Iranian Journal of Physics Research, Vol. 20, No. 3, 2020
DOI: 10.47176/ijpr.20.3.61074

Research note

Evolution of the generalized multifrcatal dimension of dark matter density field in the Illustris simulation

M Yousefzadeh and S M S Movahed

Department of Physics, Shahid Beheshti University, 1983969411, Tehran, Iran

E-mail:.m.s.movahed@ipm.ir

(Received 10 June 2020 ; in final form 25 August 2020)

Abstract

The study of cosmic large-scale structures provides valuable information regarding the initial condition and the evolution of random filed approaches. In this paper, relying on the scaling properties of stochastic field, we examine the geometric properties of the dark matter density field in the N-body simulations. To this end, we examine the scaling properties of iso-density lines in the (1+2)-dimensional fields that are cut-out from the (1+3)-dimensional fields of the N-body simulations that are quantifiable using the modified multifractal dimension, D_q. The scaling properties holds for the afore-mentioned fields in all existing redshifts in the simulation. All iso-density threshold contours display a regular geometric shape in the highest accessible redshift, but they exhibit a multifractal property when reducing the redshift. Due to the non-Gaussianity of the low redshift transitioning fields, the multifractal property can mostly be caused by the distribution function's deviation from Gaussianity. The evolution of the D_q scaling exponent with respect to redshift demonstrates that for the positive q's, the monofractal property mostly holds, while the mentioned exponent is highly redshift dependent for the negative q's. This can be employed as a sensitive criterion for distinguishing different models for large-scale cosmic structure formations.

Keywords: random field, scaling properties, dark matter N-body simulation

For full article, refer to the Persian section