Tracing the cosmic web

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Abstract

The cosmic web is one of the most striking features of the distribution of galaxies and dark matter on the largest scales in the Universe. It is composed of dense regions packed full of galaxies, long filamentary bridges, flattened sheets and vast low-density voids. The study of the cosmic web has focused primarily on the identification of such features, and on understanding the environmental effects on galaxy formation and halo assembly. As such, a variety of different methods have been devised to classify the cosmic web – depending on the data at hand, be it numerical simulations, large sky surveys or other. In this paper, we bring 12 of these methods together and apply them to the same data set in order to understand how they compare. In general, these cosmic-web classifiers have been designed with different cosmological goals in mind, and to study different questions. Therefore, one would not a priori expect agreement between different techniques; however, many of these methods do converge on the identification of specific features. In this paper, we study the agreements and disparities of the different methods. For example, each method finds that knots inhabit higher density regions than filaments, etc. and that voids have the lowest densities. For a given web environment, we find a substantial overlap in the density range assigned by each web classification scheme. We also compare classifications on a halo-by-halo basis; for example, we find that 9 of 12 methods classify around a third of group-mass haloes (i.e. Mhalo ∼ 1013.5 h−1 M⊙) as being in filaments. Lastly, so that any future cosmic-web classification scheme can be compared to the 12 methods used here, we have made all the data used in this paper public.

Keywords

Methods: data análisis, Dark matter, Large-scale structure of the Universe, Cosmology: theory