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Hydrodynamical Simulations of Non-thermal Pressure in Galaxy Clusters

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Cosmological constraints from X-ray and microwave observations of galaxy clusters are subjected to systematic uncertainties. Non-thermal pressure support due to internal gas motions in galaxy clusters is one of the major sources of astrophysical uncertainties. Using mass-limited samples of galaxy clusters from high-resolution hydrodynamical cosmological simulations, we characterize the non-thermal pressure fraction profile and study its dependence on redshift, mass, and mass accretion rate. We find that the non-thermal pressure fraction profile exhibit universality across redshift when galaxy cluster radii are defined with respect to the mean matter density of the universe instead of the commonly used critical density. We also find that the non-thermal pressure is predominantly radial, and the gas velocity anisotropy profile exhibits strong universality when galaxy cluster radii are defined with respect to the mean matter density of the universe. However, we find that the non-thermal pressure fraction is strongly dependent on the mass accretion rate of the galaxy cluster. We provide fitting formulae for the universal non-thermal pressure fraction and velocity anisotropy profiles of gas in galaxy clusters. We will discuss implications of our results for cosmological studies based on galaxy cluster counts and SZ power spectrum.

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