The egg-carton Universe

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The distribution of superclusters in the Local Supercluster neighbourhood presents such a remarkable periodicity that some kind of network must fit the observed large scale structure. A three dimensional chessboard has been suggested\(^1\). The existence of this network is really a challenge for currently-suggested theoretical models. For instance, CDM models of the formation of the large scale structure predict a random distribution of superclusters\(^2\). If the filaments of matter that are now observed building up the network are fossil relics of over-dense regions of magnetic field energy before Recombination, then it has been shown\(^3\) 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. Our aim in this paper is to show that the real large-scale structure is actually fitted by the theoretical octahedron structure.

For this task, a systematic statistical procedure is “a priori” to be preferred. However, such a procedure is difficult to develop, and the natural human ability to recognize structures provides a faster search, even if it introduces a degree of subjectivity. In this case, however, the identification of real octahedra is so clear and the network is so noticeably well defined that a direct inspection is straightforward.

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\(^2\) and a high density of superclusters is to be found\(^4\). 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\(^4\). 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 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\(^1\) (hereafter BEKS), but the BEKS probe line cuts our structure at length intervals shorter than the octahedron side. 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 \( SGZ = 0 \).

Figure 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 \( A_1, A_2, \ldots, B_1, B_2, \ldots \). Vertexes approximately contained in the \( SGZ = a/\sqrt{2} \) plane are called \( A_5, B_5, C_5, D_5 \) and vertexes approximately contained in the \( SGZ = -a/\sqrt{2} \) plane are called \( A_6, B_6, C_6, D_6 \).

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\(^5\) (hereafter ETJEA) and the void catalog by Einasto et al\(^6\) (hereafter EETDA).

### Identification of superclusters

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

- **B1** \( \equiv \) A3; **B2** \( \equiv \) ETJEA 16 + Grus-Indus; **B4** \( \equiv \) Pisces; **B5** \( \equiv \) Aquarius-Cetus; **B6** \( \equiv \) Horologium-Reticulum. Edge **B3B4** \( \equiv \) Piscis-Cetus. Edge **B1B6** \( \equiv \) Phoenix. Edge **B4B5** \( \equiv \) Perseus-Pegasus. **C1** \( \equiv \) B3. **C5** \( \equiv \) ETJEA 207. **C6** \( \equiv \) Fornax. Edge **C1C2** \( \equiv \) Sculptor + ETJEA. **D2** \( \equiv \) Tucana. **D4** \( \equiv \) 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** \( \equiv \) 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 became 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 would be associated with the large Piscis-Cetus attraction.

**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.

Therefore, though very massive concentrations like that of Piscis-Cetus may deform the net, it is very clearly identifiable and previously 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.

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Legends for figures:

Figure 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.$^4$. Units for SGX and SGY should be multiplied by $h^{-1}$. The obscuration zone and the Broadhurst et al.$^1$ probe line are also shown.

Figure 2.- Schomatic 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.
