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Magnetic fields and large scale structure in a hot Universe

IV. The egg-carton Universe

E. Battaner and E. Florido

Departamento Fisica Teorica y del Cosmos, Universidad de Granada, Spain

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Abstract. Considering the possibility of a network of octahedra contacting at their vertexes for the large scale structure of the present Universe, as was discussed in previous papers of this series, we now try to identify real octahedra in the observed distribution of superclusters and voids. This identification is easy and clear. The network seems to have been deformed locally near the great mass associated to the large Piscis-Cetus complex.

Key words: cosmology: large-scale structure of Universe

1. Introduction

Current models of the large-scale structure of the Universe are based on CDM, first introduced by Peebles (1982), with Gaussian fluctuations. These models predict that the distribution of galaxies should be random on very large scales, with large positive values of the correlation function, and vanishing values for scales larger than about 30 Mpc (Einasto et al. 1997a,c). Peaks and valleys should be expected but they should be randomly distributed.

In contrast, a considerable regularity is now becoming evident. Broadhurst et al (1990) found 10 periodic peaks separated by about 128 h^{-1}Mpc in a pencil beam survey. Einasto et al. (1994) observed superclusters residing in chains separated by voids of diameters 100 h^{-1}Mpc forming a regular network. The 2D power spectrum of the Las Campanas Redshift Survey confirmed a peak at a wavelength of 100 h^{-1}Mpc (Tucker et al. 1997, Landy et al. 1996). This value has also been found for the distribution of QSO absorption-line systems (Quashnock et al. 1996). The CMB spectrum also shows a spike at the same wavenumber (Atrio-Barandela et al. 1997). The 3D regularity is at present an observational evidence mainly after the works of Tully et al. (1992) and the Tartu group (Einasto et al. 1997a,b,c). An oscillating correlation function has been obtained by this group in clear contradiction with present CDM models. The detailed history of the controversy between the predicted chaotic and the observed regular structures has been summarized by Einasto et al. (1997a).

A sharp maximum on the power spectrum of galaxies and clusters of galaxies also confirms the regular structure (Einasto et al. 1997c; Retzlaff 1998; Tadros et al. 1998, among others), as well as the interpretation of the peak by Einasto et al. (1997b).

Therefore, the distribution of superclusters in the Local Supercluster neighborhood presents such a remarkable periodicity that some kind of network must fit the observed large scale structure. A three dimension chess-board (Tully et al. 1992) or a honeycomb structure (Einasto 1997) have been suggested. If the filaments of matter that are now observed building up the network are fossil relics of over-dense regions of associated to regions with larger magnetic field energy before Recombination, then it has been shown (Battaner et al. 1997a,b; Florido & Battaner 1997) that the simplest network compatible with magnetic field constraints is made up of octahedra contacting at their vertexes. This suggests a set of superimposed egg-carton structures. This network closely reminds the three dimension chess-board suggested by Tully et al. (1992). Our aim in this paper is to show that the real observed large-scale structure is actually fitted by the theoretical octahedron structure and show that this magnetic explanation is an interesting possibility to explain observations.

For this task, we have benefited from previous statistical analyses, and the recognition of the octahedron network was noticeably easy, rendering a full statistical analysis unnecessary.

2. The observed large scale structure

A fundamental plane of the egg-carton network would contain a large number of filaments and therefore a large number of superclusters. One of these fundamental planes can be identified with the SGZ=0 plane. In a plane very close to this one the high periodicity in the distribution of matter was discovered (Einasto et al. 1997c) and a high density of superclusters is to be found (Tully et al. 1992). This means in practice that the plane of the Local Supercluster coincides with this fundamental plane. Fig. 1 shows the 10^{-3} clusters Mpc^{-3} contour in the plane SGZ=0 from Tully et al. (1992). The identification of a fundamental direction within this plane is straightforward. There is a noticeable alignment passing through Draco, Ursa Major, Leo, Hercules and the Great Attractor, and a long chain of smaller clusters ending at Tucana. Another fundamental direction perpendicular to this is also easily identified in the line connecting the elongated Shapley Concentration, Hercules, the

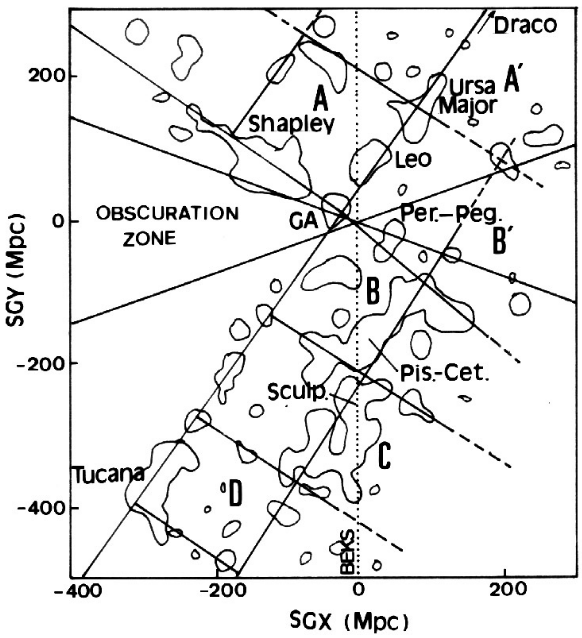

Fig. 1. The octahedron network in a fundamental plane nearly coincident with the SGZ = 0 plane superimposed to the 10^{-3} clusters MPC^{-2} contour from Tully et al. (1992). Units for SGX and SGY should be multiplied by h^{-1}. The obscuration zone and the Broadhurst et al. (1990) probe line are also shown

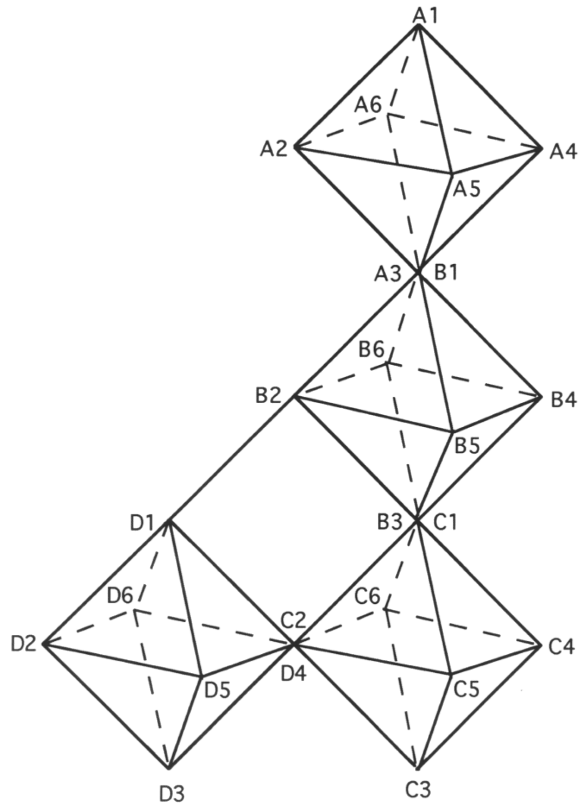

Fig. 2. Schematic plot of identified octahedra. A, B, C and D are the observed octahedra. Points 1, 2, 3 and 4 are in the SGZ = 0 plane. Points 5 lie over the sheet plane. Points 6 lie under the sheet plane. The axes in this figure would be similar to those in figure 1

Great Attractor and Perseus-Pegasus. Other details in this map enable the obtention of the octahedron side, a, of about 150 h^{-1} Mpc ($h = H_0/100$). This is higher than the period of 130 h^{-1} Mpc found by Broadhurst et al. (1990) (hereafter BEKS), but the BEKS probe line cuts our structure at length intervals shorter than the octahedron side. The value of "a" is closer to the period of oscillations found by Einasto et al. (1997a) in the Southern hemisphere. At planes $SGZ = a/\sqrt{2}$ (half a diagonal of the octahedra, about 106 h^{-1} Mpc) and $SGZ = -a/\sqrt{2}$ the other vertexes of the identified octahedra are to be found. Other planes at $SGZ = na\sqrt{2}$ (with n being an integer) would contain other fundamental planes parallel to $SGZ = 0$.

Fig. 2 provides a schematic view of the identified octahedra. A and B belong to a region for which supercluster catalogues are complete. C and D are also well identified and some vestiges of A' and B' can also be appreciated. Vertexes approximately contained in the $SGZ = 0$ plane are called $A1$, $A2\ldots$, $B1$, $B2\ldots$. Vertexes approximately contained in the $SGZ = a/\sqrt{2}$ plane are called $A5$, $B5$, $C5$, $D5$ and vertexes approximately contained in the $SGZ = -a\sqrt{2}$ plane are called $A6$, $B6$, $C6$, $D6$.

Virtually the whole sample of superclusters and voids does, in fact, match the theoretical egg-carton structure. To identify the network structure, we used the supercluster catalog from Einasto et al. (1997d) (hereafter ETJEA) and the void catalog by Einasto et al. (1994) (hereafter EETDA).

3. Identification of superclusters

A1 ≡ extension of the Virgo-Coma supercluster. A2 ≡ ETJEA 127. A3 ≡ Hydra-Centaurus. A4 ≡ Ursa Maior. A5 ≡ ETJEA 154. A6 ≡ Sextans. Edge A2A3 ≡ Shapley concentration; Edge A3A4 ≡ Leo; Edge A1A2 ≡ ETJEA 126; Edge A1A4 ≡ Virgo-Coma; Edge A3A5 ≡ Hercules.

B1 ≡ A3; B2 ≡ ETJEA 16 + Grus-Indus; B4 ≡ Pisces; B5 ≡ Aquarius-Cetus; B6 ≡ Horologium-Reticulum. Edge B3B4 ≡ Piscis-Cetus. Edge B1B6 ≡ Phoenix. Edge B4B5 ≡ Perseus-Pegasus. C1 ≡ B3. C5 ≡ ETJEA 207. C6 ≡ Fornax. Edge C1C2 ≡ Sculptor + ETJEAS. D2 ≡ Tucana. D4 ≡ C2.

There are other superclusters matching the net not contained in the plotted octahedra A, B, C, D. Draco lies in the next vertex in the direction A3A4. Leo A is at the lower point in the octahedron before A. Over A1, ETJEA 154 is found at the next point. Piscis-Aries is at the edge extrapolating B1B4. ETJEA 63 lies below B2. Fornax-Eridanus is found below B3 in the next octahedron. Above B3, there is Aquarius B. Edge B2D1 ≡ ETJEA 6. Microscopium is at the edge above B2D1. Aquarius-Capricornio is above B3B5. Aquarius B, is above B3B5. All these perfectly match the proposed net.

All important superclusters are included in the above list, with the possible exceptions of Leo A, Bootes and Grus. We interpret the above as meaning that Aquarius would correspond to the vertex above B3, but that here the net has become deformed due to the huge gravitational attraction produced by the Piscis-Cetus large mass. The fundamental plane is also gravitationally deformed by Piscis-Cetus. Under this interpretation, the larger concentration found in the SGY =0 plane (Einasto et al. 1994) would be associated with the large Piscis-Cetus attraction.

4. Identification of voids

In accordance with the above description, there are two kinds of voids: intra-octahedric and inter-octahedric voids. Connection must exist between all of them, as a network of filaments is being considered, but especially between inter-octahedric voids. The following numbering corresponds to the number in the EETDA void catalog. 1 ≡ inside B. 2 ≡ below B3B4. 3 ≡ below B2. 4 ≡ below B3. 5 ≡ inside B. 6 ≡ below B3B4. 7 ≡ below B4 (though too low; this is the same deformation induced by Piscis-Cetus). 8 ≡ inside the octahedron below B. 9 ≡ below A3, in the South Local Void, SLV. 10 ≡ inside A'. 11 ≡ on the line A6A'6. 12 ≡ below edge A1A4. 13 ≡ inside the octahedron below A. 14 ≡ inside A, somewhat too low. 15 ≡ below A2. 16 ≡ below A1A4. 17 ≡ below A1A2. 18 ≡ inside A. 19 ≡ inside A. 20 ≡ above A1A4, is Bootes Void. 21 ≡ above A3A4. 22 ≡ above A'1A'2. 23 ≡ above A1A4. 24 ≡ above A3, is the North Local Void, NLV. Only 25, 26 and 27 do not perfectly match the structure.

5. Conclusions

Though very massive concentrations like that of Piscis-Cetus may deform the net, it is very clearly identifiable. Previous studies that detected regularities and periodicities are in agreement and explained by the 3D picture of this egg-carton network. Magnetic field inhomogeneities with typical lengths greater than the horizon along the radiation dominated era are able to explain this network. Therefore, very large-scale magnetic fields may have played a very important role in building up the present large-scale structure of the Universe.

Related to the problem of this regular lattice, very important could be the presence of fine structure inside the large octahedra. A fine structure has been studied by Lindner et al. (1996) suggesting a fractal structure. In another paper, Battaner (1998) has considered the possibility of a fractal octahedron structure over the range 100-10 Mpc. For a ratio equal to 3 for the sizes of large and small octahedra, there would be 7 small octahedra inside a large one, and the fractal dimension would be 1.77, the lower value of the series 1.77, 2, 2.13 . . . of possible dimensions. However, more data considering more voids in detail and more thought are required to establish an identification of this fractal octahedron network with the observed fine structure.

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