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Can quantum theory explain dark matter?

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Abstract. Certain solutions to a gravitational form of Schrodinger's equation can yield stable, macroscopic eigenstate solutions having no classical analogue, with properties resembling those of dark matter. Some more tractable solutions show: (1) radiative lifetimes far exceeding the universe's age, implying negligible emission and inherent stability w.r.t. gravitational collapse, (2) negligible interaction with EMR and visible matter, (3) potential to give rise to flat rotation curves and (4) eigenstate energies and 'sizes' consistent with that expected for the galactic halo. Traditional baryonic particles occupying such eigenstates will be invisible and weakly interacting, and may be assimilated into galactic evolution scenarios without significantly disturbing BBN ratios. It is proposed that such structures may explain the nature and origin of dark matter.

1. Introduction

Nesvizhevsky et al.(2002) have experimentally demonstrated the quantized nature of gravity and thus applying Schrödinger's equation to gravity should be valid in regions $r >> $ Schwartzschild radius r_s. There is nothing in quantum theory that forbids the existence of a 'macroscopic eigenstructure' formed from a plethora of the gravitational eigenstate solutions, populated with traditional particles, around a large central potential such as a massive primordial black hole (MPBH) $\geq 10^{35}$ kg, as predicted by Ashfordi, N., McDonald, P. & Spergel, D. N. (2003), the structure size limited only by the energy of the highest quantum eigenstate E_n approaching a suitably defined minimum binding energy. It is proposed that such structures might explain the nature and origin of dark matter, and form the 'wimp-like' skeletal basis of galaxies and clusters. Note that many experiments demonstrate a variety of macroscopic quantum effects (see for example Friedman et al. 2000) and superluminally connected quantum systems, macroscopically entangled over many kilometers (Zbinden et al. 2000).

2. Eigenstate Radiative Lifetime, Stability, Particle and Photon Interactions, Energy and Size, Density Profile

Relatively pure, high n, ℓ eigenstate solutions (large n Laguerre polynomials with $(\ell_{min}(\equiv n - p_{max}) \leq \ell \leq n-1$ and $n \leq 10^{34})$ have all the properties required for dark matter (Ernest 2001). $p_{max} \sim 10$ gives a sufficient number of eigenstates to accommodate the mass of dark matter in a galactic halo. Analysis shows:

(1) Radiative lifetime τ ($= (3\varepsilon_0 \pi\hbar c^3)/(\omega^3 p_{if}^2)$ where $p_{if} \equiv$ dipole matrix element $\langle i|e\mathbf{r}|f\rangle$) can be $> 10^6 t_0$ ($t_0 \equiv$ age of the universe) when $\ell \sim n$, resulting in long term structural stability, and inability to further gravitationally collapse.

(2) Low interaction rates with both particles and photons, which arises from the overlap integrals being negligible unless the state energy differences are virtually zero. This occurs because high n, ℓ states are closely spaced and, unlike their atomic counterparts, are sharply truncated and exhibit highly symmetric oscillations capable of causing effective cancellation whenever $(\ell, n)_{final}$ differs sufficiently from $(\ell, n)_{initial}$. For example, bound inelastic Compton scattering, the relevant inelastic scattering process here, is negligible through the overlap integral $\langle f|\mathbf{e}^{\imath(\mathbf{k}_i - \mathbf{k}_f)\cdot\mathbf{r}}|i\rangle$ (Jung 2000), unless $\mathbf{k}_i \approx \mathbf{k}_f$. Similar overlap integral arguments apply for stimulated transitions and most interactions between traditional 'visible' particles and those in relatively pure high n, ℓ eigenstates. Note also that the $p_{max} < 10$ eigenstate fraction is negligible in 'localized' particles.

(3) If high n states with $\ell_{min} \leq \ell \leq n-1$ and their z-projection sublevels are all filled, $1/r^2$ radial density profiles result, leading to flat rotation curves at outer galactic radii. Formation scenarios incorporating universal expansion and particle dynamics also suggest the possibility of shallower profiles at low r.

(4) A central potential mass $\sim 10^{42}$ kg gives an eigenstate radius r_n ($\approx b_0 n^2$, $b_0 \equiv$ Bohr radius equivalent) $\sim 10^{22}$ m, coincident with E_n approaching a suitably defined approximate minimum binding energy.

3. Discussion and Formation Scenario

Eigenstructures formed around MPBHs through a process of 'gravitational recombination', the fraction of matter ending up in relatively pure eigenstates depending on rate of universal cooling versus rate of expansion, and the rate at which matter could be retained in the concurrently forming gravitational wells. It appears that the MPBH mass is critical in determining the filling rate and hence final mass achievable before the recombination rate peters out due to expansion. Rough estimates suggest eigenstructure masses of $> 10^{42}$ kg are achievable with MPBH masses of 7×10^{35} kg. Galaxies formed later via standard gravitational collapse of the residual matter. Rough estimates suggest recombination ceased with 90 s and BBN ratios would not have been effected. In any case, the expected deviations from accepted BBN ratios in the high density asymmetry regions caused by MPBH potentials and formation process would be 'buried' in the eigenstructure and 'invisible' to modern BBN ratio measurements.

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