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VELOCITY FIELDS IN SKEWED CDM MODELS: OBSERVATIONAL DATA VS. N–BODY SIMULATIONS

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Abstract

We consider a composite sample of 1184 optically selected galaxies (which we group in 704 objects) with known radial peculiar velocities. We perform a detailed statistical analysis, calculating bulk flow and velocity correlation functions both for this sample and for mock catalogs extracted from N–body simulations with both Gaussian and skewed (i.e. non–Gaussian) CDM models.

1 The data sample, the statistics and the numerical simulations

The data sample we used was compiled from the 'Mark II' data files. These are a collection of several data for both spirals, ellipticals and S0 galaxies: the used catalogs and the rules followed in grouping the galaxies to reduce uncertainties are the same as in [4]. The final sample here considered consists of 1184 galaxies grouped in 704 objects. All distances in the sample have a uniform Malmquist bias correction.

The *bulk flow* for a galaxy catalog with N objects, endowed with peculiar velocities $\mathbf{v}_i$, can be defined as $v^\alpha_{bulk} = (M^{-1})^{\alpha\beta}\sum_{i=1}^N u_i^\beta$, where $u_i^\alpha \equiv (\mathbf{v}_i\cdot\hat{\mathbf{r}}_i)\hat{\mathbf{r}}_i^\alpha$ is the α component ($\alpha = 1,2,3$) of the radial peculiar velocity of the i–th galaxy. The *projection matrix* $M^{\alpha\beta} = \sum_{i=1}^N \hat{r}_i^\alpha \hat{r}_i^\beta$ takes into account the geometry of the sample.

Another relevant statistics is the *velocity correlation function*, defined as $\psi_1(r) = \sum_{pairs(r)} \mathbf{u}_1\cdot\mathbf{u}_2/\sum_{pairs(r)}\hat{\mathbf{r}}_1\cdot\hat{\mathbf{r}}_2$, where the sum is extended over galaxy pairs with distance r (see e.g. [2]).

In order to mimic the large–scale peculiar velocity field we ran PM N–body simulations with 128^3 particles with box–size 26,000 km/sec. We assumed a flat Universe with Hubble constant $H_0 = 50$ km/sec/Mpc. The velocity field was assumed to have a CDM power–spectrum with a normalization fixed such that the variance of linear mass fluctuation in a sphere of radius 800 km/sec is unity, consistently with the COBE results.

We built up our simulated catalogs (see e.g. [2]) by locating the 'observer' in a grid–point with features similar to those of the Local Group. We imposed constraints on the local values of the peculiar velocity and density contrast and on the quietness of the local flow: further details can be found in

[4], where a similar analysis was performed using Monte Carlo simulations of the linear velocity field in Gaussian CDM models with varying Ω_0, spectral index n and bias parameter b. We then measured radial peculiar velocities by sampling the velocity field at the same positions of the observed galaxies. To account for random galaxy distance errors we perturbed each distance and radial peculiar velocity with Gaussian noise as in [1].

2 Skewed CDM models: description and preliminary results

The skewed CDM models we consider are the same as those analyzed by [3], namely *Lognormal* (LN) and *Chi-squared* with one degree of freedom (χ^2), chosen as distributions for the peculiar gravitational potential, before the action of the CDM transfer function. Each non-Gaussian distribution splits in two models: the *positive* (LN_p and χ^2_p) and *negative* (LN_n and χ^2_n) ones, according to the sign of the skewness for linear mass-fluctuations. Initial conditions are assigned in terms of the gravitational potential following the method described in [3]. For comparison we ran also simulation with *Gaussian* (G) primordial fluctuations. We performed 2 simulations for each model and selected 50 catalogs from each simulation corresponding to a modest oversampling of each simulated box.

The analysis of the probability distribution for the absolute value of the bulk flow v_{bulk} (not plotted here) does not show particular differences between the various models: they have a similar probability to reproduce the observational data: $v_{bulk} = 306 \pm 72$ km/sec.

In Figure 1 we show the probability distribution for the velocity correlation function $\Psi_1(r)$ vs. the separation r for Gaussian and both Chi-squared models: Lognormal models generally have a behaviour similar to the Chi-squared models with the same sign of primordial skewness. The thick solid line and squares with error bar (1 σ) are the observed results obtained from our catalog. The different lines refer to the mean (thin solid line) and to the 5%, 25%, 75% and 95% percentiles (dotted and dashed lines) for the simulated catalogs. The probability distribution for the skew-negative model is narrower and closer to observational data, while the skew-positive model shows a larger distribution with larger values of $\Psi_1(r)$ on small scales. More results will be presented in a forthcoming paper.

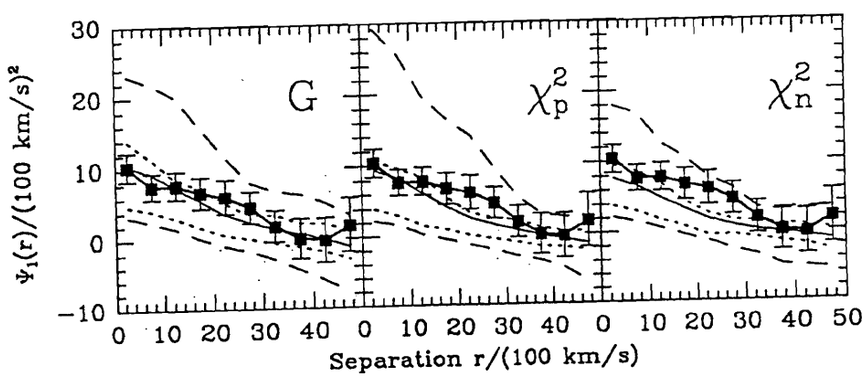

Figure 1. The probability distribution for the velocity correlation function $\Psi_1(r)$ vs. the separation r for the different models. The meaning of the different lines is described in the text.

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