Disentangling the Sunyaev–Zeldovich Effect and Diffuse Emission sub–structure in galaxy clusters

Siddharth Malu & Abhirup Datta
Centre of Astronomy, IIT Indore, Indore, India

Sergio Colafrancesco
School of Physics, University of the Witwatersrand, Johannesburg, South Africa

Surajit Paul
Department of Physics, SP Pune University, Pune, India

September 15, 2016

Abstract

Inverse Compton scattering of CMB photons off the thermal and non-thermal electrons in the atmospheres of galaxy clusters, usually referred to as Sunyaev–Zeldovich Effect (SZ effect), has been observed in many clusters in recent times (Bleem et al. (2015); Zwart et al. (2011)) though the SZ effect signal from cluster sub-structure has been detected only in a few clusters (Malu et al. (2011); Massardi et al. (2010)) in the Ku and K bands (12–24 GHz). Upper limits for the SZ effect signal from non–thermal electrons have also been derived (Colafrancesco et al. 2013). At the same time, in these clusters, both radio halos and radio relics have been observed at high frequencies, i.e. in the 12–24 GHz frequency range (Malu et al. (2010,2011); Stroe et al. (2015)). This poses a unique challenge of separating positive and negative components in Ku, K-band images, and possibly also at higher frequency bands. Current observations (Malu et al. 2011) show that both diffuse emission and SZ effect features can be observed in the center of clusters. Spectra of diffuse emission – both radio halos and relics – are neither known, nor is there any firm predictions for them. Additionally, SZ sub–structure in clusters is expected to exist over a range of spatial scales. This is therefore a complex problem, which requires ultra deep, high–resolution observations of galaxy clusters in the range 12–24 GHz, and possibly beyond. The SKA1–mid is ideal for Ku band ($\sim$ 14 GHz) observations, provided the thermal SZ effect is either absent, or can be precisely modeled in the observed region, and we intend to produce a cluster survey using SKA1–mid. However, for completely disentangling the two effects, a higher frequency instrument may be needed.

We present here results from 16–20 GHz observations of a southern mini–survey of galaxy clusters which show both diffuse emission as well as SZ effect – in one instance, in the same cluster. These results point to the need for an iterative approach which includes modeling the diffuse emission and SZ effect sub–structures, as well as a careful characterization of positive and negative features observed in high–frequency ($>$ 12 GHz) images of galaxy clusters. In this context, we will also discuss prospects for detection of SZ effect using SKA1–mid, at $\sim$ 14 GHz (Band-5).