THE NEUTRINO MASS AND THE CELLULAR LARGE SCALE STRUCTURE OF THE UNIVERSE

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ABSTRACT. We show how within the theoretical framework of a Gamow cosmology with massive neutrinos, the observed correlation functions between galaxies and between clusters of galaxies, naturally lead to a "cellular" structure of the Universe. From the size of "elementary cells" we derive constraints on the value of the masses and chemical potentials of the cosmological "inos". We outline a procedure to estimate the "effective" average mass density of the Universe. We predict also the angular size of the inhomogeneities to be expected in the cosmological black body radiation as remnants of this cellular structure. A possible relation of our model to a fractal structure is indicated:

That the further we look for galaxies and clusters of galaxies the lower is the average density of the Universe, decreasing in distance with a fixed power law, may be considered, if confirmed, one of the major results of modern observational cosmology (de Vaucouleurs 1970). This result is apparently in clear disagreement with the commonly accepted view in theoretical cosmology that the further we look in space the earlier epochs of the Universe are explored and, consequently, the higher should be the observed average density of our Universe. This theoretical view, first introduced by Friedmann, further developed by Gamow, has obtained a patent observational confirmation by the discovery of Hubble law and the cosmological black body radiation (see e.g. F. Melchiorri and R. Ruffini 1986 and references therein).

There must exist, therefore, a cutoff distance, D_c, at which the highly inhomogeneous component with decreasing density ends (an "elementary cell"). On large enough scales the usual homogeneous and isotropic distribution, to be expected in a Friedmann model, has to be recovered.

The determination of this cutoff is the topic of this communication (see also Ruffini et al., 1986): we show how the Gamow cosmology, deeply modified by the existence of massive "inos", naturally leads to the existence of a characteristic mass scale, M_c, and size, D_c, at which this cutoff should occur. This scale is fixed by the epoch t_{nr} (or equivalently redshift z_{nr}) at which the "inos" become non-relativistic

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and the mass M coincides with the mass contained within the horizon at that epoch.

Observations at spatial distances $D > D_c$ should reveal an overall structure of the Universe composed of a set of such "elementary cells" each one of mass M_c observed at different phases of cosmological evolution, all the way up to $z = z_{nr}$ where the strict usual features of a Friedmann universe are recovered (see Fig. 1).

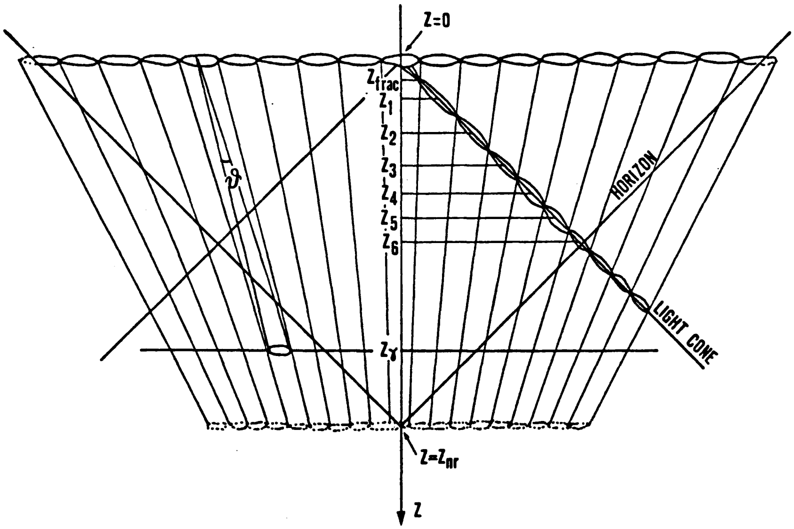

FIG. 1. A sketch of the evolution of the cellular structure of the Universe. The vertical axis is the axis of redshifts (increasing downwards). From the top to the bottom we can find; z = 0 which represents the present time with the array of elementary cells as they are nowadays; $z_1, z_2, \ldots, z_n$ which are the redshifts at which we actually see the centers of the successive cells, it is also sketched the light cone of the observations; $z = z_\gamma$ which represents the surface of last scattering, Θ is the angular scale of the cellular structure at the decoupling time; finally $z = z_{nr}$ is the time at which the cells formed via gravitational instability.

Since z_{nr} is larger than the redshift correponding to the decoupling of matter and radiation, the formation of this cellular structure may leave an imprint in the cosmological black body radiation. The angular scales of the expected inhomogeneities are evaluated.

In each "elementary cell" the density is a function of the volume considered and we cannot speak of an average cosmological density. Due care should be taken, therefore, in evaluating the "effective" average density of the Universe, since we do our observations from within our elementary cell, an extrapolation procedure is given (see Fig. 2)

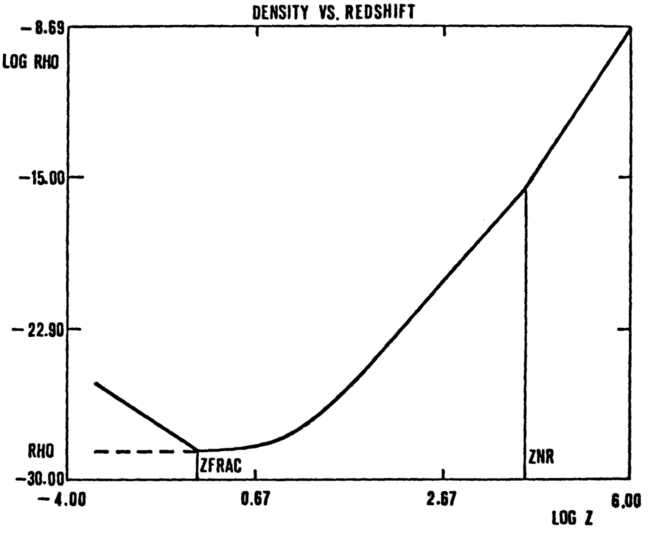

FIG 2. This is a log-log plot of the behavior of the density of the Universe as a function of redshift. The first zone, up to $z = z_{frac}$, is the self similar (fractal) part, inside a single cell. As we exit this zone we have the increasing of the density as the cube of the cosmological redshift up to $z = z_{nr}$. At this point the density will follow the fourth power of the redshift as in the usual Friedmann Universe.

The consistency of this theoretical framework with the previous cosmological considerations (Ruffini *et al*., 1983, Ruffini and Song 1986) as well as the requirement that the "elementary cell" be larger than a minimum size do impose constraints on the masses and chemical potentials of the cosmological "inos".

The possible relevance of these considerations to a fractal cosmological structure are discussed.

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DISCUSSION

DEKEL: How do you compare your result of 9 ev from galaxies with the classical Tremaine-Gunn result that obtained higher neutrino masses?

RUFFINI: The approach of Tremaine-Gunn is meaningless; it is wrong to pretend that considerations on the density distribution of degenerate or semi-degenerate configurations can be inferred by merely imposing limits on the occupation number in phase space of a classical isothermal sphere, even taking into account the presence of visible matter.

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