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LARGE-SCALE SHEAR AND ALIGNMENT OF COSMIC STRUCTURES

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Alignment of clusters of galaxies with their nearest neighbour as well as with other clusters residing in filamentary supercluster have both been detected, by well controlled observations and by spectrum- dependent cosmological numerical simulations. Recently an unexpected correlation was detected between the orientations and shapes of images of background galaxies affected by gravitational lensing. This correlations can be reproduced only if there exist and intrinsic, small but non-negligible correlation between galaxies, even if they are far away in redshift space. By analyzing the primordial density field, we show that there is a considerable number of density fluctuations with their main axes aligned with those of the large-scale tidal field, which survive the non-linear evolution. The results are sensitive to the power spectrum.

A correlation between small and large-scale density fields naturally arises as a general property of Gaussian random fields. The correlation between two real-valued random variables X and Y is defined in terms of their rms σ^2_X and σ^2_Y (Adler 1981) as $\gamma_{XY} = \sigma^2_{XY}/(\sigma_X \sigma_Y)$. Variables measured on different filtering scales are not independent (Bardeen et al. 1986; Padmanabhan 1993; West 1994). For a field characterized by a power law spectrum $P(k)$, we get

$$\sigma^2_{ab} \equiv <\delta_a \delta_b>= \int P(k) W_G(kr_a) W_G(kr_b) d^3k \ ,$$

where W_G is the smoothing window function and r_a and r_b are the filtering scales. Flat spectra produce stronger correlations than flatter ones, where correlation means alignment between small-scale fluctuations with the major axes of their host large-scale fluctuations. In order to quantify the contribution of long and short wavelength waves to build up the density field, we have filtered the density field to different scales to analize how the amplitud of the density peaks change. For a maximum filtering radius, we calculate the main components of the inertia tensor for large fluctuations and compare the relative orientation density peaks obtained by using a smaller filtering radius. This enables us to detect any alignment similar to those reported for galaxies within flat supercluster. We also detected alignmet of the type cD with their host clusters but also between neighbouring clusters. These types of coherence occur around the highest peaks but not for low ones. The results were sensitive also to the power spectrum. In our case we used a power law; n=-2 presented more statistically significant alignments. These results suggest that there is an important primordial population of density fluctuations which was born already aligned with the shear tensor, they are little influenced during the grow of the non-linear cosmic structures, and could preserve their initial orientation. Neighbouring density fluctuations are affected by the same environmental conditions and therefore correlations as those reported recently are expected.

An extended analysis on this subject is presented in González & Romano (2001). The evidence of intrinsic orientation and shape correlations are presented by Lee & Pen (2000), Mackey et al. (2001), Pen & Lee (2000) and Heavens (2001). For a review on the different types of alignment effects see West (1994) and Plionis & Basilakos (2001).

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