Numerical Realizations of Galaxies in Cosmological Perturbation Theory

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Objective

The project uses numerical realizations of cosmological perturbation theory to go from small initial matter fluctuations to galaxies at late times when they are observed. First, Gaussian initial conditions are generated from a given power spectrum of fluctuations (depending on cosmological parameters): this requires using random number generators and mapping their results to Gaussian-distributed random numbers, thus creating a Gaussian random field on a grid in Fourier space. The next step goes from these fluctuations to the final matter fluctuations by evolving via perturbation theory: this requires to compute the linear displacement field in Fourier space, then FFT back to real space to construct source terms for the second-order cosmological solution which obeys a Poisson equation, which is solved by FFT techniques. Once the second-order solution for the displacement field is obtained, it is used to displace the particles on a grid to their final position [1]. Finally, these particles are converted to galaxies using consistent galalxy-bias perturbation theory to second order (modifying the Poisson solutions). The final galaxy distribution can then be analyzed.

References

[1] F. Bernardeau, S. Colombi, E. Gaztañaga, R. Scoccimarro. *Large-scale structure of the Universe and cosmological perturbation theory*, Physics Reports 367 (2002) 1 - 248.