flux luminosity distance $r_L(z)$. Then the energy-flux luminosity effective distance is

$$r_L(z) = (1 + z)r(z) = c(1 + z) \int_0^z \frac{dz'}{H(z')} \tag{14}$$

The dimensionless "energy-flux" luminosity effective distance is then given by

$$d_L(z) = (1 + z) \int_0^z \frac{H_0 dz'}{H(z')}. \tag{15}$$

For the uniformly expanding universe $H(z) = (1 + z)H_0$ and $d_L(z) = (1 + z)\ln(1 + z)$.

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