Universe Expansion by Blackbody Radiation

Thomas Prevenslik
Discovery Bay, Hong Kong, China

1. Introduction and Theory

Hubble redshift as proof of an expanding Universe has been shown [1] to be invalid because of cosmic dust particles (DPs). However, the Universe for other reasons may still is expanding. Indeed, the DPs may be considered to be the dust of cold dark matter in the Standard Model of modern cosmology. The Standard Model is a homogeneous mix of DPs in a spherical bath of Cosmic Microwave Background (CMB) radiation. Generally accepted as a first approximation for the evolution of the Universe, the Standard Model does not include stars or clusters of galaxies because such objects are much denser than the typical part of the Universe. The Standard Model is governed by the Friedmann equations,

$$\left(\frac{\ddot{a}}{a}\right)+\frac{\kappa c^2}{a^2}-\frac{\Lambda c^2}{3}=\frac{8\pi G}{3}\rho \tag{1}$$

$$2\frac{\ddot{a}}{a}+\left(\frac{\dot{a}}{a}\right)^2+\frac{kc^2}{a^2}-\Lambda c^2=-\frac{8\pi G}{c^2}p \tag{2}$$

where, a is the scale factor of size, κ is the curvature, G is the gravitational constant, and c is the speed of light. The pressure p and density ρ are functions of time, but otherwise uniform throughout the Universe. An equivalent pair of equations for the Standard Model is,

$$\dot{\rho}=-3\frac{\dot{a}}{a}\left(\rho+\frac{3p}{c^2}\right) \tag{3}$$

$$\frac{\ddot{a}}{a}=-\frac{4\pi G}{3}\left(\rho+\frac{3p}{c^2}\right)+\frac{\Lambda c^2}{3} \tag{4}$$

Accelerated expansion $\ddot{a} > 0$ of the Universe in (4) is observed to occur by either specifying a scalar field pressure, $p < -\rho c^2/3$ or through a positive cosmological constant $\Lambda > 0$. Expansion is taken as positive $\ddot{a}$ acceleration while collapse is negative.

Currently, dark energy is thought [2] to cause the expansion of the Universe. Sometimes called the Zero Point Field (ZPF), dark energy is the field equivalent of the Zero Point Energy (ZPE) that corresponds to the ground state of atoms and molecules. Unlike the ZPE that has been verified in numerous experiments, the ZPF has never been measured. Instead, the measurement of Casimir forces between a pair of parallel plates in a vacuum is inferred as proof of the existence of the ZPF or dark energy in the gap between the plates. But the forces measured in Casimir experiments have been explained [3] by the room temperature blackbody (BB) radiation emitted from the atoms in the surfaces of Casimir's plates. Similarity arguments therefore allow the hypothesis that the dark energy thought causing the expansion of the Universe based on the redshift of Supernovae light to also be explained by BB radiation at the CMB at 2.725 K.

The purpose of this paper is to show the dark energy
thought to be the source of Universe expansion is BB radiation at 2.725 K.

However, BB radiation as the source of Universe expansion is required to somehow produce a repulsive force between any pair of DPs in the typical Universe that exceeds the force of gravitational attraction. Astronomers [2] ignore the spotty WMAP data to conclude the uniformity of CMB radiation after the Big Bang as evidence net repulsion is precluded from all DPs in the typical Universe. However, the spotty CMB is consistent with the emission from atoms in the DPs not yet in thermal equilibrium at 2.725 K – not from the remnants of the Big Bang in the vacuum. Uniform CMB radiation is not consistent with the Big Bang occurring at a single point, but rather uniformly throughout the Universe. Today, the fact that the CMB radiation is spotty means the atoms in all DPs in the typical Universe are in near thermal equilibrium at 2.725 K.

BB radiation producing repulsion [4] between a pair of DPs is caused by scattering of CMB radiation even though the pair is assumed to be in a uniform thermal bath. Although the repulsion is consistent with uniform CMB radiation everywhere, there is a more fundamental reason, and that is every DP in the typical Universe emits spherical BB radiation that acts as pressure on other DPs to produce a repulsive force in opposition to the gravitational attraction. Regardless, the repulsive force between the DP pair by scattering is the same as that by radiation pressure, both of which mediated by the square of the separation R. For DP pairs having areas A_i and A_j, the repulsive force F_γ produced is,

$$F_\gamma = \frac{A_i A_j}{4\pi R^2} U \tag{5}$$

where, U is the BB energy density of space. In terms of the temperature T,

$$U = \frac{8\pi h}{c^3}\int_0^\infty \frac{\upsilon^3 d\upsilon}{\exp\left(\frac{h\upsilon}{kT}\right)-1} = \frac{8\pi^5 k^4}{15(hc)^3} T^4$$

which gives the Stefan-Boltzmann constant σ in terms of the BB energy density,

$$\sigma = \frac{c}{4T^4} U = \frac{2\pi^5 k^4}{15 c^2 h^3} \tag{6}$$

The gravitational attraction force F_G between the pair of masses,

$$F_G = \frac{m_i m_j G}{R^2} \tag{7}$$

where, G is the gravitational constant. Hence, the net force F between the mass pair is,

$$F = F_\gamma - F_G = \frac{A_i A_j}{4\pi R^2} U - \frac{m_i m_j G}{R^2} = \frac{m_i m_j}{R^2}\left(\frac{U}{4\pi}\frac{A_i A}{m_i m_j} - G\right) \tag{8}$$

For pairs of spherical DPs having $A = A_i = A_j = \pi r^2$ and $m = m_i = m_j = 4\pi\rho r^3/3$, where r is the DP radius, the same mass density ρ gives,

$$\frac{A}{m} = \frac{A_i}{m_i} = \frac{A_j}{m_j} = \frac{3}{4\rho r} \tag{9}$$

Combining,

$$F = \frac{m_i m_j}{R^2}\left[\frac{1}{4\pi}\left(\frac{3}{4\rho}\right)^2 \frac{U}{r_i r_j} - G\right] \tag{10}$$

In the present epoch at T = 2.725 K, the energy density $U = 4.16\text{x}10^{-14}$ J/m^3. Taking a 0.25 micron radius DP which is the accepted [5] upper bound size of DPs having density ρ = 2200 Kg/m^3 gives the net force F

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$$F = \frac{m_i m_j}{R^2}\left[6.15\text{x}10^{-9} - 6.67\text{x}10^{-11}\right] \tag{11}$$

Hence, $F = F_\gamma - F_G > 0$ and all DP pairs in the typical Universe are repulsed from each other. However, the repulsion diminishes if one DP in the pair is larger than the other. For $G = 6.67\text{x}10^{-11}$ m^3/Kg-s^2, Fig. 1 shows the net pair force F between the 0.25 micron radius DP is repulsive only if the larger DP has radius r < 35 m. For larger DPs that we commonly observe on earth, the repulsion tends to vanish allowing gravitational attraction to dominate the net DP pair interaction.

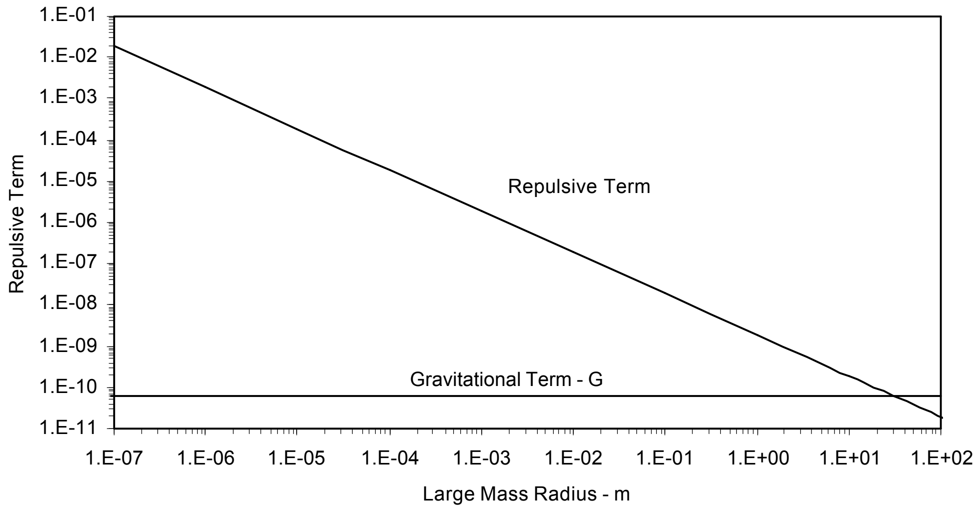

Fig. 1 Repulsion of 0.25 micron DP by Large DP Mass

In the present epoch, the typical Universe embodied by a dust cloud of submicron DPs is governed by a repulsive net force $F > 0$, although F decreases with the square of the separation R. Since a Universe comprising all 0.25 micron radius DP pairs is repulsive, it can only be concluded the Universe is expanding, but certainly not at the rate given by the Hubble law. With regard to Universe collapse, the repulsive force F_γ begins as $T \to 0$. Subsequently, the temperature might be expected to increase eventually leading to the next Big Bang – not from nothing as claimed now by cosmologists, but rather by the collapse of the Universe on itself.

The BB cosmological constant Λ is,

$$\Lambda = \frac{4\pi G}{c^2} U = \frac{32\pi^6}{15} \frac{Gk^4}{c^5 h^3} T^4 \tag{12}$$

In the present epoch with the CMB at 2.725 K, the cosmological constant, $\Lambda = 3.12 \times 10^{-40}\ s^{-2}$. Based on measurements by the *High-Z Supernova Team* and the *Supernova Cosmological Project* [6-7] the value of the cosmological constant is given [8] as $\Lambda \approx 10^{-35}\ s^{-2}$. Since $\Lambda > 0$, the Friedmann equations suggest the Universe is expanding by BB radiation at 2.725 K even though DPs negate [1] the redshift in the Hubble law.

2. Numerical Simulations

In the Friedmann equations, the expansion rate of the Universe assumes the recession velocities are given by Doppler's effect for the redshift of supernovae light. However, if cosmic dust negates [1] the notion of redshift as the basis for converting redshift of supernova light to expansion rate by Doppler's effect.

How then may the expansion rate of the Universe be estimated?

Numerical simulations of DPs allow an estimate of the Universe expansion using Newtonian mechanics for a cubical box in a molecular dynamics (MD) analysis. The MD simulation was based on a Fortran 77 program called the "Leap-frog" algorithm given in Allen-Tildesley [9]. The MD box located at the center of the cloud of DPs comprised a total of 500 DPs arranged in a face-centered-cubic (FCC) lattice corresponding to the Universe mass density $\rho_U = 5 \times 10^{-27}$ Kg/m^3. Taking the DPs to be spherical of radius r = 0.25 micron amorphous silicate having density 2200 Kg/m^3, each DP has a mass $m = 1.44 \times 10^{-16}$ Kg. The MD simulation box therefore had sides $L = [500m/\rho_U]^{1/3} \sim$ 24000 m with the spacing between DPs corresponding to ~ 3024 m. This is far larger than the MD box used in atomic and molecular analysis. Moreover, MD analysis is usually conducted using periodic boundary conditions, but for the purposes here to understand how DP pair-wise interactions cause expansion and collapse in the Friedmann dust model, periodic boundary conditions were not used.

Typically, Lennard-Jones interactions between atoms and molecules are used in MD analysis. But for the simulation of the dust cloud embodied in the Friedmann equations, the pair-wise repulsive - attractive force between DPs given in (11) was used. It is noted the force is repulsive if the temperature T is sufficiently high, but becomes attractive if the temperature vanishes. Only 2 bounding simulations were run, the first at T = 0 that corresponds to a collapse from the initial FCC lattice to a small region and the second the expansion of the collapsed region that tends to approach the initial configurations.

The MD simulation of collapse for a few DPs is illustrated in Fig. 2. The time is in billions of year giving the time of Universe collapse for DPs at 18000 m to be about 0.34 billion years and a rate < 1.5×10^{-12} m/s.

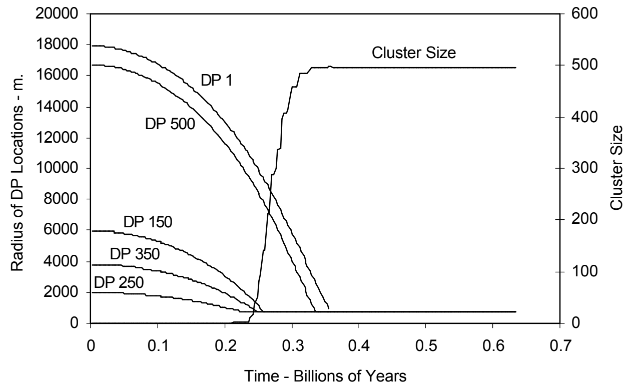

Fig. 2 Universe Collapse at Temperature T = 0 K and Cluster Radius = 750 m

A time step of 5×10^{11} s was necessary to resolve the collapse The MD simulation gives the collapse based on clustering of DPs within a cluster radius of 750 m to be about 0.23 billion years. In contrast, the Friedmann equations do not give any insight to the collapse rate of the Universe compared to the expansion rate because the Big Bang is assumed to occur instantaneously from nothing.

The MD simulation of expansion shows expansion velocities far smaller than given by Hubble's law of 82 km/s-MPc which at 1 MPc corresponds to a rate of 82 km/s. Nevertheless, the MD expansion rate was found to be 10x greater than the MD collapse rate. This may be expected from (11) in that independent of the separation distance R, the repulsion at T = 2.725 K produces a net force F that is as at least 3 orders of magnitude greater than that by gravitational attraction. The MD simulation in expansion was performed at a time step 10x smaller than for collapse. The Universe expansion is illustrated in Fig. 3.

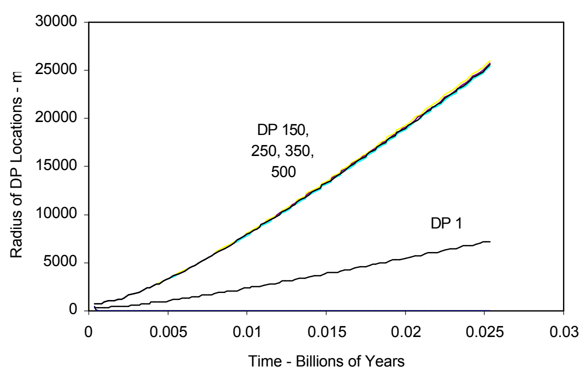

Fig. 3 Universe Expansion at Temperature T = 2.725 K from Cluster Radius = 750 m

The expansion of the DPs is observed to not follow the same path as the collapse. All DPs were in a FCC lattice at the beginning of the collapse, but sufficient randomization occurs within the cluster at the end of the collapse so that a return to the FCC locations is not possible. The expansion in Fig. 3 shows DPs 150, 250. 350., and 500 expand at a similar but higher rate compared to DP1. The average expansion rate of 25000 m in 0.025 billion years corresponds to about 3×10^{-11} m/s.

3. Discussion

3.1 Equilibrium between Radiation and Gravitation

Of interest is the temperature T at which the net force F between DPs vanishes marking the beginning of gravitational collapse. Fig. 4 gives the DP radius r is given in terms of temperature T,

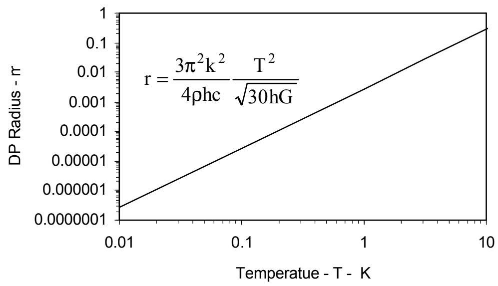

Fig. 4 Balance of Gravitation and Radiation Forces

For the DP range [5] from 0.005 to 0.25 microns, Fig. 4 shows T < 0.01 K are required to balance gravitational attraction. At this time, the Universe would be considered static.

3.2 Universe Expansion Rate

The Universe expansion rate can be estimated by considering the MD simulation box of sides L located at the center of the Universe. Since the DP flux must be conserved in the radial direction, the velocity V at the Universe radius R is related to the velocity v at the edge L/2 of the MD simulation box,

$$V = \left(\frac{L}{2R} \right)^2 v \tag{14}$$

Assuming the Universe is spherical of radius R = 1×10^{10} light years ~ 3×10^{25} m, the MD simulation box having L = 24000 m and velocity v = 3×10^{-11} m/s gives V ~ 1×10^{-43} m/s, an almost imperceptible rate. \

3.3 Collapse Temperatures

The Big Bang is assumed to produce high temperatures instantaneously. But high temperatures may also be produced in the collapse of the static Universe. Consistent with the Friedmann equations, an adiabatic collapse is assumed. Fig. 5 shows for a Universe radius Ro = 3×10^{25} m and temperature To = 2.725 K, the temperature T increases to over one million K with only 2 orders of magnitude reduction in the Universe radius.

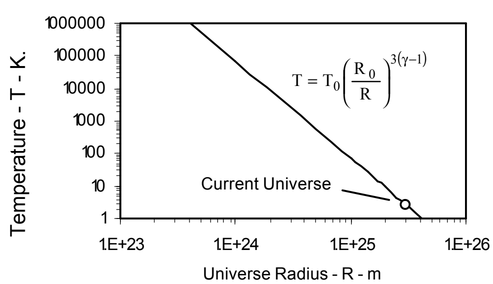

Fig. 5 Collapse Temperatures

4. Conclusions

- The Friedmann equations embody the typical Universe as a cloud of submicron DPs. Massive objects such as stars and galaxies are excluded in the typical Universe.

- The typical Universe is shown not to collapse on itself as once thought by Einstein. With the CMB at 2.725 K, the net pair-wise forces between radiation and gravitation are shown to produce a net repulsive force, thereby suggesting an expanding Universe but certainly not at Hubble velocities. Whether the net force is repulsive or attractive is independent of their separation distance, but the magnitude of the net force decreases by the square of the separation distance.

- The Universe expansion velocities based on the MD analysis are imperceptibly small, so as to suggest a static Universe first proposed by Einstein. To avoid a collapsing Universe, Einstein introduced the cosmological constant only later to retract it as unnecessary once Hubble presented redshift data that showed the Universe was expanding. Had Einstein questioned Hubble's finding, he might have reverted to his earlier position that the Universe is static in dynamic equilibrium with itself.

- The BB cosmological constant is found to be on the order of 10^{-40} s^{-2} and is reasonably close to the values predicted due to dark energy. But this may be irrelevant because the MD simulation based on Newton's equations or from the Friedmann equations for a static Universe do not depend on the cosmological constant.

- Friedmann equations are usually solved with the boundary condition of the Hubble expansion velocity. But solutions of the Friedmann equations based on the cosmological constant alone give a static Universe.

- Gravitation is predicted to balance the radiation pressure as CMB temperatures are lowered from 2.725 K to about 0.01 K at which time the Universe begin to collapse. In the Big Bang, high temperatures are produced at a single point. However, significant temperature increases occur in a static Universe for a collapse in Universe radius of only two orders of magnitude.

- The negation of an expanding Universe based on the redshift of Supernova light in DPs is consistent with the imperceptible velocities in the MD simulation for a static Universe.

- The Big Bang most likely did not begin from nothing, but if it occurred at all was caused by the imperceptible collapse of the Universe on itself.

References

[1] Prevenslik, T. "Dark energy and cosmic dust," Informally presented at the "Invisible Universe Conference, Paris, 28 June – 3 July, 2009.
[2] Alimi, J-M, "Invisible Universe Conference: Toward a new cosmological paradigm," Palais de l'Unesco, Paris 29 June – 3 July, 2009.
[3] Prevenslik, T. "Casimir Force by Blackbody Radiation," www.nanoqed.org, 2009.
[4] Dinculescu, A. "On a repelling force between particles in a bath of thermal radiation," Astrophys Space Sci. (2007) 310, pp. 281-4.
[5] Weingartner, J.C. and Draine, B.T., "Dust Grain Size Distributions and Extinction in the Milky Way, large Magellanic Cloud, and Small Magellanic Cloud," AsJ, 548, 296, 2001.
[6] Riess, A.G., et al., *Astronom. J.* 116, 1009, 1998. (astro-ph/9805201)
[7] Pearlmutter, S., et al., *Nature* 391, *Astrophys. J.* 51, 1998. (astro-ph/9812133)
[8] Carmeli, M. and Kuzmenko, T., "Value of the Cosmological Constant: Theory versus Experiment," arXiv:astro-ph/0102033 v2, 4 Feb 2001.
[9] M. P. Allen and D. J. Tildesley, *Computer Simulation of Liquids*, Clarendon Press - Oxford, 1987.