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A Simple Estimate for the Mass of the Universe: Dimensionless Parameter A and the Construct of "Pressure"

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Abstract

Employing a simple model for "pressure", a solution of 10^{52} kg for the mass of the Universe was obtained which was identical in orders of magnitude to both empirical estimates and different theoretical solutions derived from more complicated equations. The transforming coefficient was within the error margins of the dimensionless parameter A employed to constrain dark energy models. Application of this mass to Schwarzchild's equation for singularity indicated that about 19% of the universe, now presumed to be dark matter, would meet this criterion. Dimensional analysis requires the mass of the universe to increase as its four-dimensional representation expands.

Introduction

Quantification of the mass (M) of the Universe is one of the most challenging problems of physical cosmology. Paul Dirac (1947) assuming a zero-curvature, concluded the mass of the Universe was finite and could be described by a large dimensionless number $N=10^{78}$ that could be referenced to the mass of a hydrogen atom. That solution is within the order 10^{51} kg. More recently the value of 10^{52} kg has been reported by Lauroesch (1998) who averaged masses and distributions of densities of stars and by Kolombet (1995) who employed the physical constants of the electron. Although contemporary approaches to physical cosmology have emphasized the complexity of mathematical descriptions, convergence of quantitative solutions from simple applications of universal functions might also be revealing.

A Simple Estimate of the Mass of the Universe

If the relationships between velocity, density and pressure are generalizable from mechanical to electromagnetic forces, then the "pressure", P, of the Universe might be estimated. An adequate description of the present Universe has been argued to require a cosmic substratum characterized by negative pressure (Balakan, et al., 2003) and geometric terms in fourth-order gravity. The simplest equation for pressure is $P = c^2 d$ where c is the speed of light and d is density. For this calculation the average density of space was assumed to be equivalent to 1 proton per m^3 or 1.672×10^{-27} kg/m^3. This estimate was based upon the assumed average of 1 proton/cc within galactic space (Wyatt, 1964) and the estimated distances between galaxies.

The calculated value for this "pressure" is 15.027×10^{-11} kg/m s^2. This numerical value is within the order of magnitude of the Newtonian Gravitational Constant (G) of 6.672×10^{-11} m^3/kg s^2. For the units for pressure to be equivalent to the units of G, kg/m s^2 must be multiplied by 0.444 m^4/kg^2 to obtain m^3/kg s^2. This relationship suggested that the quadruplication of the extension of the Universe must be equivalent to the square of its mass if its pressure and gravitation are intercalated. The value 0.444 is remarkably similar to the dimensionless parameter A (Weinberg, 1989; Wu and Yu, 2007), measured between .452 and .458, which has been employed to constrain models for dark energy and reflects a peak found in baryonic acoustic oscillations (Wu and Yu, 2007).

To obtain m^4 the multiplication of four metric dimensions was required. This was achieved by multiplying values for the three dimensions of space by the product of the speed of light and time [(m/s) x s=m]. If the Universe is expanding at the speed of light and the universe is in the order of 10 billion years old or 1 x 10^{10} yr x 3.156 x 10^{7} s/yr or 3.156 x 10^{17} s old, light would have travelled to 3.00 x 10^{8}m/sec x 3.156 x 10^{17} s or 9.467 x 10^{25} m from its origin or within a diameter of 18.934 x 10^{25} m.

The quadruplication (m^4) of this value would be 12.851 x 10^{104} m^4 and for unity to be obtained (m^4/kg^2) the metric must be divided by 12.851 x 10^{104} kg^2. This means the mass is 3.585 x 10^{52}kg. However, when multiplied by .444 the identity for this aggregate would be 5.654 x 10^{104} and hence the required mass would be 2.378 x 10^{52} kg. These calculated values are identical in powers of 10 to that estimated empirically by J. Lauroesch (1998) who based his measurements upon the mass of the sun, the estimated numbers of stars within a galaxy, and the estimated numbers of galaxies in the Universe.

Convergent Validity

The value 10^{52} kg is also rationally related to fundamental units and constants. For example, the product of the constants of the three pervasive forces of the Universe, u_o (permeability of a vacuum, 1.26 x 10^{-6} N/A^2), e_o (permittivity of a vacuum, 8.85 x 10^{-12} C^2/N m^2 and G (gravitational constant, 6.67 x 10^{-11} N m^2/kg^2) is 74.38 x 10^{-29} m/kg. If this metric is multiplied by the estimated mass of the Universe, 2.378 x 10^{52} kg calculated from the above assumptions, the resulting length is about 1.769 x 10^{25} m.

This is within an order of magnitude of the estimated width of the Universe. The discrepancy with various estimates of the width of the universe, based on older estimates of age such as 13.2 billion years, would involve only minute variations in the coefficients of the three constants throughout the volume of the universe. Interestingly, the "pressure" of 15.027 x 10^{-11} kg/m s^2 multiplied by the estimated volume of the universe (in the order of 1.131 x 10^{78} m^3) results in a total energy value (1.700 x 10^{68} J) that is within the same order of magnitude as the total energy equivalence of the mass of 2.378 x 10^{52} kg (2.140 x 10^{69} J).

The value for mass derived from m^4 did not adjust for any intrinsic oblateness of universal space. If the space was similar to galaxies such that the depth is in the order of one-tenth of the width, then the adjusted value would be .900 x 10^{102} or .949 x 10^{52} kg or after first multiplication by .444, .632 x 10^{52} kg. This would result in a length of .470 x 10^{25} m or about 4% of its integrated length.

The congruence may suggest the existence of shared but "hidden variance" within the principles that determine the properties of all increments of space and time within the Universe. However the caveat is they may also reflect the intrinsic circularities predicted by Gödel's incompleteness theorem within the basic units and fundamental constants, G, c, and h (Planck's constant). The minimum and maximum limits of space and time are often calculated or inferred from these values (Mansfield and Malin, 1976).

Conclusions and Implications

The "pressure" model implicit to these calculations generates three important implications. First, most of the mass is distributed along the outer periphery of the Universe. This inference would be supported by the calculations and conclusions of Varshni (1976). This gradient of mass density would suggest the presence of an opposing source of "pressure" that is outside, surrounding the Universe, and directed inward.

The existence of an opponent process might be revealed because of the dark energy component with negative pressure (Copeland et al, 2006). The simplest candidate for dark energy is the cosmological constant (Peebles and Ratra, 2003) whose value is within the range of error of the value 0.444. It was required for the simple equation for dynamic pressure to be related to the gravitational constant developed here.

Secondly, if the powers of ten for m^4/kg^2 are identities, the mass of the Universe must continue to increase if its four dimensional extension increases. Although many cosmologists study the past evolution of the Universe, there is theoretical and conceptual relevance to considering the future evolution of the Universe

(Islam, 1977; Hoffman et al, 2007). The results of this simple model suggest that, as proposed by Milne and reported by Singh (1961), the actual mass of the ultimate universe is infinite unless there is some as yet unknown boundary condition that is followed by a period of contraction.

Third, the implication that most of the mass would be distributed along the periphery of the Universe and the source of this mass gradient originates from outside of the boundary becomes more significant when the Schwarzchild equation of 2 MG/c^2 for the radius of a singularity is applied. If the value for the mass of the Universe is employed, then the radius is double the quotient for the product of 2.378×10^{52} kg x 6.67×10^{-11} m^3/kgs^2 divided by 9×10^{16} m^2/s^2 or 3.530×10^{25} m. This order of magnitude approaches the estimated radius of the Universe assuming it is 10 billion years old (the value assumed for the calculation of its mass).

From this perspective, about 19% of its linear extent, i.e., 3.530×10^{25} m divided by 9.467×10^{25} m) could be a singularity. On the other hand if the assumed oblateness factor is considered in the calculation of m^4, the radius would be $.938 \times 10^{25}$ m which is about 4% of this integrated metric. It may not be coincidence that measurements support a universe containing approximately 4% baryons, 75% dark energy and 21% dark matter (Hoffman et al, 2007).

The similarity of the order of magnitude for the estimated mass of the universe with other approaches and the internal consistency of the results presented here can be interpreted as a support for their validity. Convergence of quantitative solutions from simple applications of universal functions may continue to be revealing.

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