Gravitational Eigenstates in the Cosmos: The Answer to Dark Matter?

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Introduction
A wealth of observational astrophysics suggests a universe dominated by invisible, weakly interacting, yet unknown particles. The conventional theory surrounding this so-called Dark Matter and its associated cosmology (Lambda Cold Dark Matter - LCDM) has been very successful on the largest scales but ever increasing difficulties with observations suggest that some serious modification is needed at the cluster level and below. Additionally, despite enormous research effort, no suitably stable, weakly interacting particle has so far been detected. By adopting a quantum approach it may be shown that Dark Matter arises quite naturally in the universe, provided it is applied to an eigenstate mix characteristic of traditional localised particles. But a gravitational quantum approach additionally predicts new and exciting phenomena: the existence of certain non-classical 'dark' eigenstates; states which, when occupied even by ordinary visible baryonic matter, will render it stable, invisible and weakly interacting, automatically resulting in the production of Dark Matter. Importantly, it means also that an all-baryonic universe consistent with primordial nucleosynthesis might be possible. The theory is particularly appealing now that the existence of gravitational eigenstates has been verified experimentally[1].

A Weak Gravity Quantum Equation
Schrödinger’s equation may be recast into a suitably approximate form for weak gravity[2,3,4]. For large n, the low-p states of Figure 1 are weakly interacting irrespective of the Hamiltonian interaction potential or selection rule relaxation. The schematic in Figure 4 shows why this is so. Two types of transitions from an initial low-p state S are possible: (1) low-p→high-p crossings (small φ p→large φ p) or (2) high→low (large φ p→small φ p). Each case is forbidden: in (1), state separation occurs before significant energy or momentum changes occur; in (2), differences in spatial oscillation frequency (SOF) result in infinitesimal overlap integrals whenever energy or momentum changes are significant. The effectiveness of the SOF in nullifying overlap integrals is exemplified by the factor (p/2π)(L/n pnl m) in the radial dipole moment for p→l transitions. b nl ε p→nl m decreases because of the factor (p/2π) when np≫nl m.

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Example: Photon Scattering
Traditional (Raleigh or Compton) photon scattering off broad-eigensepectral, localised particles requires the spinor more general eigenstate transfer, but for low-p eigenstates that transfer is much more limited. As in the atomic case, momentum/energy changes in the scattered photon must be accompanied by corresponding conservation-preserving stimulated transitions in the eigenstate spectrum. Ernest[5] showed that the lifetime of a galactic, halo-baryonic photon is given by L / α γ S / npnl m, where L = npnl m/2, α is the photon frequency, photon bandwidth, halo volume, eigenstate density and dipole moment element respectively. Since npnl m decreases dramatically as np→∞, it was also shown[5] that for frequencies α ≪ npnl m corresponding to the transition ∆l = +1 and ∆p = +1 from the state n = 5 × 1014 s−1 to r = 10−14 m, so that scattering at these undetectably low frequencies is rapid. However the overwhelming influence of 1/ ∆p leads to r ≪ 1014 m when ∆p = 3, and for ∆p ≪ 4 the lifetime is much less than the halo transit time. Since detectable frequencies require ∆p ≫ 104 then clearly halos composed of low-p eigenstates will be completely transparent to any observable electromagnetic radiation.

The Dark Quantum States and Radiative Lifetimes
The high-n, low-p states lying along the leftmost diagonals of Figure 1 form the basis of Dark Matter. These lifetimes and weakly interacting nature progressively increase with increasing values of n. For example in Figures 2 and 3 we show plots of the states of dark electromagnetic dipole decay time as function radius and central mass for various reasonable binding energies (large compared to the cosmic background radiation energy ≈ 100 MeV) in the form of well depth and size. The increases in state decay time with size and mass reflect an analogous effect in the atomic case (Rydberg states). But with gravity wells, lifetimes can continue to increase because the central potential mass can be made arbitrarily large, to the point where large-sized states in deep gravitational potential wells can have lifetimes on the order of the age of the universe. For an enclosed mass of 10^20 kg, a = 1 proton-occupied state at typical outer halo radius of 10^23 m has a binding energy of ~400 eV and a lifetime of ~10^13 s, resulting in negligible emission and an inability to gravitationally collapse. High-p states do not have these long decay times.

Eigenstructure Formation
At the last phase transition (e+/e− at ~10^13 G) supermassive primordial black holes (SMPBH) 10^16–10^21 kg form[6]. With baryonic particle densities at this time 10^21 kg m−3, 0.01 slashes in the universe is expected to be composed of states of each of the form [6,7] n pnl m ≈ 10^40−10^50. The model accommodates eigenstructure masses 10^16–10^21 kg m−3. Low-p states act as regulators, but present day halos do not have a unique value.

Predictions
By their very nature the dark gravitational eigenstates are difficult to detect. The following require some possible exceptions: 1) production and scattering of the lowest electromagnetic frequencies (below present detection); 2) excess power in the WMAP anisotropy spectrum at l > 20000; 3) hot gas and x-ray radiation in galactic mergers; 4) halo-to-galaxy interactions; and 5) Dark Matter distribution expected to be symmetrical; 6) universal galactic magnetic field profiles; 7) some faint halo glow, possibly from Coulomb recombination or from scattering to low-l states; 8) non-cusp-like Dark Matter density profiles; 9) evidence of Dark/Matter conversion over cosmic time; 10) possible spatial variation of elemental abundances; 11) universal halo profiles; 12) an order of magnitude for the visible to total matter ratio.

Conclusion
In this paper we have presented an outline of the robust gravitational eigenstate theory of Dark Matter, and calculated trends in the electromagnetic dipole decay times of charged particles and dark gravitational eigenstates of the corresponding potential wells. The experimentally demonstrated existence of quantized gravitational states, and the observations of super-horizon quantum collapse processes, essentially demanded the existence of Dark Matter formed from traditional visible baryons as a direct and inevitable consequence of the theory - that Dark Matter being formed in the deep wells of horizon-mass primordial black holes created at the last (e+e−) phase transition. There is strong theoretical evidence that the gravitational recombination equilibrium sufficiently early to reduce the 'Maxwellian' baryon density to levels consistent with those expected for primordial nucleosynthesis ratios. Matter in the universe is essentially an incomplete recombining 'gravitational plasma' whose density has fallen so much that the gravitational recombination equilibrium corresponding to present day temperatures has never been achieved: the residual, gravitationally-uncombined, broad-eigensepectral matter at present day temperatures remains as the visible matter we observe today. It remains to carry out observations to detect the interesting new dark quantum states of gravity.