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Constraints on the excess energy in low-mass systems

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We present the $K - T$ scaling relation of the individual galaxies (mostly early-type galaxies), groups, and clusters. The given relation is based on 168 targets observed with $Chandra$ X-ray Observatory. We derive entropy at R_{2500} and build $K_{2500} - T$ relation covering 0.3 – 15.0 keV of temperature and 10^{12} – $10^{15} M_{\odot}$ of total mass bands. We find that entropy at R_{2500} scales with averaged temperature as $K_{2500} \propto T^{0.68 \pm 0.05}$, leading to the break of a self-similar model. We compare our measurements with previous results and find precise agreement with $K - T$ relations obtained for entropies at R_{200} and R_{500} radii. The break of the self-similar model indicates the presence of non-gravitational processes at the cores of low- and high-mass systems which provide an additional heating that is known as entropy excess in $K - T$ relation. We show that AGN feedback is likely mechanism producing this additional heating. We also show that active nuclei in low-mass systems are better able to prevent the significant level of star formation due to enough cooling nearby the nucleus to maintain the energetic feedback loop by measuring the level of heating per gas particle in hot atmospheres of low- and high-mass systems. In addition, using radio flux and luminosity we build the entropy-cavity power relation, finding a weak correlation of $K_{2500} \propto P_{cav}^{0.25 \pm 0.5}$.

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