

# Dynamical 3-Space: Supernovae and the Hubble Expansion — the Older Universe without Dark Energy

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We apply the new dynamics of 3-space to cosmology by deriving a Hubble expansion solution. This dynamics involves two constants;  $G$  and  $\alpha$  — the fine structure constant. This solution gives an excellent parameter-free fit to the recent supernova and gamma-ray burst redshift data without the need for “dark energy” or “dark matter”. The data and theory together imply an older age for the universe of some 14.7 Gyrs. The 3-space dynamics has explained the bore hole anomaly, spiral galaxy flat rotation speeds, the masses of black holes in spherical galaxies, gravitational light bending and lensing, all without invoking “dark matter” or “dark energy”. These developments imply that a new understanding of the universe is now available.

## 1 Introduction

There are theoretical claims based on observations of Type Ia supernova (SNe Ia) redshifts [1, 2] that the universe expansion is accelerating. The cause of this acceleration has been attributed to an undetected “dark energy”. Here the dynamical theory of 3-space is applied to Hubble expansion dynamics, with the result that the supernova and gamma-ray burst redshift data is well fitted without an acceleration effect and without the need to introduce any notion of “dark energy”. So, like “dark matter”, “dark energy” is an unnecessary and spurious notion. These developments imply that a new understanding of the universe is now available.

### 1.1 Dynamical 3-Space

At a deeper level an information-theoretic approach to modelling reality, *Process Physics* [3, 4], leads to an emergent structured “space” which is 3-dimensional and dynamic, but where the 3-dimensionality is only approximate, in that if we ignore non-trivial topological aspects of the space, then it may be embedded in a 3-dimensional geometrical manifold. Here the space is a real existent discrete fractal network of relationships or connectivities, but the embedding space is purely a mathematical way of characterising the 3-dimensionality of the network. Embedding the network in the embedding space is very arbitrary; we could equally well rotate the embedding or use an embedding that has the network translated or translating. These general requirements then dictate the minimal dynamics for the actual network, at a phenomenological level. To see this we assume at a coarse grained level that the dynamical patterns within the network may be described by a velocity field  $\mathbf{v}(\mathbf{r}, t)$ , where  $\mathbf{r}$  is the location of a small region in the network according to some arbitrary embedding. The 3-space velocity field has been observed in at least 8 experiments [3, 4]. For simplicity we assume here that the global topology of the network is not significant for the local dynam-

ics, and so we embed in an  $E^3$ , although a generalisation to an embedding in  $S^3$  is straightforward and might be relevant to cosmology. The minimal dynamics is then obtained by writing down the lowest-order zero-rank tensors, of dimension  $1/t^2$ , that are invariant under translation and rotation, giving

$$\nabla \cdot \left( \frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla) \mathbf{v} \right) + \frac{\alpha}{8} ((\text{tr} D)^2 - \text{tr}(D^2)) = -4\pi G \rho, \quad (1)$$

$$D_{ij} = \frac{1}{2} \left( \frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i} \right), \quad (2)$$

where  $\rho(\mathbf{r}, t)$  is the effective matter density. The embedding space coordinates provide a coordinate system or frame of reference that is convenient to describing the velocity field, but which is not real. In *Process Physics* quantum matter are topological defects in the network, but here it is sufficient to give a simple description in terms of an effective density.  $G$  is Newton’s gravitational constant, and describes the rate of non-conservative flow of space into matter, and data from the bore hole  $g$  anomaly and the mass spectrum of black holes reveals that  $\alpha$  is the fine structure constant  $\approx 1/137$ , to within experimental error [5, 6, 7].

Now the acceleration  $\mathbf{a}$  of the dynamical patterns in the 3-space is given by the Euler or convective expression

$$\begin{aligned} \mathbf{a}(\mathbf{r}, t) &= \lim_{\Delta t \rightarrow 0} \frac{\mathbf{v}(\mathbf{r} + \mathbf{v}(\mathbf{r}, t)\Delta t, t + \Delta t) - \mathbf{v}(\mathbf{r}, t)}{\Delta t} = \\ &= \frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla) \mathbf{v}. \end{aligned} \quad (3)$$

As shown in [8] the acceleration  $\mathbf{g}$  of quantum matter is identical to the acceleration of the 3-space itself, apart from vorticity and relativistic effects, and so the gravitational acceleration of matter is also given by (3). Eqn. (1) has black hole solutions for which the effective masses agree with observational data for spherical star systems [5, 6, 7]. These black holes also explain the flat rotation curves in spiral galaxies [9].

## 2 Supernova and gamma-ray burst data

The supernovae and gamma-ray bursts provide standard candles that enable observation of the expansion of the universe. The supernova data set used herein and shown in Figs. 2 and 3 is available at [10]. Quoting from [10] we note that Davis *et al.* [11] combined several data sets by taking the ESSENCE data set from Table 9 of Wood–Vassey *et al.* (2007) [13], using only the supernova that passed the light-curve-fit quality criteria. They took the HST data from Table 6 of Riess *et al.* (2007) [12], using only the supernovae classified as gold. To put these data sets on the same Hubble diagram Davis *et al.* used 36 local supernovae that are in common between these two data sets. When discarding supernovae with  $z < 0.0233$  (due to larger uncertainties in the peculiar velocities) they found an offset of  $0.037 \pm 0.021$  magnitude between the data sets, which they then corrected for by subtracting this constant from the HST data set. The dispersion in this offset was also accounted for in the uncertainties. The HST data set had an additional 0.08 magnitude added to the distance modulus errors to allow for the intrinsic dispersion of the supernova luminosities. The value used by Wood–Vassey *et al.* (2007) [13] was instead 0.10 mag. Davis *et al.* adjusted for this difference by putting the Gold supernovae on the same scale as the ESSENCE supernovae. Finally, they also added the dispersion of 0.021 magnitude introduced by the simple offset described above to the errors of the 30 supernovae in the HST data set. The final supernova data base for the distance modulus  $\mu_{obs}(z)$  is shown in Figs. 2 and 3. The gamma-ray burst (GRB) data is from Schaefer [14].

## 3 Expanding 3-space — the Hubble solution

Suppose that we have a radially symmetric density  $\rho(r, t)$  and that we look for a radially symmetric time-dependent flow  $\mathbf{v}(\mathbf{r}, t) = v(r, t)\hat{\mathbf{r}}$  from (1). Then  $v(r, t)$  satisfies the equation, with  $v' = \frac{\partial v(r, t)}{\partial r}$ ,

$$\frac{\partial}{\partial t} \left( \frac{2v}{r} + v' \right) + vv'' + 2\frac{vv'}{r} + (v')^2 + \frac{\alpha}{4} \left( \frac{v^2}{r^2} + \frac{2vv'}{r} \right) = -4\pi G\rho(r, t). \quad (4)$$

Consider first the zero energy case  $\rho = 0$ . Then we have a Hubble solution  $v(r, t) = H(t)r$ , a centreless flow, determined by

$$\dot{H} + \left(1 + \frac{\alpha}{4}\right) H^2 = 0 \quad (5)$$

with  $\dot{H} = \frac{dH}{dt}$ . We also introduce in the usual manner the scale factor  $R(t)$  according to  $H(t) = \frac{1}{R} \frac{dR}{dt}$ . We then obtain the solution

$$H(t) = \frac{1}{\left(1 + \frac{\alpha}{4}\right)t} = H_0 \frac{t_0}{t}; \quad R(t) = R_0 \left(\frac{t}{t_0}\right)^{4/(4+\alpha)} \quad (6)$$

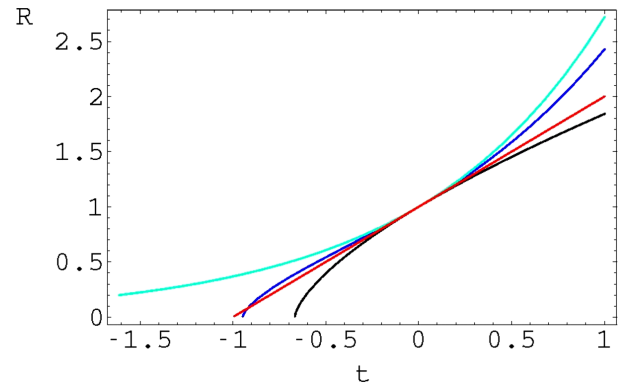


Fig. 1: Plot of the scale factor  $R(t)$  vs  $t$ , with  $t = 0$  being “now” with  $R(0) = 1$ , for the four cases discussed in the text, and corresponding to the plots in Figs. 2 and 3: (i) the upper curve (green) is the “dark energy” only case, resulting in an exponential acceleration at all times, (ii) the bottom curve (black) is the matter only prediction, (iii) the 2nd highest curve (to the right of  $t = 0$ ) is the best-fit “dark energy” plus matter case (blue) showing a past deceleration and future exponential acceleration effect. The straight line plot (red) is the dynamical 3-space prediction showing a slightly older universe compared to case (iii). We see that the best-fit “dark energy”-matter curve essentially converges on the dynamical 3-space result. All plots have the same slope at  $t = 0$ , i.e. the same value of  $H_0$ . If the age of the universe is inferred to be some 14Gyrs for case (iii) then the age of the universe is changed to some 14.7Gyr for case (iv).

where  $H_0 = H(t_0)$  and  $R_0 = R(t_0)$ . We can write the Hubble function  $H(t)$  in terms of  $R(t)$  via the inverse function  $t(R)$ , i.e.  $H(t(R))$  and finally as  $H(z)$ , where the redshift observed now,  $t_0$ , relative to the wavelengths at time  $t$ , is  $z = R_0/R - 1$ . Then we obtain

$$H(z) = H_0(1+z)^{1+\alpha/4}. \quad (7)$$

We need to determine the distance travelled by the light from a supernova before detection. Using a choice of coordinate system with  $r = 0$  at the location of a supernova the speed of light relative to this embedding space frame is  $c + v(r(t), t)$ , i.e.  $c$  wrt the space itself, where  $r(t)$  is the distance from the source. Then the distance travelled by the light at time  $t$  after emission at time  $t_1$  is determined implicitly by

$$r(t) = \int_{t_1}^t dt' (c + v(r(t'), t')), \quad (8)$$

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

$$r(t) = cR(t) \int_{t_1}^t \frac{dt'}{R(t')}. \quad (9)$$

Expressed in terms of the observable redshift  $z$  this gives

$$r(z) = c(1+z) \int_0^z \frac{dz'}{H(z')}. \quad (10)$$

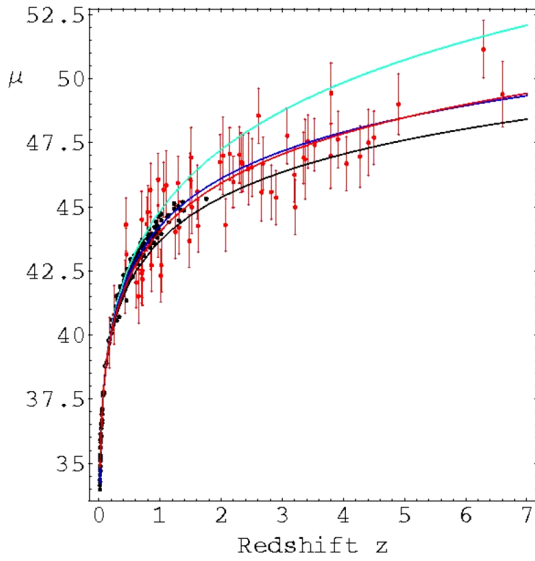


Fig. 2: Hubble diagram showing the combined supernovae data from Davis *et al.* [11] using several data sets from Riess *et al.* (2007) [12] and Wood-Vassey *et al.* (2007) [13] (dots without error bars for clarity — see Fig. 3 for error bars) and the Gamma-Ray Bursts data (with error bars) from Schaefer [14]. Upper curve (green) is “dark energy” only  $\Omega_\Lambda = 1$ , lower curve (black) is matter only  $\Omega_m = 1$ . Two middle curves show best-fit of “dark energy”-matter (blue) and dynamical 3-space prediction (red), and are essentially indistinguishable. However the theories make very different predictions for the future and for the age of the universe. We see that the best-fit ‘dark energy’-matter curve essentially converges on the dynamical 3-space prediction.

The effective dimensionless distance is given by

$$d(z) = (1+z) \int_0^z \frac{H_0 dz'}{H(z')} \quad (11)$$

and the theory distance modulus is then defined by

$$\mu_{th}(z) = 5 \log_{10}(d(z)) + m. \quad (12)$$

Because all the selected supernova have the same absolute magnitude,  $m$  is a constant whose value is determined by fitting the low  $z$  data.

Using the Hubble expansion (7) in (11) and (12) we obtain the middle curves (red) in Figs. 2 and the 3, yielding an excellent agreement with the supernovae and GRB data. Note that because  $\frac{\alpha}{4}$  is so small it actually has negligible effect on these plots. Hence the dynamical 3-space gives an immediate account of the universe expansion data, and does not require the introduction of a cosmological constant or “dark energy”, but which will be nevertheless discussed next.

When the energy density is not zero we need to take account of the dependence of  $\rho(r, t)$  on the scale factor of the universe. In the usual manner we thus write

$$\rho(r, t) = \frac{\rho_m}{R(t)^3} + \frac{\rho_r}{R(t)^4} + \Lambda \quad (13)$$

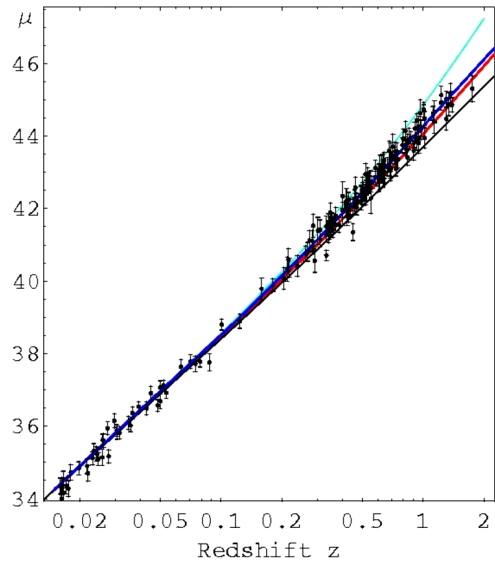


Fig. 3: Hubble diagram as in Fig. 2 but plotted logarithmically to reveal details for  $z < 2$ , and without GRB data. Upper curve (green) is “dark-energy” only, next curve down (blue) is best fit of “dark energy”-matter. Lower curve (black) is matter only  $\Omega_m = 1$ . Lower of two middle curves (red) is dynamical 3-space parameter-free prediction.

for matter, EM radiation and the cosmological constant or “dark energy”  $\Lambda$ , respectively, where the matter and radiation is approximated by a spatially uniform (i.e independent of  $r$ ) equivalent matter density. We argue here that  $\Lambda$  — the dark energy density, like dark matter, is an unnecessary concept. Then (4) becomes for  $R(t)$

$$\frac{\ddot{R}}{R} + \frac{\alpha}{4} \frac{\dot{R}^2}{R^2} = -\frac{4\pi G}{3} \left( \frac{\rho_m}{R^3} + \frac{\rho_r}{R^4} + \Lambda \right) \quad (14)$$

giving

$$\dot{R}^2 = \frac{8\pi G}{3} \left( \frac{\rho_m}{R} + \frac{\rho_r}{R^2} + \Lambda R^2 \right) - \frac{\alpha}{2} \int \frac{\dot{R}^2}{R} dR. \quad (15)$$

In terms of  $\dot{R}^2$  this has the solution

$$\dot{R}^2 = \frac{8\pi G}{3} \left( \frac{\rho_m}{(1-\frac{\alpha}{2})R} + \frac{\rho_r}{(1-\frac{\alpha}{4})R^2} + \frac{\Lambda R^2}{(1+\frac{\alpha}{4})} + bR^{-\frac{\alpha}{2}} \right) \quad (16)$$

which is easily checked by substitution into (15), where  $b$  is an arbitrary integration constant. Finally we obtain from (16)

$$t(R) = \int_{R_0}^R \frac{dR}{\sqrt{\frac{8\pi G}{3} \left( \frac{\rho_m}{R} + \frac{\rho_r}{R^2} + \Lambda R^2 + bR^{-\alpha/2} \right)}} \quad (17)$$

where now we have re-scaled parameters  $\rho_m \rightarrow \rho_m/(1-\frac{\alpha}{2})$ ,  $\rho_r \rightarrow \rho_r/(1-\frac{\alpha}{4})$  and  $\Lambda \rightarrow \Lambda/(1+\frac{\alpha}{4})$ . When  $\rho_m = \rho_r = \Lambda = 0$ , (17) reproduces the expansion in (6), and so the density terms in (16) give the modifications to the dominant purely spatial

expansion, which we have noted above already gives an excellent account of the data.

From (17) we then obtain

$$H(z)^2 = H_0^2 (\Omega_m (1+z)^3 + \Omega_r (1+z)^4 + \Omega_\Lambda + \Omega_s (1+z)^{2+\alpha/2}) \quad (18)$$

with

$$\Omega_m + \Omega_r + \Omega_\Lambda + \Omega_s = 1. \quad (19)$$

Using the Hubble function (18) in (11) and (12) we obtain the plots in Figs. 2 and 3 for four cases:

- (i)  $\Omega_m = 0, \Omega_r = 0, \Omega_\Lambda = 1, \Omega_s = 0$ , i.e a pure “dark energy” driven expansion,
- (ii)  $\Omega_m = 1, \Omega_r = 0, \Omega_\Lambda = 0, \Omega_s = 0$  showing that a matter only expansion is not a good account of the data,
- (iii) from a least squares fit with  $\Omega_s = 0$  we find  $\Omega_m = 0.28, \Omega_r = 0, \Omega_\Lambda = 0.68$  which led to the suggestion that the “dark energy” effect was needed to fix the poor fit from (ii), and finally
- (iv)  $\Omega_m = 0, \Omega_r = 0, \Omega_\Lambda = 0, \Omega_s = 1$ , as noted above, that the spatial expansion dynamics alone gives a good account of the data.

Of course the EM radiation term  $\Omega_r$  is non-zero but small and determines the expansion during the baryogenesis initial phase, as does the spatial dynamics expansion term because of the  $\alpha$  dependence. If the age of the universe is inferred to be some 14Gyrs for case (iii) then, as seen in Fig. 1, the age of the universe is changed to some 14.7Gyr for case (iv). We see that the one-parameter best-fit “dark energy”-matter curve essentially converges on the no-parameter dynamical 3-space result.

## 4 Conclusions

There is extensive evidence for a dynamical 3-space, with the minimal dynamical equation now known and confirmed by numerous experimental and observational data. As well we have shown that this equation has a Hubble expanding 3-space solution that in a parameter-free manner manifestly fits the recent supernova data, and in doing so reveals that “dark energy”, like “dark matter”, is an unnecessary notion. The Hubble solution leads to a uniformly expanding universe, and so without acceleration: the claimed acceleration is merely an artifact related to the unnecessary “dark energy” notion. This result gives an older age for the universe of some 14.7Gyr, and resolves as well various problems such as the fine tuning problem, the horizon problem and other difficulties in the current modelling of the universe.

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