Abstract

The Universe contains approximately 6 times more dark matter than normal baryonic matter, and a directly observed fundamental difference between dark matter and baryons would both be significant for our understanding of dark matter structures and provide us with information about the basic characteristics of the dark matter particle. We discuss one distinctive feature of dark matter structures in equilibrium, namely the property that a local dark matter temperature may depend on direction. This is in stark contrast to baryonic gases. We used X-ray observations of two nearby, relaxed galaxy clusters, under the assumptions of hydrostatic equilibrium and identical dark matter and gas temperatures in the outer cluster region, to measure this dark matter temperature anisotropy $beta_dm$, with non-parametric Monte Carlo methods. We find that $beta_dm$ is greater than the value predicted for baryonic gases, $beta_gas = 0$, at more than $3sigma$ confidence. The observed value of the temperature anisotropy is in fair agreement with the results of cosmological N-body simulations and shows that the equilibration of the dark matter particles is not governed by local point-like interactions in contrast to baryonic gases.