PLANCK MASS PLASMA ROTON SOLUTION OF THE COSMOLOGICAL CONSTANT PROBLEM

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ABSTRACT

The failure by the large hadron collider to detect supersymmetry and the Higgs particle, suggests to replace supersymmetry with another fundamental symmetry, for example the symmetry of the Planck mass plasma where the vacuum is made up by an equal number of positive and negative Planck mass particles. The Planck mass plasma has for each mass component a phonon-roton spectrum and it can explain the observed small positive cosmological constant. The masses of the elementary particles are here explained by the gravitational field energy of pole-dipole particles, which explain Dirac spinors as composed from gravitationally interacting positive and negative masses.

1. INTRODUCTION

For the minimally supersymmetric standard model (MSSM) to agree with the experimental facts requires a miraculous fine-tuning of the cosmological constant by about 56 orders of magnitude to compensate the zero point vacuum energy. If the cosmological constant would be zero, the easiest way to avoid this problem would be to assume that the zero point energy is exactly cancelled by some still unknown principle. However this idea does not work because the observational evidence obtained from distant supernova explosions shows that the cosmological constant is not zero, but rather very small and positive [1, 2]. But a positive cosmological constant leads to an accelerated universal expansion. Furthermore, if the cosmological constant is set equal the energy density of the dark energy, this energy density is about of the same order of magnitude as the energy density of the matter in the universe at our moment in the history of the cosmic expansion. This appears to be a highly accidental coincidence, because the matter density decreases during the expansion unlike the cosmological constant which should remain constant.

It is the Planck mass plasma hypothesis [3, 4, 5] which not only can give a plausible explanation for this coincidence, but this hypothesis also permits to obtain a value for the cosmological acceleration parameter $q = \ddot{R}R / c^2$, where R is the world radius and $\ddot{R}$ its acceleration. The Planck mass plasma hypothesis replaces supersymmetry by the assumption that space is densely occupied with an equal number of positive and negative Planck masses. Following the "Zitterbewegung" analysis by Schrödinger of the Dirac equation [6, 7], it was shown by Hönl and Papapetron [8, 9, 10, 11] that with the assumed existence of negative masses one can derive the Dirac equation. Accordingly, all fermions would be composed of bosons, and supersymmetry would not be fundamental. With the mathematical apparatus by Bopp [12], to obtain bound state solutions of pole-multipole mass configurations, I was able to derive for the pole-dipole mass configuration a maximum of four excited states, making up a maximum of four families in the standard model [4,5].

With an equal number of positive and negative Planck masses the cosmological constant is zero as in supersymmetric theories and the universe euclidean flat. In its groundstate the Planck mass plasma is a two component positive-negative mass superfluid possessing a phonon-roton energy spectrum for each component. Assuming that the shape of the phonon-roton spectrum measured in superfluid helium is universal, this would mean that in the Planck mass plasma this spectrum has the same shape, with the Planck energy replacing the Debye energy in superfluid helium.

Rotons can be viewed as small vortex rings with the ring radius of the same order as the vortex core radius. A fluid with cavitons has a negative pressure, and the same is true for a fluid of vortex rings [13, 14, 15]. It is the centrifugal force which creates a vacuum in the vortex core, making a vortex ring to behave like a caviton with a negative pressure, which in accordance to Einstein's gravitational field equations causes an outward acceleration.

2. PLANCK MASS PLASMA HYPOTHESIS

With the Planck length $r_p = \sqrt{\hbar G / c^3}$ and the Planck force $F_p = c^4 / G$, the Planck mass plasma hypothesis makes the following assumptions [3, 4, 5]:

1. The ultimate building blocks of matter are Planck mass particles which obey the laws of classical Newtonian mechanics, but there are also negative Planck mass particles.
2. A positive Planck mass particle exerts a short range repulsive and a negative Planck mass particle a likewise attractive force, with the magnitude and range of the force equal to the Planck force F_p and the Planck length r_p.
3. Space is filled with an equal number of positive and negative Planck mass particles, with each Planck length volume in the average occupied by one Planck mass particle.

This hypothesis makes the following predictions:

1. Nonrelativistic quantum mechanics as an approximation with departures from the approximation suppressed by the Planck length.
2. Lorentz invariance as a dynamic symmetry for energies small compared to the Planck energy.
3. A spectrum of quasiparticles very much like the particles of the standard model, and beyond the standard models phonons and rotons.

It further leads to a solution for the problem of quantum gravity, with a finitistic (Non-Archimedean) formulation.

It was previously shown that the phonon-roton spectrum can explain the phonons as the dark energy and the rotons as the nonbaryonic cold dark matter [14]. And it will here be shown that it can even explain the magnitude of the cosmological acceleration.

3. SPINOR ROTONS

From the experimentally established phonon-roton spectrum in superfluid helium one obtains for the roton energy a value about 0.16 times the Debye energy. Replacing the Debye energy with the Planck energy $m_p c^2$, where m_p is the Planck mass, the mass of the rotons in the Planck mass plasma should be $m_r \approx 0.16 m_p$. In the two-component superfluid Planck mass plasma, there are positive and negative mass rotons $m_r^{\pm} = \pm 0.16 m_p$.

We now consider the gravitational interaction of a positive mass roton with a negative mass roton, separated by the distance r. For this (positive-negative) mass dipole the energy of the gravitational field is positive and with $m_r^{-} = -m_r^{+}$ given by

$$E = -\frac{G m_r^{-} m_r^{+}}{r} = \frac{G \left| m_r^{\pm} \right|^2}{r} \tag{1}$$

According to the mass-energy equivalence, this field has the mass

$$m = \frac{E}{c^2} = \frac{G\left|m_r^{\pm}\right|^2}{c^2 r} \tag{2}$$

A second equation is given by the uncertainty relation

$$\left|m_r^{\pm}\right| rc \simeq \hbar \tag{3}$$

Eliminating r from (2) and (3) one obtains

$$m = \frac{G\left|m_r^{\pm}\right|^3}{\hbar c} \tag{4}$$

or because of $Gm_p^2 = \hbar c$,

$$\frac{m}{m_p} = \left(\frac{\left|m_r^{\pm}\right|}{m_p}\right)^3 \tag{5}$$

With $m_r^{\pm} \simeq \pm 0.16 m_p$, one finds that $m/m_p \simeq 4\times 10^{-3}$, or $mc^2 \simeq 4\times 10^{16} GeV$. If the positive gravitational field mass is added to the positive mass of the mass dipole, one obtains a pole-dipole mass configuration from which one can derive the Dirac equation. It is the small residual mass *m* of the gravitational field which is the mass of a Dirac particle.

While without the mass of the gravitational field a mass dipole would lead to self-acceleration, a pole-dipole configuration leads to a helical motion, along the helix reaching the velocity of light. It is from this configuration that one can derive the Dirac equation. We therefore call this configuration a spinor roton, and suggest that the non-baryonic cold dark matter is made up of it.

The much lighter elementary particles of the standard model are in a likewise way made up from much smaller pole-dipole configurations of lower energy quantized vortex configurations of the Planck mass plasma [3, 4, 5].

4. COSMIC ACCELERATION

The cosmic expansion can be compared with the expansion of a hot gas in a Laval nozzle. If at the beginning of the expansion the temperature of the gas is T, and its specific heat at constant pressure c_p, the expansion velocity is given by [16]

$$\mathrm{v} = \sqrt{2c_p T} \tag{6}$$

With the specific heat ratio $\gamma = c_p/c_v$ we can write for (6)

$$\mathrm{v} = \sqrt{2\gamma c_\mathrm{v} T} \tag{7}$$

where

$$\gamma = \frac{2+f}{f} \tag{8}$$

and where f is the number of degrees of freedom for the molecules of the expanding gas. If the molecules of the expanding gas have only three translational degrees of freedom, one has with $f=3$, $\gamma=5/3$. But if they have in addition three rotational degrees of freedom, one has with $f=6$, $\gamma=4/3$. Therefore, if during the expansion the gas gives off some of energy stored in the three rotational degrees for the benefit of the translational degree of freedom, the expansion velocity is increased. But through the excitation of internal degrees of freedom in the molecules, by the excitation of electronic energy levels, f can become much larger. For $f=\infty$, one would have $\gamma=1$, and the expansion velocity would be increased even more.

For a gas of spinor rotons, where many Planck mass particles take part in the double vortex configuration the number of the internal degrees of freedom is likely to be very large, and we take $f=\infty$, whereby $\gamma=1$. After all the internally stored energy in the spinor rotons is consumed, the accelerated expansion comes to an end. It is this temporary acceleration which can mimic a small positive cosmological constant.

The conversion of rotational in translational energy is ruled by the second law of thermodynamics and can go as in a Carnot process at constant temperature. Here is it how it works: We differentiate (7) with regard to time keeping T constant:

$$2\mathrm{v}a = 2\dot{\gamma}c_{\mathrm{v}}T = \frac{\dot{\gamma}}{\gamma}\mathrm{v}^2 \qquad (9)$$

where *a* the acceleration of the expanding flow of rotons, hence

$$a = \frac{1}{2}\frac{\dot{\gamma}}{\gamma}\mathrm{v} \qquad (10)$$

in (10) we may put

$$\dot{\gamma} = \Delta\gamma / \tau \qquad (11)$$

where $\Delta\gamma$ is the difference for γ if f=3 and f=∞, and $\tau = R/c$ the age of the universe. For γ we take the average $\bar{\gamma}$ during the time τ:

$$\gamma = \bar{\gamma} = (\gamma + 1)/2 \qquad (12)$$

With γ=5/3 and setting v=c we find that

$$a = \frac{c^2}{R}\frac{\gamma - 1}{\gamma + 1} = \frac{1}{4}\frac{c^2}{R} \qquad (13)$$

For the non-dimensional acceleration parameter $q = \ddot{R}R/c^2$, we find by setting $a = \ddot{R}$, that *q*=1/4=0.25.

We compare this value with the measured values of q given by Caldwell and Kamionkowski [17]. For the redshift z=2, in the distant past, these authors obtain *q*=0.4, and for the present time *q*=-0.5. For z=1, somewhere in the middle, they find that *q*=0.25, as in our simple model.

5. CONCLUSION

According to Weinberg [18], the dark energy - small positive cosmological constant – problem is the most important unsolved problem facing elementary particles physics. String theories can accommodate a small cosmological constant only with great difficulty [19]. With a "string-landscape" of about 10^{500} possible universes, it means that our universe would have to be one of them where all the parameters of minimally supersymmetric standard model have the right value to make our existence possible. This seems very implausible.

The Planck mass plasma model, where supersymmetry is replaced by a plasma of positive and negative masses, and where physical reality is in the three space and the one time dimension as for all physics laboratories, has no difficulty to explain the dark energy and the small positive cosmological constant. The density of the phonos and rotons of this plasma decrease during the cosmic expansion in the same way as the density of ordinary matter. However, for the total amount of all the energies to add up to zero, requires that in the formation of the positive mass Dirac spinor rotons, and to a lesser degree the Dirac spinors of ordinary matter, negative energy must be carried away. This leads to the question, where did this negative energy go? One possibility is that it is located in the large voids separating the cluster of galaxies in the metagalaxy.

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