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Supercluster straightness as a cosmological test

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We present how an anisotropic pattern of the cosmic web, which is vividly reflected in the filamentary structure of supercluster, changes if 1)the nature of dark energy differs from the cosmological constant or 2)the gravitational law deviates from the general theory of relativity with/without massive neutrinos. 1)The coupled dark energy (cDE) model where the coupling between dark energy and dark matter exists and 2)the f(R) gravity model which substitutes Ricci scalar R with function f(R) in the Einstein-Hilbert action with\without massive neutrinos are considered for the former and latter cases, respectively. Since the anisotropy of the clustering of galaxy clusters is represented in the degree of straightness of the supercluster, we calculate spine specific size of the supercluster as a measure of its straightness using the halo catalogs of N-body simulations for respective cosmologies at various epochs. It is found that both the cDE and f(R) gravity models have the effect of significantly bending the superclusters resulting in the smaller mean values of the spine specific sizes compared to that of the ΛCDM, whereas the massive neutrinos contribute to straightening the superclusters. Although the f(R) gravity with the massive neutrinos of the specific total neutrino mass is hard to discriminate from the ΛCDM since the effect of the f(R) gravity on the supercluster straightness is suppressed at the current epoch, its mean specific size deviates significantly from the value of the standard cosmology in higher redshifts ($z \geq 0.3$). On the grounds that the difference in the degree of the supercluster straightness of cDE (f(R) gravity) from the ΛCDM increases (decreases) with redshift, the supercluster straightness should play a role of powerful cosmological test. A physical interpretation of our results as well as their cosmological implications are discussed.

Collaboration

Jounghun Lee, Baojiu Li, Marco Baldi

Primary author: Mr SHIM, Junsup (Seoul National University)

Co-authors: Dr LI, Baojiu (Durham University United Kingdom); Prof. LEE, Jounghun (Seoul National University); Dr BALDI, Marco (University of Bologna)

Presenter: Mr SHIM, Junsup (Seoul National University)

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