The effect of AGN feedback on Sunyaev-Zel’dovich properties of simulated galaxy clusters

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Abstract

The accurate measure of the masses of galaxy clusters is one of the most important goals in astrophysics and cosmology, as it requires a full understanding of cluster formation and evolution. To calibrate cluster total mass a mass observable, such as the X-ray luminosity, is used. In a non-radiative setup, mass is determined by AGN feedback and the normalization of the scaling relations with respect to non-radiative simulations is a common challenge. We computed the Bondi rate by multiplying the Bondi factor by a rate, while the fraction of the radiative feedback includes SN feedback and metal enrichment. The CSF case plus the effect of AGN feedback includes a non negligible impact on the gas mass (and cluster total mass). The pivot X parameter, the X-ray equivalent in the integrated SZ effect, is defined as the product of the total mass and Y parameter, the Y-parameter, the gas mass evaluated within R500.

Simulations

NR – non-radiative hydrodynamical simulations based on the improved SPH formulation presented in Beck et al. (2016)

CSF – simulations accounting for the effects of radiative cooling, star formation, supernovae (SN) feedback and metal enrichment. The radiative evolution and metal enrichment are based on the model by Tornatore et al. (2007). Metal dependent radiative cooling rates and the effects of a uniform UV-ray background radiation are included. According to models by Wiersma et al. (2009) and Haardt & Madau (2012), kinetic feedback from galactic outflows powered by SN explosions is based on Springel & Hernquist (2003) and is characterized by a wind model.

AGN – includes same physical processes as in the CSF case plus the effect of AGN feedback.

The subgrid model for super-massive black hole (BH) accretion and AGN feedback has been presented in Steinborn et al. 2015:

- mechanical outflows and radiation are combined and included in form of thermal feedback
- the efficiency of mechanical and thermal feedback depend on both the (Eddington-limited) gas accretion rate and the BH mass and on accretion rate, while the fraction of the radiative feedback coupled to the surrounding gas as thermal feedback is fixed at e = 0.05
- the efficiency of mechanical and thermal feedback depend on both the (Eddington-limited) gas accretion rate and the SMH mass, providing a smooth transition between radio and quasar mode
- eddington-limited gas accretion onto BHs is computed by multiplying the Bondi rate by a boost factor: a factor e = 0.05 when we neglect hot gas accretion (eBH = 0) and consider only cold gas accretion, for which the Bondi accretion rate is boosted by a factor eBH = 100

References


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The SZ effect is proportional to the integrated thermal pressure of the intracluster medium along the line of sight and therefore it is an increase in scatter; if we focus only on massive clusters, the normalization and slope of the scaling relation for the complete set of groups and clusters in the “complete sample” is close to self-similar for different impact on the corresponding Y500 scaling relations (planck Collaboration et al. 2013). In general, both cluster populations show a consistency within 1-2 with the observations by Sayers et al. (2013), especially in inner cluster regions; mean pressure profile of NCC systems is lower in cluster outskirts (r>R500), in better agreement with the observational determinations by Arnaud et al. (2010) and Planck Collaboration et al. (2013a).

- mean profiles of CC/NCC clusters are in good agreement with each other at intermediate radii (0.2<r/R500<1) and as expected clearly diverge from each other in inner cluster regions.

- the large dispersion in cluster outskirts is mostly produced by a clumpier gas distribution in outer regions of disturbed massive galaxy clusters

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