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Non-thermal radio emission from dark matter annihilation processes in simulated Coma like galaxy clusters

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Abstract. Taking secondary particles produced from dark matter (DM) annihilation process to the origin of the extended diffuse radio emission observed in galaxy clusters, we studied both their morphology and radio spectral profile using simulated Coma like galaxy clusters. We have considered a neutralino annihilation channel dominated by $b\bar{b}$ species with a branching ratio of 1 and neutralino mass of 35 GeV with annihilation cross-section of $1{\times}10^{-26}$ cm^3 s^{-1}. The radio emission maps produced for the two simulated galaxy clusters which are based on the MUsic SImulation of galaxy Clusters (MUSIC) dataset reveal the observed radio halo morphology showing radio emission both from the central regions of the cluster and substructures lying out off cluster centre. The flux density curve is in a good agreement for $\nu \leq 2$ GHz with the obsevational values for the Coma cluster of galaxies showing a small deviation at higher frequencies.

Keywords. Dark matter (DM) annihilation, neutralino, radio emission, integrated flux

1. Introduction

Observations have revealed that there is a diffuse radio emission in cluster of galaxies which is non-thermal synchrotron in origin. The diffuse extended radio emission of the Coma cluster of galaxies was investigated by Willson (1970). Several years later, extended diffuse radio emission was also detected at the periphery of the Coma cluster and at the center of the Perseus cluster (van Weeren *et al.* 2019). This diffuse extended radio sources are not associated to the individual galaxies and their origin and evolution is still a matter of debate (Colafrancesco *et al.* 2015). It is therefore important to carry out new studies aimed at discriminating between these theoretical models. We studied the radio emission from DM annihilation/decay processes in two simulated Coma like galaxy clusters at different frequencies choosen to make comparison with the observational results of (Thierbach *et al.* 2003). We model the radio emission from DM annihilation processes because of the fact that the clusters are dominated by DM and since the Coma cluster is one of the best studied we choose simulated Coma like galaxy clusters. For this purpose we took two simulated Coma like galaxy clusters, named SGC280 and SGC282.

2. Methodology

A fortran code is used to allocate the DM and gas density on a three dimensional cube of side 2 Mpc which is grided into smaller cubes of side $\sim$ 10 kpc. Now knowing the DM and gas density in each cube help us to determine and allocate the magnetic

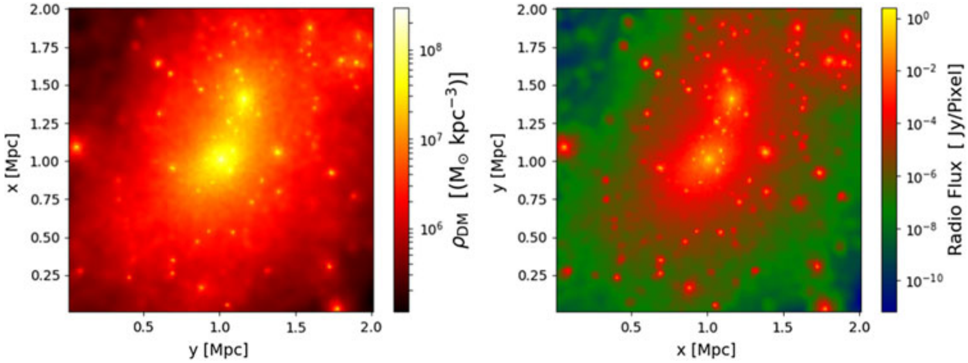

Figure 1. The DM density map of SGC280 [Left Panel] and radio emission map of SGC280 [Right Panel] at 110 MHz.

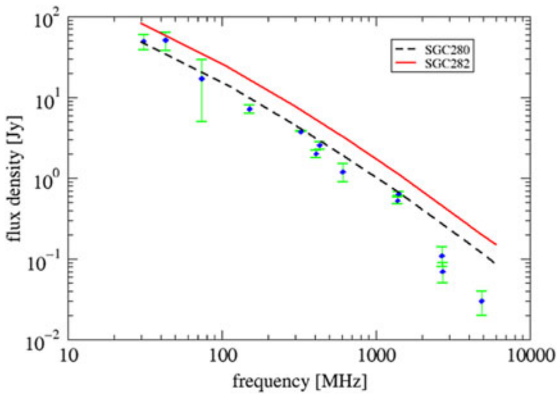

Figure 2. Integrated radio flux for SGC282 and SGC280 indicated in red (solid) and dark (broken) curves, respectively in comparison to the observational data of radio emission of Coma cluster indicated in blue dots from Thierbach *et al.* (2003).

field and electron density within the cluster which in turn allow us to compute the gyro- and plasma frequency. Combining this results with the electron production spectra from the DarkSUSY package (a fortran package that calculate the yield of particles per a neutralino annihilation) enables us to calculate all the necessary ingrediants for the synchrotron emission. Finally, the local emissivity and the integrated flux density are computed in each cube.

3. Implications

All the densest regions on the maps which are near the center and out of the center are the sources (or amplifiers) of higher radio emission (see Fig. 1 [Left Panel]). And this is clearly depicted in Fig. 1 [Right Panel] by the radio emission map which is morphologically similar to the DM density distribution map (Giovannini *et al.* 2012). From the curves in Fig. 2 we can see that the flux density decreases as frequency increases in both cases. This indicates that the integrated radio spectrum of SGC280 is in a good agreement with the observed radio spectrum of the Coma cluster of galaxies (Thierbach *et al.* 2003).

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