A Possible Theoretical Mass of the Universe Calculated Using The Friedman Dust Universe Model with Einstein's Lambda

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1 Abstract

A theoretical value for the total positively gravitating mass of the universe is implied by the mathematical structure of the dust universe model. A simple formula is obtained that gives the value of this mass quantity in terms of Newton's gravitational constant, G, the Cosmological constant or Einstein's Lambda, Λ, and the velocity of light, c. This result depends on taking a fundamental view of an epoch time conditioned relation, obtained earlier, between the universe's content of positively gravitating mass density and the universe's content of negatively gravitating mass density, $\rho_{\Lambda}^{\dagger} = 2\rho_{\Lambda}$, where the last quantity mentioned is Einstein's dark energy density. The value obtained is approximately $2.00789 \times 10^{53}\ kg$, The approximation aspect depends on the currently measured or assumed values for G and Λ.

Keywords: Cosmology, Dust Universe, Dark Energy, Dark matter
Cosmological Constant, Friedman Equations
General Relativity, Newton's Gravitation constant

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2 Introduction

The work to be described in this paper is an application of the cosmological model introduced in the papers *A Dust Universe Solution to the Dark Energy Problem* [23], *Existence of Negative Gravity Material. Identification of Dark Energy* [24] and *Thermodynamics of a Dust Universe* [33].

All of this work and its applications has its origin in the studies of Einstein's general relativity in the Friedman equations context to be found in references ([16],[22],[21],[20],[19],[18],[4],[23]) and similarly motivated work in references ([10],[9],[8],[7],[5]) and ([12],[13],[14],[15],[7],[25],[3]). The applications can be found in ([23],[24],[33],[37],[35][41]). Other useful sources of information are ([17],[3],[31],[27],[30],[29]) with the measurement essentials coming from references ([1],[2],[11],[38]). Further references will be mentioned as necessary. In the following pages, I shall demonstrate that the dust universe model can be used to arrive at a formula for the total positively gravitating mass of the universe. This is achieved with the help of a time conditioned relation between positively gravitating mass and the negatively gravitating mass now thought to pervade the whole universe and described by Einstein with his cosmological constant Λ. The following theory structure from the dust universe model is required for this project.

The density functions for positively gravitating mass, dark energy and the ratio, $r_{\Lambda,DM}(t)$, of dark energy to positively gravitating mass $\rho(t)$, as functions of time are respectively represented by

$$\begin{aligned} \rho(t) &= (3/(8\pi G))(c/R_\Lambda)^2 \sinh^{-2}(3ct/(2R_\Lambda)) && (2.1)\\ \rho_\Lambda^\dagger &= (3/(4\pi G))(c/R_\Lambda)^2 && (2.2)\\ r_{\Lambda,DM}(t) &= \rho_\Lambda^\dagger/\rho(t) = 2\sinh^2(3ct/(2R_\Lambda)) && (2.3)\\ r_{\Lambda,DM}(t_c) &= 2\sinh^2(3ct_c/(2R_\Lambda)) = 1 && (2.4)\\ t_c &= (2R_\Lambda/(3c))\coth^{-1}(3^{1/2}) \approx 2.1723367\times 10^{17}\ s. && (2.5) \end{aligned}$$

The time t_c at which the acceleration changes from negative to positive is given by equation (2.5) above. This time is a fundamental constant which only depends on Λ and c and notably does not depend on mass. The two equations (2.1) and (2.2) which together imply (2.3), I now see as spatially *local* fundamental properties of space time in the dust universe model. All the structure of this model can be obtained form these two equations by at least two different interpretations of the positively gravitating mass density function $\rho(t)$. The original interpretation of this density in the full universe context is to associate it with a volume, $V_U(t)$, and an *arbitrary input constant mass* quantity, M_U, for the universe of the form

$$\begin{aligned} \rho(t) &= M_U/V_U(r(t)) && (2.6)\\ V_U(r(t)) &= \frac{4\pi}{3}r^3(t) && (2.7) \end{aligned}$$

so making it possible to locate the form and dependence on time of the radius, $r(t)$, of the expanding or contracting universe. This is the sense that I now see the first two equations as fundamental. Given next is the structure for the radius of the universe $r(t)$ that can be deduced from above for the positive time branch of the theory.

$$\begin{aligned}
r(t) &= (R_\Lambda/c)^{2/3}C^{1/3}\sinh^{2/3}(3ct/(2R_\Lambda)) && (2.8)\\
b &= (R_\Lambda/c)^{2/3}C^{1/3} && (2.9)\\
C &= 8\pi G\rho(t)r^3/3 = 2M_U G && (2.10)\\
R_\Lambda &= |3/\Lambda|^{1/2} && (2.11)\\
r(t) &= b\sinh^{2/3}(3ct/(2R_\Lambda)) && (2.12)\\
r^3(t_c) &= (R_\Lambda/c)^2 M_U G. && (2.13)
\end{aligned}$$

Firstly, let us see how far the two equations (2.1) and (2.2) can be interpreted regarding them as fundamental. The expression for my version of dark energy density, (2.2), which is in fact twice Einstein's version, presents directly no physical interpretational clue. In fact both versions are equally puzzling. However, if we invoke the dimensional structure of the gravitation constant, G,

$$G = M_G^{-1}L_G^3T_G^{-2} \tag{2.14}$$

expressing G in terms of suitably powered mass, length, and time constant parameters giving the value of G, it is clear that two of the parameters can be chosen at random leaving the third to be determined by the expression (2.14). Thus let us make the choices $L_G = R_\Lambda$ and $T_G = R_\Lambda/c$ leaving M_G to be determined by the original expression for G,

$$\begin{aligned}
G &= M_G^{-1}R_\Lambda^3(R_\Lambda/c)^{-2}) && (2.15)\\
&= M_G^{-1}R_\Lambda c^2 && (2.16)\\
M_G &= \frac{R_\Lambda c^2}{G} && (2.17)\\
r^3(t_c) &= (R_\Lambda)^3\frac{M_U}{M_G}. && (2.18)
\end{aligned}$$

The last but one entry above gives the consequent value for M_G necessary to ensure that G remains invariant in value under these substitutions. The last entry gives the value of $r^3(t_c)$, (2.13), in terms of the new parameters.

In the next display, I give the form that Einstein's version of the dark energy density takes followed by the form that my version of the dark energy density takes in terms of the substituted parameters

$$\rho_\Lambda = M_G/(8\pi R_\Lambda^3/3) \tag{2.19}$$

$$\rho_\Lambda^\dagger = M_G/(4\pi R_\Lambda^3/3). \tag{2.20}$$

There is no issue here as to which of these two versions is correct. They are both correct but represent different aspects of the dark energy spatial material. Einstein's version is a raw energy density describing physically his mathematical Λ term from the stress energy momentum tensor in his field equations. My version is the pressure enhanced version required by the stress energy momentum tensor to fully describe the gravitational effect of dark energy and gives the value of positive energy density (2.20) for effective negatively gravitational mass everywhere and for all time. Einstein's version (2.19) is correctly half this value. Thus the physical meaning for both of the versions is clearly represented in terms of the new parameters. The expression (2.20) states that the effective physical dark energy density is equal to having a mass quantity M_G enclosed in a desitter volume of size $V_\Lambda = 4\pi R_\Lambda^3/3$. The formula (2.20) for $\rho_\Lambda^\dagger$ is a very definite and simple result giving information about the universe's astro-space character and our knowledge of its value is only restricted by the accuracy with which we know by measurement or otherwise the constants G and Λ. From the interpretation of the dust universe model using (2.6) and (2.7) together with an arbitrary value of the positively gravitating mass within the universe boundary, M_U, say, let us the consider the formula (2.3) taken at epoch time, $t = t_c$, the time when the universe has zero radial acceleration. At that time, the formula reduces to

$$M_U/V_U(r(t_c)) = \rho(t_c) = \rho_\Lambda^\dagger = M_G/(4\pi R_\Lambda^3/3) \tag{2.21}$$

$$= M_U/(4\pi R_\Lambda^3 M_U/(3M_G)) = M_G/(4\pi R_\Lambda^3/3). \tag{2.22}$$

The last equality in (2.21) giving the alternatively expressed density obtained earlier and because $r^3(t_c) = R_\Lambda^3 M_U/M_G$ by (2.18). Taking into account both equations we see that a change in the value of the mass of the universe in the formulae can be made consistently provided the change in value of $r(t_c)$ that is involved in the change of parameters is taken into account. However, it is also clear that taking the definite and fixed value M_G

for the mass of the universe in place of the original M_U, some what arbitrary though informed choice, does make some simplification. In particular $r(t_c) = R_\Lambda$ is the result. Using the same sequence of steps in the case of a primitive galaxy, which is just an un clumped region of definite amount of mass M_g in a volume V_g at time t_c, say, we get

$$M_g/V_g(r(t_c)) = \rho(t_c) = \rho_\Lambda^\dagger = M_G/(4\pi R_\Lambda^3/3) \quad (2.23)$$

$$= M_g/V_g(R_{\Lambda,g}) = M_g/(4\pi R_{\Lambda,g}^3/3). \quad (2.24)$$

Taking into account both equations above, in this case, because $r(t_c)$ equals a smaller radius, $R_{\Lambda,g}$, it follows that

$$M_G/(4\pi R_\Lambda^3/3) = M_g/(4\pi R_{\Lambda,g}^3/3) \quad (2.25)$$

$$\Longrightarrow \frac{M_g}{M_G} = \left(\frac{R_{\Lambda,g}}{R_\Lambda}\right)^3, \quad (2.26)$$

which is the sensible statement that the ratio of the mass of a galaxy to the mass of the universe is equal to the ratio of the volume of a galaxy to the volume of the universe at time t_c. Thus the amount of mass used in the formalism is arbitrary and the formalism gives consistent results provided account is taken of all relevant facets.

3 Conclusions

The dust universe model can be used to calculate a theoretical value for the mass of the universe. This quantity of mass is represented above as

$$M_G = \frac{R_\Lambda c^2}{G} = \left(\frac{3c^4}{\Lambda G^2}\right)^{1/2} \approx 2.00789 \times 10^{53}\ kg. \quad (3.1)$$

I cannot claim that the value of M_G *is* the mass of the universe. Any very large quantity of mass will work in the formalism because the formalism can describes any packet of cosmologically conserved region of *substratum* mass over epoch time. However, the quantity of mass M_G is quite definite in value and it does give a clear physical explanation of the dark energy density $\rho_\Lambda^\dagger$, picking up the physically significant version of this quantity, rather than the less physically significant Einstein version. Another thing in its favour is that it confers on the radius of the universe at time, t_c, a definite and special status, $r(t_c) = R_\Lambda$, which goes well with the special and invariant status of the time t_c itself. M_G is about a power of ten larger than some estimates I have seen. Of course, I would like it to turn out to be the actual mass of the universe. Only time will tell.

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