

# Making baryons dark: variation of cross section with approach to equilibrium

Allan D Ernest and Matthew P. Collins

Charles Sturt University,  
Locked Bag 588, Wagga Wagga, Australia, 2678  
email: aernest@csu.edu.au

**Abstract.** We show that as equilibrium is approached in deep gravity wells, such as those of galactic halos, gravitational quantum theory predicts that radial particle densities  $\rho(r)$  tend toward  $1/r^2$  profiles, and photon-baryon scattering cross sections are significantly reduced.

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I throw a baseball across the galaxy. Classical and quantum physics predict the same behavior for this localized macroscopic-massed object. This does not hold for un-coalesced protons and electrons however. In a quantum analysis, their properties come from a weighted summation over the wavefunction's eigenspectral ensemble. Deep gravity wells, such as those of galaxies, contain many *weakly interacting*, gravitational quantum states. These high energy ( $n$ ), high-angular-momentum ( $\ell$ ), energetically-favorable, halo-well gravitational quantum states are stable, weakly interacting and have radiative lifetimes  $\gg$  Hubble time (Ernest 2009, 2012). Einstein B coefficients for some high- $\ell$  states are  $10^{30}$  times less than for low- $\ell$  states. Substantial contribution of these states to a particle wavefunction leads to non-classical, counter-intuitive behavior: reduced cross sections by virtue of eigenspectral composition. Baryons with these eigenspectra can function as the weakly-interacting-massive particles (WIMPs) of cold dark matter (LCDM) theory.

We calculate equilibrium radial density profiles for arbitrary halo baryons, as predicted by quantum theory. The radial probability density distributions and eigenenergies of each of the gravitational eigenstates in the well, and their statistical weightings at equilibrium, are found from quantum theory. We then sum over the weighted eigenstate densities for each  $r$ . Remarkably, our analysis shows that all halo radial density profiles universally move towards  $1/r^2$  distributions as they approach equilibrium. That is, ordinary baryons form similar radial density profiles to dark matter at equilibrium. We also calculate interaction rates with approach to equilibrium. Direct calculation of transition rates from overlap integrals in  $1/r$  potentials at low- $n$  allow estimating rates in deep halo wells when they cannot be calculated explicitly. Averaging over the weighted equilibrium distribution then gives the average photon absorption cross section at equilibrium  $\sigma_{equil}$  which may be compared with that for a localized particle ensemble  $\sigma_{local}$ . We find that  $\sigma_{equil}/\sigma_{local} \approx 0.15$ , showing that “equilibrium” baryons in deep gravity wells are, on average, at least 6 times “darker” with respect to electromagnetic scattering than localized ones. Many of the individual high- $\ell$  states are so weakly interacting however, that if they were formed in the early universe, these super-dark WIMP-like states could still be trapped today.

## References

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