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The effect of AGN feedback on Sunyaev-Zeldovich properties of simulated galaxy clusters

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Abstract. We studied the imprints that feedback from Active Galactic Nuclei (AGN) leaves on the intracluster plasma during the assembly history of galaxy clusters. To this purpose we used state-of-the-art cosmological hydrodynamical simulations based on an updated version of the Tree-PM SPH GADGET-3 code, comparing three sets of simulations with different prescriptions for the physics of baryons (including AGN and/or stellar feedback). We explore the effect of these different physics, in particular AGN feedback, on IntraCluster medium (ICM) properties observed via Sunyaev-Zel'dovich (SZ) effect using an extended set of galaxy clusters ($\sim$ 100 clusters with M_{500} masses above $5 \times 10^{13} M_{\odot}$/h). Some of the main findings are that the scaling relation between the integrated SZ flux and the galaxy cluster total mass is in good accordance with several observed samples, especially for massive clusters, and does not show any clear redshift evolution, with the slope of the relation close to the theoretical one in the AGN feedback case. As for the scatter of this relation, we obtain a mild dependence on the cluster dynamical state.

Keywords. galaxies: clusters: general, (galaxies:) intergalactic medium, galaxies: active, methods: numerical, cosmology: observations

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The accurate measure of the masses of galaxy clusters is one of the most important goals in order to use them as tracers of cosmic evolution (Borgani&Kravtsov 2011). To calibrate cluster total mass a number of observable quantities can be used. However, physical processes in galaxy clusters (e.g. galactic winds powered by supernovae and AGN feedback) can affect the observed properties of the IntraCluster Medium (ICM), having a non negligible impact on the determined masses (Planelles *et al.* 2016, Biffi *et al.* 2016).

We used a simulated cluster sample that consists of 29 Lagrangian regions extracted from a parent Dark Matter (DM) only simulation (described in Bonafede *et al.* 2011), resimulated at higher resolution including the baryonic component. The complete sample of ~ 100 clusters with $M_{500} > 3\times10^{13} M_{\odot}/h$ was resimulated including different prescriptions for the physics of baryons: NR - non-radiative physics; CSF - cooling, star formation, feedback by supernovae, metal enrichment and galactic winds, and AGN - as CSF but adding AGN feedback (see Planelles *et al.* 2016 and Steinborn *et al.* 2015 for details). Clusters in the AGN model were further classified into (i) regular/disturbed, according to their global dynamical state and in (ii) CC(cool-core)/ NCC(non-cool-core)-like halos according to their core thermodynamical properties (see Rasia *et al.* 2015).

We were interested in the impact that different physical processes as AGN feedback have on the observed Sunyaev-Zeldovich (SZ) effect and the related scaling relations (see Giodini *et al.* 2013). The integrated SZ effect $Y_{\rm SZ}$ is proportional to the integrated thermal pressure of the intracluster medium along the line of sight and therefore it is an ideal proxy for the cluster total mass M. We found that the $Y_{\rm SZ} - M$ relation is close to the theoretical self-similar prediction for simulated clusters, with a scatter of $0.06 - 0.07$ that is lower than the one reported in observations. Consistently with previous numerical analysis, results at R_{500} for the complete sample do not show any significant dependence on the included physics. When analyzing the pressure profiles of the ICM and its evolution we found that small changes in this profiles, depending on either the dynamical state or the cool-coreness of the considered systems, have different impact on the corresponding $Y_{SZ} - M$ relation. In particular, cluster dynamical state measured at R_{500} is not strongly correlated with its cool-coreness.

We further explore the evolution with redshift of the $Y_{\rm SZ} - M$ relation. For all the three models we observe that the normalization and slope for this relation do not show any evolution with redshift, while only the scatter increases from 0.06 (at $z = 0$) to 0.10 (at $z = 1$). The scatter is reduced to $0.03 - 0.05$ when we restrict to massive clusters, in agreement with previous numerical studies. We also observe that residual variation of cluster properties in radiative simulations (CSF, AGN) with respect to non-radiative ones (NR) are a consequence of overcooling that removes gas from the hot phase. Including AGN feedback partially prevents cooling and brings the slope of the $Y_{SZ} - M$ relation in closer agreement with the theoretical value.

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