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Can the Cosmological Constant stabilize Galaxy Clusters?

JACKSON has proposed that the cosmological constant is negative, and so large as to stabilize the clusters of galaxies without "hidden mass"[1]. But if we explain the stability of clusters of galaxies in this way, the entire universe must implode during the time taken for one galaxy to cross a cluster once; this conclusion is independent of the Hubble constant, and the motions in the clusters would arise mainly from the Hubble expansion itself, since there is no time over which to define a steady state.

The cosmological constant acts so as to provide a gravitational force in local Newtonian coordinates that increases linearly with distance r from the local Newtonian origin, like a simple harmonic oscillator. Specifically, the equivalent potential is $-\frac{1}{6}\lambda r^2$, as can be seen from Jackson's first equation. When λ dominates Jackson's virial theorem reduces to the statement that the mean kinetic and potential energies are equal for a simple harmonic oscillator. The quasi-Newtonian picture holds to all distances, and the curvature radius $R(t)$ of the whole universe obeys the equation

$$\mathrm{d}^2R/\mathrm{d}t^2 = +\tfrac{1}{3}\lambda R \qquad (1)$$

when the mass density and pressure are negligible compared with the cosmological constant. The extra contribution of matter to the long-range attractive force can only shorten the time scale. Because the frequency of a simple harmonic oscillator is independent of amplitude, and because the cosmological constant is the principal source of binding in Jackson's models, the time taken for a galaxy to traverse a cluster equals the time for one oscillation of the whole cosmos. Jackson noted the short ages of his models, and proposed to reduce the Hubble constant. This would indeed allow a long time for stellar evolution, but all length scales change together in such a way that the equality of transit time and oscillation time is preserved.

Application of the virial theorem rests on the assumption that the system studied is in a steady or quasi-steady state. Such a state is not applicable to a system which has existed for less than the time required for one member to cross it. The difficulty is that in applying the virial theorem to a cluster of galaxies, we assume that the dispersion of velocities in the system exceeds the velocity obtained by multiplying its diameter by the Hubble constant, and that this dispersion serves as a measure of some kind of contrast between the cluster and the cosmos as a whole. If the masses of the galaxies represent only a small perturbation on the cosmic force law, it seems proper to assume that their deviation from a pure Hubble motion is small. In this view, models with large negative cosmological constant would involve one simple self-similar oscillation, with all distances obeying the same law (equation 1).

If we assume that the "mass discrepancy" in clusters of galaxies is an artefact, resulting from optical superposition of galaxies at many distances undergoing Hubble motion, we must explain the apparent spatial concentration of galaxies in clusters. If we believe that there is indeed an excess velocity dispersion in clusters, we must give some basis for its origin, for the cosmological constant is universal and cannot act selectively in local regions.

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Possible Method for determining the Planck Constant of Cosmic Photons

SOME years ago, Bahcall and Salpeter[1] suggested that photons arriving from distant quasi-stellar objects (QSO) might not have the same Planck's constant, h, which we normally measure in the laboratory. In particular, they suggested a test which could be used to determine a dependence of h on the redshift parameter, z, of photons arriving from these objects. They proposed to measure the wavelength λ of such photons using a grating spectrometer. The photon energy ε could be independently measured by a prism instrument. The product

$$\varepsilon\lambda = \varepsilon c/\nu = hc \qquad (1)$$

could then be directly determined and compared with the product hc, obtained using a laboratory source. Existing measurements already imply a constancy of hc to about 1 part in 10^3, where c and ν represent the photon speed and frequency.

It is interesting that Planck's constant represents not only a relationship between ε and ν, but also serves as a measure of the spin angular momentum $\hbar = h/2\pi$ along a photon's direction of propagation. For this reason, one wonders just how a photon with spin angular momentum component $\hbar' = \hbar + \delta\hbar(\neq\hbar)$ would interact with ordinary matter. How, for example, would it be absorbed by an astronomical radiation detector? And how, in particular, would the quantum mechanical angular momentum conservation relations be obeyed in such an interaction?

Before dealing with such questions, it is important to consider whether or not a photon for which $\delta\hbar\neq 0$ can interact with normal matter at all. This problem is tantamount to asking whether variations $\delta\hbar\neq 0$ are in principle observable. If they are not, then clearly photons with $\hbar'\neq\hbar$ could well exist, but would not be subject to physical laws and would be physically uninteresting. The very selection of a source, such as a QSO or pulsar, whose radiation is to be analysed for variations of $\delta\hbar$ from zero, already implies that we expect interaction with matter to be possible. In fact, how else would our photographic plate or photon counter have detected the source in the first place?

Interactions with astronomical detectors, however, are quite complex. There may exist collective effects which allow the interaction with photons. In isolated atoms, such effects might not exist, and these atoms might not be capable of interacting with anomalous photons.

The purpose of this letter is to suggest that photons will not be absorbed by some interstellar constituents,