The Rescaling Symmetry Principle.

John Hunter, graduate from the University of York
john@gravity.uk.com

ABSTRACT
A symmetry principle is discussed whereby the whole universe can change scale. It is shown that a reinterpretation of 'expansion' of the universe, (due to changing scale factor), as a 'rescaling', can lead to a redshift of light, due to a changing of Plancks constant with time. Predictions for the magnitudes of supernovae against redshift are made and found to be in good agreement with supernovae data, without recourse to dark energy. Matter density, of one quarter critical density, occurs naturally from Einsteins equations, with an equation of state parameter of -1 (in accordance with values inferred from WMAP data). It is concluded that the reinterpretation of a solution of the equations of General Relativity, for the universe, may be necessary. The question of inertia is considered, and the new interpretation of General Relativity is found to support modern views on its cause.

Key words: Cosmology: distance scale, cosmological parameters, dark energy

1 INTRODUCTION

Currently the 'concordance model' is widely accepted, the Big Bang model based on General Relativity with inflation, dark energy and dark matter. Although the concordance model has been successful in explaining many observations, its whole philosophical foundation seems to be lacking. In only a few decades many important new concepts have had to be introduced to adapt the Big Bang/General Relativity model. This might be necessary, but each new concept has deep unanswered questions associated with it.

Inflation was introduced in 1981 (Guth 1981), to explain observations that the universe is near critical density. There is, however, no understanding of why it began or ended, or of the nature of the underlying cause of inflation.

Due to the observations of distant supernovae (Riess et al 2007), cosmologists have concluded that there exists 'dark energy', the nature of which is poorly understood. There is a lack of an understanding of a physical mechanism, by which dark energy causes an accelerating expansion of the universe.

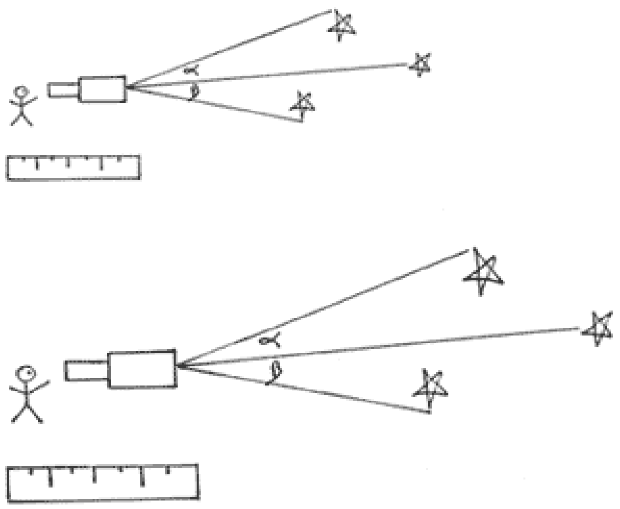
It is found that the two concepts above are unnecessary if there is an alternative interpretation of the expansion of the universe, a continuous and global changing of all length scales, and all physical constants, which is undetectable to us locally. As no change is measurable locally it is called the rescaling symmetry principle. This changing of scales is not a change of co-ordinate system, for one observer compared to another, but a simultaneous and ongoing change for the whole universe.

2 THE RESCALING SYMMETRY PRINCIPLE AND ITS CONSEQUENCES

2.1 The rescaling symmetry principle.

According to the rescaling symmetry principle, every length in the universe may increase or decrease with almost no noticeable effect to the inhabitants, (figure 1). This continuous and ongoing change in length scale must happen to every length in the whole universe simultaneously, including the size of people, atoms and distances between all objects. Every physical constant must vary too, with the change depending on the number of length dimensions in the quantity.

Figure 1 Sketch to show a rescaling universe



A common cosmological time (t) is assumed.

Quantities then rescale according to

$$\frac{dQ}{Q} = aHdt \qquad (1)$$

where 'a' is the number of length dimensions in quantity Q. H is the rescaling constant, which is half of Hubbles constant H_0

$$Q = Q_0 \exp(aHt) \qquad (2)$$

Table 1. The value of 'a' for various physical quantities.

Quantity	*a*
All lengths	1
Speed of light	1
Plancks constant	2
Particle masses	0
Permittivity of free space	-3
Fine structure constant	0
Gravitational constant	3
Hubbles constant	0
Forces	1
Quanity with n length dimensions	n

There has been no convincing evidence for the change of any physical constant with time, although there have been various proposals starting with Dirac's hypothesis of a varying G, (Dirac, 1937). With this proposal the changes would not be measurable.

The symmetry principle requires that any local experiment, to measure the change of any physical quantity, in a rescaling universe, would yield a null result. This is due to other relevant quantities rescaling too.

For example if an attempt were made to measure the change in the speed of light by timing the passage of a light beam over a given distance, since both the distance and the speed of light rescale in proportion the time of passage would remain the same.

Lunar Laser Ranging has restricted changes in the value of G to 1 part in 10 billion per year. Local measurements would not reveal any change in G with time, due to the symmetry principle. Measurements using distant sources, would also not reveal a change in G with time. An attempt could be made by measuring the velocity of rotation (with Doppler shift) and radius of rotation, of a system similar to the earth-sun system, but many light years away. We would decide (due to the speed of light rescaling too) that the velocity is the same as for the solar system. The radius too would appear the same (e.g. the time of light to cross the orbit would be unchanged) and we would conclude that G was the same in both cases.

The model is consistent with observations that there is no significant change in the fine structure constant with time (Murphy et al. 2001), as it is dimensionless.

The rescaling symmetry principle applies to the whole universe simultaneously. It seems as though the universe could be regarded as static, with no change of any physical quantity. However because a rescaling universe is one that is larger now than it used to be, there are some observational differences between the static and rescaling universe cases. These arise from the conservation of energy, as described below.

2.2 The redshift of light.

In a rescaling universe, a photon of light arriving from a distant star, would be emitted at a time when Plancks constant was lower (h_0).

Figure 2. The redshift of light

By the time it has arrived at earth Plancks constant would be

$$h = h_0 \exp(2Ht) \tag{3}$$

where t is the time since the emission of the photon. H is the rescaling constant (half of Hubbles constant, H_0).
If the energy of the photon is conserved

$$f = f_o \exp(-2Ht) \tag{4}$$

Where f is the frequency measured at earth, f_0 is the frequency of the photon when emitted from a distant star. So light becomes redshifted with time. In this model the redshift of light is due to the rescaling universe, instead of an expanding universe.

The redshift of light is from

$$1 + z = \exp(2Ht) \tag{5}$$

which matches observations for low z, and the ratio of the scale factor of the universe, at the time of arrival, to the scale factor at the time of emission of the photon is

$$\exp(Ht) = \sqrt{1+z} \tag{6}$$

2.3 The Value of G

General Relativity has traditionally, no ‘explanation’ for the value of the gravitational constant, G. With this interpretation, it is clear from Newtonian considerations, why the universe should be at critical density, (see Appendix A). It is so that energy is conserved in a rescaling universe. The rescaling (which has a constant rate) causes gravitation so that energy is conserved, and the value of G is determined by the rate of rescaling. It is expected that a cosmology based on a future amended or reinterpreted version of General Relativity will incorporate Big Bang theory. It is suggested in Appendix A how this might come about.

2.4 A solution of Einsteins equations.

For constant H, $a = a_0 \exp(Ht)$, where a is the scale factor of the universe, Einsteins equations of General Relativity reduce to the De Sitter model. Any change of scale factor is now interpreted as a 'rescaling' not 'expansion' in the traditional sense. The rescaling constant is H, half of Hubbles constant $2H$.

$$8\pi G \frac{\rho}{c^2} = -\Lambda + \frac{3H^2}{c^2} + \frac{3k}{a^2} \qquad (7)$$

$$8\pi G \frac{p}{c^4} = \Lambda - \frac{3H^2}{c^2} - \frac{k}{a^2} \qquad (8)$$

so for a flat universe with k = 0, and $\Lambda = 0$

$$p = -c^2 \rho \qquad \text{(i.e. } \omega = -1) \qquad (9)$$

and

$$\rho = \frac{3H^2}{8\pi G} \qquad (10)$$

therefore the traditionally inferred value of omega(matter) would be

$$\Omega_m = \frac{3H^2 / 8\pi G}{3H_0^2 / 8\pi G} = 0.25 \qquad (11)$$

because $H_0 = 2H$

In reality $\Omega_m = 1$, as the denominator should contain H not H_0, and $\Omega_\Lambda = 0$. It is not necessary to include the concepts of inflation, or dark energy, in this model as the universe is naturally at critical density.

This value is consistent with the WMAP results.
Measurements from WMAP5, lead to an inferred value (Dunkley et al. 2008) for omega(matter) of 0.258 (0.030). Their preferred model is a flat ΛCDM model with k = 0, and an equation of state parameter, ω, of -1. A value for the maximum likelihood for omega(matter) is given as 0.249.

The values derived from the above solution to Einsteins equations, are k = 0, omega(matter) = 0.25, using H_0 in the denominator of (11), and ω = -1 .
It therefore seems possible that a dark energy has been wrongly assumed, where in reality no such phenomenon exists. The conclusion of the existence of dark energy, is due to a misunderstanding of the relationship between scale factor and redshift, and the value of the rescaling constant.

3. THE SUPERNOVAE DATA

The flux F due to distant supernovae is given by

$$F = \frac{L}{4\pi d_L^{\ 2}} = \frac{L}{4\pi(1+z)^3 d_p^2} \qquad (12)$$

where d_L is the luminosity distance, L is luminosity and d_p is the 'proper distance'. The flux is reduced by three factors of (1+z) in the rescaling interpretation. Two are the same as traditional theory, due to the increased time of arrival of each wavelength, (of redshift z), and the energy of the wave being reduced. The third is due to the area (A) of the surface of the sphere, centred on the supernova, rescaling during the time of travel of the photon (t).

An area rescales according to

$$A\exp(2Ht) = A(1+z) \qquad (13)$$

from formula (5), so

$$d_L = (1+z)^{\frac{3}{2}} d_p \qquad (14)$$

for a photon emitted a time T ago, with the speed of light rescaling during travel.

$$d_P = \int_0^T c\exp(-Ht)dt \qquad (15)$$

This gives

$$d_p = \frac{c}{H}(1-\exp(-HT)) \qquad (16)$$

since H is half of Hubbles constant H_0, and from (6)

$$d_P = \frac{2c}{H_0}(1-\frac{1}{\sqrt{1+z}}) \qquad (17)$$

Combined with (14), (17) gives

$$d_L = \frac{2c}{H_0}(1+z)\left(\sqrt{1+z}-1\right) \qquad (18)$$

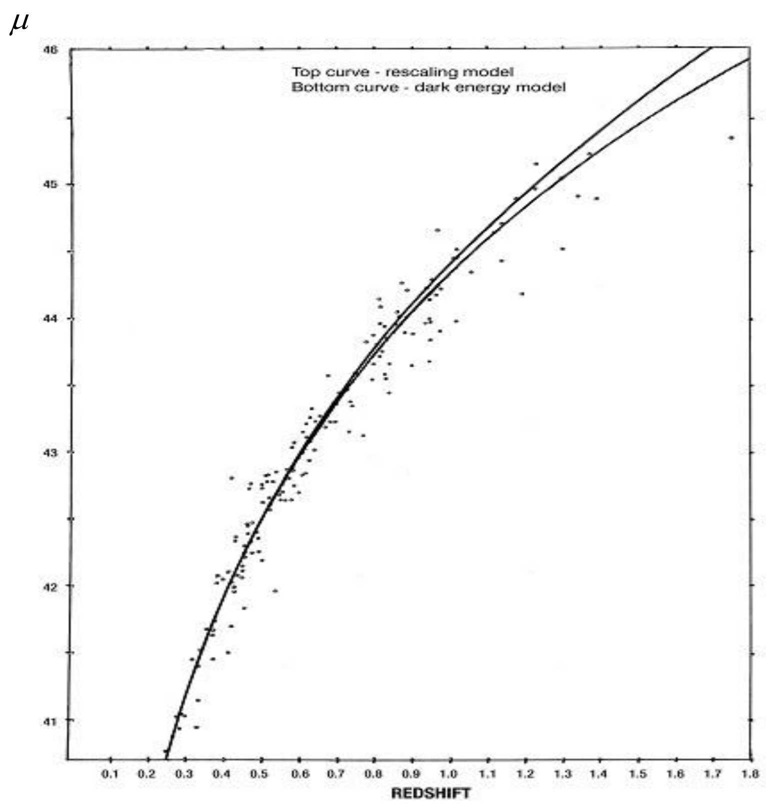
the distance modulus is

$$\mu = 25 + 5\log d_L \qquad (19)$$

Using (18) in (19), there is a good match to the supernovae data (Riess 2007), gold set. The chi-squared fit is 183.8 for 182 degrees of freedom. This close match is with H_0, constant, with no requirement for a dark energy component of the universe.

Figure 3 shows a comparison between the rescaling model and the dark energy model for the supernova data. Hubbles constant is a variable parameter in these plots. The top curve is for the rescaling model with H_0 = 65.1kms^{-1}Mpc^{-1}. The bottom curve is for the best flat dark energy model with H_0 = 63.8kms^{-1}Mpc^{-1} (Wright 2007). The dark energy model also has another variable parameter, the matter density, for the curve shown omega(matter) = 0.27. The match from the rescaling interpretation uses no such extra variable parameter. For the rescaling interpretation, the deceleration parameter q(z) = -1 (constant), whereas for dark energy theory q(z) varies, in a way that is not understood (Shapiro & Turner, 2006).

Figure 3 Supernova moduli with redshift, for rescaling and dark energy models.



As can be seen from figure 3, the curves are very similar. Both curves give a close match to the data at low redshifts (where the curves are almost identical).

The rescaling interpretation gives a slightly closer match for intermediate redshifts z = 0.4 – 0.6. The dark energy model gives a closer match at higher redshifts, although the number of points is fewer at the higher redshifts. For the data point z = 1.755, the standard deviation is 0.36 mag, whereas the typical standard deviation for the other points is about 0.2 mag.

4. CONCLUSIONS AND PREDICTIONS.

There may have been a serious and long-standing misinterpretation of the 'expansion' of the universe.

This conclusion is from philosophical reasoning and supported by two pieces of evidence.

i) The value of the omega(matter) inferred from WMAP data.
ii) The relation between supernovae magnitudes and redshift.

The rescaling interpretation predicts that future measurements of supernovae will be in accord with formula (18). An inferred value for omega(matter) of 0.25 is also predicted.

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APPENDIX A THE VALUE OF G.

By using Newtonian considerations, other features expected from of a reinterpretation (or amendment) of General Relativity are now considered.

If the total energy due to each mass m is conserved in a rescaling universe, then

$$mc^2 - \frac{GMm}{R} = 0 \qquad \text{(A1)}$$

as, at a later time the total energy would be

$$(mc^2 - \frac{GMm}{R})\exp(2Ht) \qquad \text{(A2)}$$

where the second term in (A1) represents the combined contributions to the potential energy due to the rest of the universe, of mass M, up to the Hubble radius R, so

$$G = \frac{Rc^2}{M} \qquad \text{(A3)}$$

Small numerical constants are omitted for simplicity.
The significance of equation (A3) is that gravity is caused by rescaling – i.e. the phenomenon of gravitation and the value of G, is a result of the conservation of energy in a rescaling universe. This naturally leads to a universe at critical density, and to a reduction in gravitational mass for masses of high mass to radius ratio as shown below.

For a large stationary mass, (A1) is amended to

$$mc^2 - \frac{GMm}{R} - \frac{Gm^2}{r} = 0 \qquad \text{(A4)}$$

The gravitational mass is interpreted to be

$$mc^2 - \frac{Gm^2}{r} \qquad \text{(A5)}$$

Equation (A5) indicates that a reinterpretation of General Relativity which incorporates the rescaling symmetry principle will include the reduction in gravitational mass for dense objects. Such a mechanism may allow a large collapsing mass to 'bounce' giving rise to explosive, or ejection phenomenon. Such a future theory may be able to account for the spherical void phenomenon of the large scale structure, and incorporate Big Bang cosmology (Hunter, 2009).

On the question of inertia, Berkeley proposed that acceleration can be measured only relatively and Mach proposed that inertia was due to the presence of distant matter in the universe (Barbour J, 1995). Later Sciama (Sciama, 1953) suggested that inertia is a gravitational effect and by an analogy with electromagnetism proposed that gravity could account for inertia so long as formula (A3) was approximately true. Nowadays inertia is more definitely believed to be of gravitational origin (Nordtvedt, 1988).

Gaps in the understanding of inertia would remain, however. To summarise, energy (and mass) gravitates, and gravitation then causes inertia, provided (A3) is true. The questions of why energy gravitates, and why (A3) is true, are (with the rescaling interpretation) answered, both are so that energy is conserved. Why inertia is an instantaneous resistance to acceleration may be addressed by the Wheeler–Feynman absorber theory (Wheeler, 1945 & 1949).

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