A Thermal Basis for Gravitational Quantum Vacuum Polarization Descriptive Account of a Fundamental Process in a Friedman Dust Universe with Einstein's Lambda

James G. Gilson j.g.gilson@qmul.ac.uk
School of Mathematical Sciences
Queen Mary University of London
Mile End Road London E14NS

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1 Abstract

A descriptive account is given for the dust universe Friedman lambda model of the universe developed earlier from general relativity by the present author. This description is wrapped around a new and very simple derivation of the model from first principles. The mathematics of this derivation rests on two classical physical equations, the formula for black body radiation and Newton's inverse square law of gravitation, so that without its descriptive wrapping the new derivation which does not involve general relativity directly would occupy about one page of this paper. The descriptive aspect is devoted to showing how the dust universe model can be decomposed into a many subunit form where each galaxy is seen as being a thermal cavity subunit. The time evolution of the whole universe can consequently be seen as being a bundling together of the thermal cavity elements to make up the time evolution structure of the whole universe. Finally, a cosmological Schrödinger equation derived earlier by the present author is significantly generalised to make possible individual quantum state descriptions of the separate galactic thermal cavity elements. Some possible future generalisations of the structure are discussed.

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* [32]. 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],[32],[36],[34][40]). Other useful sources of information are ([17],[3],[30],[27],[29],[28]) with the measurement essentials coming from references ([1],[2],[11],[37]). Further references will be mentioned as necessary.

3 The Dust Universe Model

I have given a detailed mathematical model of the Friedman dust universe in a sequence of papers starting from reference *A Dust Universe Solution to the Dark Energy Problem*([23]). This model has structure that involves the current pressing issues arising in modern cosmological theory. The structure of this theory depends heavily on the idea of dark energy and Einstein's Lambda in the context of gravitational vacuum polarization. Every aspect of this theory depends on Λ to the extent that, if Λ is put equal to zero in the mathematics of the theory, the theory also vanishes. The theory is rigorously a solution to Einstein's field equation and is related to a theoretical structure put forward by Abbe Georges Lemaître [25] in 1927. However, the irony here is that although Lemaître is said to be the father of the Big Bang, my version of this theory is not of the big bang type. This oddity suggests that he did not know about the negative time branch of the theory he put forward. My version of this theory is a substantial generalisation of his theory, involving vacuum polarization with Einstein's lambda playing the fundamental role in the structure. The theory has a complete *gravitational* vacuum theoretical basis which I hope will ultimately merge with the idea of vacuum polarisation in quantum field theory. The mathematics of this vacuum structure as worked out earlier will here be used to set the whole theory onto the idea of a physical *emergent* from the vacuum picture and at the same time retaining energy conservation intact. A driving motivation has been to construct a theory with roots into the quantum theory of matter and consequently involves the quantum zero-point energy idea. In previous papers this theory has been worked out in great mathematical detail. Here I

shall use that mathematical structure as a guide to re-derive the theory from first principles starting from a basic classical thermal equation in the original structure and Newton's inverse square law of gravity. From this new point of view the physics of the system becomes very clear and the basis takes on the form of a more classical intuitively acceptable structure in contrast with its more esoteric and mathematically complex general relativistic form.

4 The Thermal Basis

From classical thermodynamics comes the equation for the *mass density*, $\rho_\Gamma(t)$, associated with a blackbody radiation system

$$\begin{aligned} \rho_\Gamma(t) &= aT^4(t)/c^2, && (4.1)\\ a &= \pi^2 k^4/(15\hbar^3 c^3), && (4.2)\\ &= 4\sigma/c, && (4.3) \end{aligned}$$

where σ is the Stephan-Boltzmann constant,

$$\begin{aligned} \sigma &= \pi^2 k^4/(60\hbar^3 c^2), && (4.4)\\ &= 5.670400 \times 10^{-8} \quad W\ m^{-2}\ K^{-4}. && (4.5) \end{aligned}$$

This well established formula is considered applicable to bounded systems, say a spherical volume of fixed radius, containing electromagnetic radiation. The simplest physical image under which the *black body* radiation formula is thought to hold is when the radiation cannot escape but rather is always reflected back towards the spherical interior. The effect is produce a local random field of electromagnetic radiation and consequently to produce a local spatially uniform energy density of radiation at *rest* within the volume. Assuming Einstein's, $E = mc^2$, law always holds, the consequence is that the mass density above is generated from the thermal activity within the volume. Thus *rest mass* is generated from a thermal system despite the fact that the individual photons of which the system is partially composed have no rest mass. Clearly, the mass production process is a consequence of containment. A time varying temperature can occur provided, as indicated, the density function also changes with time. The formula above is said to represent the physics of a thermal cavity so that, if I use the formula above in the astronomical context, it is necessary that I explain what form the appropriate thermal cavity takes in astrophysics. However, to explain this

fundamental facet it is best that I start from what seems to me to be the simplest collection and structure of ideas on which the dust universe model can be based. It has turned out that although in the first place the theory for this model came from Einstein's general relativity it can, alternatively be based on classical Newtonian Gravitational theory with a minor extension. This extension is the addition to the Newtonian concept of gravitating mass which is positive and self attractive the idea that a form of mass can occur which is positive but can be *negatively gravitating*, in the sense that it is self repulsive and also repels Newtonian mass. Thus in this theory to distinguish the two types of mass in this work I shall add a plus or minus superscript to specify the type of any positive mass quantity. Thus m^+ and m^- are both positive quantities, the first having an attractive gravitation effect on all other masses in its vicinity and the second having a repulsive gravitating effect on all other masses in its vicinity. Clearly the first, m^+, is the usual gravitating mass of Newtonian theory. It is also convenient to denote the gravitational acceleration inducing strengths of the two types of particle by $G^+ = +G$ and $G^- = -G$ respectively. It is possible to make important deductions about the two types without any mathematical theory. The negatively gravitating particles as a consequence of their mutual repulsivity character will spread out, whereas the positively gravitating particles as a consequence of their mutual attractivity will tend to clump or form assemblies. Of course both these possibilities will take time for any equilibrium to be reached. The fact that the two types of particle have *opposite sign* gravitational influence implies that the gravitational interaction between the two types of particle can cause equilibrium configurations between them. This can be explained as follows. Consider a 3-sphere containing normal gravitating Newtonian particles with a total fixed mass, M. The contents of this sphere can contain a variety of mass sized particles distributed within in it in any way. Further let this sphere be immersed in a cloud of negatively gravitating particles, meaning that these negatively gravitating particle can be within or outside the sphere. There will be the two tendencies at work of spreading and clumping with passage of time conditioned by the spread of the negative gravitating particle being impeded by the gravitational attraction of the positively gravitating particles within the sphere acting against the spread. It seems reasonable to expect an equilibrium state can be reached when the spread is a uniform static field of negative gravitating particles with some arbitrary field of clumped

positively gravitating particle within the confines of the sphere which itself could continue to change volume while containing the fixed total of positively gravitating mass, M, possibly rearranged. Such rearrangements are possible because only the total mass of the sphere determines its external gravitational field. Assuming the centre of the sphere is its mass centre, an inwards towards the centre of the sphere, source of pressure P_Δ from the positive gravitating material within the sphere balanced by an outwards pressure P_Λ from the negatively gravitating mass material, (4.6), would likely imply an equilibrium configuration of the type discussed above,

$$P_\Delta + P_\Lambda = 0 \tag{4.6}$$

$$P_\Delta(t) - P_\Gamma(t) + P_\Lambda = 0 \tag{4.7}$$

where P_Δ does *not* depend on t so that it is consistent with the non time dependence of P_Λ. However, an equilibrium described by (4.6) does not seem to take into account the thermal photonic field involved in the formula (4.1). When we do take into account an electromagnetic component as part of the positively gravitating material within the sphere which is the situation being developed here, the component P_Δ needs to be replaced with $P_\Delta(t) - P_\Gamma(t)$, the Γ pressure being preceded with a minus sign as in (4.7) with the Δ pressure term now also taken to be time dependent. This substitution is to add the negative outward pressure that the photonic pressure would cause. This is necessary as $P_\Gamma(t)$ is defined as usual as a positive quantity but to agree with the negativity assigned to P_Λ it also has to appear with a minus sign. This may seem like sign gymnastics but it all arises because of the convention used in cosmology that positive pressure is taken to cause the inward acceleration, towards source, of normal Newtonian gravity inducing particles. Physically this addition simply means that the outward photonic pressure makes the normal inward pressure time dependent and shields it so causing the inward normal pressure to be reduced in strength. Thus the photons might be described as contributing pseudo negative gravity. It should also be recognised that even if the pressures concerned are considered to be only within the sphere their effects are transferred via Newton's gravitational law to cause an acceleration field at all positions outside the conceptual sphere defined earlier. This last effect also occurs in general relativity. In the dust universe cosmology model the theory involved a three dimensional hyper-space in which all the action is played out with time. This space is no geometrical abstraction but rather

can be taken to be our familiar three space in which we look out from earth to see the stars and in which the astronomers use their telescopes to survey distant galaxies. We can take this space also to contain a minutely small density distribution of those negatively characterised particles mentioned earlier, just a few such particles per cubic meter. There is probable no more than one such particle within the human body at any moment of time. This same 3-space will be used here involved as the back ground for the thermal cavity described earlier. Thus generally mass accumulations such as planets, stars and galaxies can be represented by thermal *hot spots*, more accurately spherical regions or bounded spherical cavities with thermally active interiors, in a sea of negatively gravitating particles at temperatures greater than the temperate given by formula (4.1), this hotspot idea will be explained in more detail later. Thus the thermal cavity can be used to represent partially isolated sub-mass accumulated parts of the whole universe changing under their own dynamics. Thus the whole universe, if such a concept is meaningful, becomes a maximally large thermal cavity. This hot spot idea can be put onto a formal basis using the start formula (4.1) in a modified form that fits this cosmological application,

$$\rho(t) = \rho_\Lambda^\dagger \left(\frac{T(t)}{T(t_c)}\right)^4 \tag{4.8}$$

$$\rho(t_c) = \rho_\Lambda^\dagger \tag{4.9}$$

$$t_c = \frac{2R_\Lambda}{3c}\coth^{-1}(3^{1/2}). \tag{4.10}$$

In the formula above, $T(t)$ is the temperature at general time t after the singularity at time zero, The time t_c is when the universe's radial acceleration is zero, $\approx 10^9 yrs$, and $T(t_c)$ is the constant temperature of the negatively gravitational particles whose spatially uniform and time constant mass density function is given by $\rho_\Lambda^\dagger$ and has a value that is twice Einstein's dark energy density, $\rho_\Lambda = \Lambda c^2/(8\pi G)$,

$$\rho_\Lambda^\dagger = \frac{\Lambda c^2}{4\pi G}. \tag{4.11}$$

From (4.8) we see that if the observation time is $t = t_c$ then the mass distribution density, $\rho(t)$, is just equal to the negatively gravitating particle mass density background, $\rho_\Lambda^\dagger$. It also follows that for temperatures $T(t) < T(t_c)$ the region concerned is at a lower temperature than the negatively gravitat-

ing particle mass density background or in other words that the temperature is higher relative to absolute zero Kelvin rather than higher relative to the background density. The background is just few degrees Kelvin above absolute zero. We are now in a position to explain the nature of the thermal cavity that underlies the definition of the positively gravitating particle mass density $\rho(t)$, 4.8. Consider the thermal mass density formula (4.9). There are at least two simple ways that this formula can be interpreted. We can describe the density function as representing a condition within a fixed volume V of a variable amount of mass $M(t)$ such as

$$\rho(t) \implies \rho_{M(t)} = M(t)/V. \tag{4.12}$$

Such an interpretation of the density function $\rho(t)$ could be useful in some contexts but a thermal cavity bounded by the constant volume V would not be a closed dynamical system in any sense because its mass contents would be not conserved with time but necessarily be moving through its boundary. Thus if we are to have a thermal cavity with a conserved mass content, then we must use a different interpretation for $\rho(t)$. Let us interpret a hot spot as a spherical region centred at the mean position of a total and constant quantity of mass M, say, thermally supported according to the formula (4.8) then the density function on the left $\rho(t)$ can be written as $\rho_M(t)$ and then more specifically we have

$$\rho(t) \implies \rho_M(t) = M/V_M(t), \tag{4.13}$$

where $V_M(t)$ is a *conceptual* spherical space volume containing all the quantity of mass, M, and which will clearly have to change with time if M is taken to be constant with the passage of time. I use the term conceptual here because this volume is defined rather than being given as a measurable quantity. Thus we now have a fixed amount of mass in a varying volume so that we can take the mass M as constituting what in general relativity is often call the *substratum material!* or a dust like distribution that spreads out uniformly with the changing volume. Of course, if such a volume is expanding then the mass density will get smaller or conversely on contraction the density gets larger. Thus effectively the outer spherical surface of the changing size sphere represents a spherical boundary suitable for defining the thermal cavity as being the enclosed volume. We can represent the spherical volume $V_M(t)$ in terms of a *conceptual* time dependent radius

vector $r_M(t)$, such that

$$V_M(t) = \frac{4\pi}{3} r_M^3(t). \tag{4.14}$$

In fact, the thermal cavity can have any enclosing boundary which has a centre of volume coincident with the centre of mass of the sphere and the same volume as the sphere because all the volumes involved contain a uniform mass distribution at any given time. Using equation (4.8) and its inverted form at (4.19) and also using equation (4.14) we have

$$\frac{M}{V_M(t)} = \rho_\Lambda^\dagger \left(\frac{T(t)}{T(t_c)}\right)^4 \tag{4.15}$$

$$M = M_\Lambda^\dagger(t) \left(\frac{T(t)}{T(t_c)}\right)^4 \tag{4.16}$$

$$M_\Lambda^\dagger(t) = V_M(t)\rho_\Lambda^\dagger \tag{4.17}$$

$$\frac{4\pi r_M^3(t)}{3M} = \frac{1}{\rho_\Lambda^\dagger}\left(\frac{T(t_c)}{T(t)}\right)^4 \tag{4.18}$$

$$r_M^3(t) = \frac{3M}{4\pi\rho_\Lambda^\dagger}\left(\frac{T(t_c)}{T(t)}\right)^4 \tag{4.19}$$

$$\frac{\rho_M(t_c)}{\rho_M(t)} = \frac{V_M(t)}{V_M(t_c)} = \frac{r_M^3(t)}{r_M^3(t_c)} = \left(\frac{T(t_c)}{T(t)}\right)^4. \tag{4.20}$$

The situation now is that within the time variable spherical volume $V_M(t)$ there is the constant amount of positively gravitating mass M given by (4.16). Also within this same volume there is the time variable amount of negatively gravitating mass $M_\Lambda^\dagger(t)$. Thus the radial Newtonian gravitational accelerating field due to both these influences at or just outside the volume at time t is

$$\ddot{r}(t) = -M_\Lambda^\dagger(t)G^-/r^2(t) - MG^+/r^2(t) \tag{4.21}$$

$$= 4\pi r^3(t)\rho_\Lambda^\dagger G/(3r^2(t)) - C/(2r^2(t)) \tag{4.22}$$

$$= 4\pi r(t)\rho_\Lambda^\dagger G/3 - C/(2r^2(t)) \tag{4.23}$$

$$= r(t)c^2\Lambda/3 - C/(2r^2(t)) \tag{4.24}$$

$$C = 2MG^+ = 2MG \tag{4.25}$$

If we multiply equation (4.23) through by $\dot{r}$, we obtain

$$\begin{aligned}
\ddot{r}(t)\dot{r}(t) &= 4\pi r(t)\dot{r}(t)\rho_\Lambda^\dagger G/3 - C\dot{r}(t)/(2r^2(t)) && (4.26)\\
\frac{d}{dt}\dot{r}(t)^2/2 &= \frac{d}{dt}r^2(t)\Lambda c^2/6 + C\frac{d}{dt}r^{-1}(t)/2 && (4.27)\\
\dot{r}(t)^2 &= (r(t)c)^2\Lambda/3 + Cr^{-1}(t) && (4.28)
\end{aligned}$$

The constant of integration that could occur in integrating (4.27) can be taken to be zero under the conditions that $\dot{r}(t)$ is taken to be infinite with $r(t) = 0$ at $t = 0$. Thus the spherical region expands with high speed from the origin, $r(t) = 0$ at time $t = 0$.

The solution to the differential equation (4.28) was obtained in paper A in the form

$$\begin{aligned}
r(t) &= b\sinh^{2/3}(\pm 3ct/(2R_\Lambda)) && (4.29)\\
R_\Lambda &= (3/\Lambda)^{1/2}. && (4.30)\\
b &= (R_\Lambda/c)^{2/3}C^{1/3} && (4.31)
\end{aligned}$$

and so using (4.29) with (4.20) we get the relations

$$\begin{aligned}
\frac{\rho_M(t_c)}{\rho_M(t)} = \frac{V_M(t)}{V_M(t_c)} &= \left(\frac{T(t_c)}{T(t)}\right)^4 = \left(\frac{\sinh(\pm 3ct/(2R_\Lambda))}{\sinh(\pm 3ct_c/(2R_\Lambda))}\right)^2 && (4.32)\\
\rho_M(t) &= \rho_\Lambda \sinh^{-2}(\pm 3ct/(2R_\Lambda)). && (4.33)
\end{aligned}$$

At this point the problem of finding the detailed description of the model is completely solved the fundamental equation for this solution, (4.29), is the formula for the radius of the thermal cavity at time t. From this formula all elements of the structure of this theory can be obtained by differentiation or algebraic manipulation as for example (4.32) and (4.33) were obtained. In particular, Hubble's time dependent space-wise constant is obtained as

$$H(t) = \frac{\dot{r}_M(t)}{r_M(t)} = (c/R_\Lambda)\coth(\pm 3ct/(2R_\Lambda)). \qquad (4.34)$$

5 Cosmological Thermal Cavities

Above I showed that the dust universe model can alternatively be derived from simple classical theory and expressed its structure in terms of thermal

cavities. The first question that arises is, how can this alternative theory be used in the astronomical context? The thermal cavity construction structure introduced above is a rigorous consequence of general relativity and it is also a local theory rather than a global cosmological theory. Local in the sense that it can be used to replace the usual global cosmology type by an *assembly* of *thermal cavities*. All such thermal cavities can be taken to be expanding as part of a global substratum. Thus there is an obvious choice for one type of physical representation of these thermal cavities. This first choice is the galactic unit. Galaxies on the average, isolated from forces other than gravity, move with the substratum flow. In fact, their motion can be regarded as defining the substratum flow. Clearly, much space wise smaller astronomical objects could be used to define astronomical thermal cavities but I shall confine the discussion here to the galactic unit. The other characteristics of galactic existence are their overall identity persistence over very long periods of epoch-time with constant total mass to a high order of accuracy.

The $\rho(t)$ that I am using can be explained by studying the three equations from earlier repeated below

$$\rho(t) = \rho_\Lambda \sinh^{-2}(\pm 3ct/(2R_\Lambda)). \tag{5.1}$$

$$\rho(t) \implies \rho_M(t) = M/V_M(t) \tag{5.2}$$

$$M/V_M(t) = \rho_\Lambda \sinh^{-2}(\pm 3ct/(2R_\Lambda)). \tag{5.3}$$

The equation (5.1) for $\rho(t)$ from the dust universe model sums up accurately all that is known physically about the expansion of the universe with epoch time, t. It is thus a very fundamental quantity and, curiously, apart from its dependence on t it only has a dependence on Einstein's Λ, the velocity of light c and G through Einstein's dark energy density, ρ_Λ. Importantly, it also does not depend on position, it is spatially homogeneous. Notably, this formula contains no mention of any quantity of mass , M, there is no such involvement at all. I first introduced this formula as a description of the density evolution for the whole universe. However, having found that this formula can be derived from Newton's theory of gravity it became clear that it is applicable to the problem of the time evolution of sub-regions of the universe. Clearly a galaxy is a large sub-region of the universe so that galaxies are natural structures on which this formula can be tested. In the second formula above I introduce a density $\rho_M(t)$ and take it equal to $\rho(t)$, the density of the universe and this then implies equation

(5.3) from which, given a definite amount of mass, M, the definite time dependent mass associated volume, $V_M(t)$, can be found. Thus if $M = M_U$, the mass of the universe, we get the time evolution density of the universe $\rho_{M,U}(t)$ and if $M = M_{galaxy}$, the mass of a galaxy, we get the time evolution of the galaxy density, $\rho_{M,galaxy}(t)$ from the formula. It is this associate definite time dependent volume associated with a galaxy of known mass that I take to be the volume of its bounding thermal cavity. From this discussion it follows that the mass densities of galaxies are all equal at the same cosmological time t for this model, but they do differ in mass content and volume with the definition of volume that I am using. This leads to a very convenient explanation for how the galaxies became separated off from each other as isolated masses over time. Up to now, I have taken the mass M contained within this conceptual volume $V_M(t)$ to be uniformly distributed within the boundary of this volume, an assumption involved in the generation of formula (5.1). However, I have also taken this total contained mass to be positively gravitating and so that *physically* it will clump with time passage and cease to be uniformly distributed. Thus the expanding volume boundary will separate from the contained mass within, so that with sufficient time this mass will occupy a volume, $V_{M,clumped}(t)$, substantially less than $V_M(t)$. Measurements will likely pick up the volume, $V_{M,clumped}(t)$, for a galaxy and so it will be ascribed a physical density larger than $\rho_M(t)$ assuming the mass has been measured accurately. Returning to the question of galactic distribution, we can infer that if initially at time just greater than the singularity time, $t = 0$, at which time it becomes possible to talk about volume, we can assume all the mass in the universe was uniformly distributed over the then small volume. The volume of the universe could then be considered partitioned into a very large number n of contiguous randomly different sized sub-volumes, very approximately $n \approx 10^{11}$, say, with the uniform mass distribution remaining unchanged by the partitioning. Every sub volume would have the same density as the whole universe. These sub-volumes with their various valued constant with time mass content could have been the seeds of the galaxies we see today having evolved with time according to the formula, (5.3), with additionally clumping to their separate centres of mass and with density only changing with the epoch time in unison with the density change of the whole universe with time. There is no provision for clumping in the original formula (5.3) and there is no need for their to be. This formula simply expresses the same Newtonian

gravitational feature that given a spherical region centred at the centre of mass of a spatially *variable* mass density of total mass M, the gravitational field at the boundary or just outside this boundary is the same as would exist if the mass M was *uniformly* distributed over the volume within the same boundary. It is tempting to refer to a thermal cavity that represents a galaxy as a three space hot spot or hot region but to do this it seems we need to use a physically measured temperature, $T_{phys,galaxy}(t)$, say for which we can say within the region of the galaxy $T_{phys,galaxy} > T(t)$. This is because $T(t)$ like $\rho(t)$ is a uniform over space quantity as can be seen from (4.32) and also is a 3-space temperature giving the temperature throughout the universe of all elements of the moving positively gravitating substratum which does not take into account local variations of temperature that would occur due to the presence of a galaxy which will be clumped with time. However, it is necessary to find some way of importing variable space position mass density distributions into the theory in order to include the effects of clumping. A way that this can be achieved is shown in the next section.

6 Cosmological Schrödinger Equation

In reference ([40]), I showed that the whole theory for the dust universe model can be obtained as a quantum density $\rho_{nl}(t)$ from the standard general Schrödinger equation (6.4) with the condition $\nabla^2\Psi_{nl,\rho}(\mathbf{r},t) = 0$ and the external potential $V(\mathbf{r},\mathbf{t})$ replaced with the feed back term $V_C(t)$ given at (6.2).

$$\frac{i\hbar\partial\Psi_{nl,\rho}(t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi_{nl,\rho}(\mathbf{r},t) + (V_C(t))\Psi_{nl,\rho}(t) \tag{6.1}$$

$$V_C(t) = -(3i\hbar/2)H(t) \tag{6.2}$$

$$H(t) = (c/R_\Lambda)\coth(\pm 3ct/(2R_\Lambda)) \tag{6.3}$$

$$i\hbar\frac{\partial\Psi(\mathbf{r},t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},t) + V(\mathbf{r},\mathbf{t})\Psi(\mathbf{r},t). \tag{6.4}$$

$H(t)$ above is the Hubble function from the dust universe theory. Here I shall generalise equation (6.1) by instead of replacing $V(\mathbf{r},\mathbf{t})$ with $V_C(t)$ in (6.4) , I shall add it and drop all the subscripts to give

$$\frac{i\hbar\partial\Psi(\mathbf{r},\mathbf{t})}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},t) + V(\mathbf{r},\mathbf{t})\Psi(\mathbf{r},t) + V_C(t)\Psi(\mathbf{r},t). \tag{6.5}$$

I now claim that the Schrödinger equation (6.5) is a general cosmological Schrödinger equation. Clearly it differs from the normal general Schrödinger equation at (6.4) in that it has a special external potential of the form $V_S(\mathbf{r},\mathbf{t}) = V(\mathbf{r},\mathbf{t}) + V_C(t)$ and is only non general in the very weak sense that it has an additional time only dependent part. Let us now consider solutions to the cosmological Schrödinger equation (6.5) with the special form

$$\Psi(\mathbf{r},t) = \Psi_1(\mathbf{r},t)\Psi_{nl,\rho}(t)). \tag{6.6}$$

Substituting this form into (6.5) and using the equation for $\Psi_{nl,\rho}(t)$ at (6.1) we get the result

$$\frac{i\hbar\partial\Psi_1(\mathbf{r},\mathbf{t})}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi_1(\mathbf{r},t) + V(\mathbf{r},\mathbf{t})\Psi_1(\mathbf{r},t). \tag{6.7}$$

Thus we have recovered the original general Schrödinger equation for the factor $\Psi_1(\mathbf{r},t)$ in equation (6.6). Consequently this factor can be any solution of that equation. Clearly the cosmological solutions of the cosmological Schrödinger equation embraces all possible quantum theory solutions to the usual general Schrödinger equation (6.7). The cosmological Schrödinger equation has the usual probability density that goes along with its solution of the form

$$\rho_S(\mathbf{r},t) = \Psi(\mathbf{r},t)\Psi^*(\mathbf{r},t) = \Psi_1(\mathbf{r},t)\Psi_1^*(\mathbf{r},t)\Psi_{nl,\rho}^2(t) \tag{6.8}$$

where $\rho_S(\mathbf{r},t)$ is a cosmological mass density with position variability of great generality which can involve all known solutions to the standard Schrödinger equation and any other solutions yet to be found. So that on this basis models of the universe can be found involving individually described galaxies of any known quantum internal structure bundled together to describe the whole universe in great detail. The model will allow galaxies to be described as cosmological hotspots.

7 Conclusions

The theoretical structure described above represents a strong unification of quantum mechanics and cosmology through the amalgamation of the cosmological Schrödinger equation from the Friedman equations originating general relativity and the general Schrödinger equation with an external

potential. The generality of the Schrödinger structure is in no way compromised by this unification so that the new cosmological version has all the variety of solutions available for cosmology as does its non cosmological form. What the theory does is to set up a cosmological platform strongly linked to the cosmological substratum which enables the mass content of the platform to be described in quantum mechanics terms. The cosmological Schrödinger equation above can be used to describe the whole or part of the universe and it can be involved in some obvious generalisations of the theory. The time evolution theory structure for any unit can be given it own time shifted coordinate so that its singularity moment has a distinctive value and it can also be assumed to originate from a distinct position in hyper-space. Many such elements could be bundled to give a different version of the total universe described above. Statistical assemblies of such bundles could be set up and then open the way for a more general cosmology based on quantum statistical mechanics. Such a move into statistical mechanics would ameliorate the difficult idea of a singularity at time zero by at least the same order of magnitude that success at searching for one needle in a haystack is improved by searching for 10^{11} needles in the same haystack. The new short derivation of the dust universe model is a surprising result as it depends only on classical concepts while confirming a structure from general relativity involving Einstein's Λ term. This seems to me to reinforce the validity and correctness of the Λ term apparently about which Einstein had such doubts.

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