Perseus in Sicily: From Black Hole to Cluster Outskirts
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High-dynamic-range 21 cm JVLA observations of the Perseus Cluster

Charles L. H. Hull[1,2,3]

[1]National Astronomical Observatory of Japan, NAOJ Chile Observatory, Alonso de Córdova 3788, Office 61B, 7630422, Vitacura, Santiago, Chile

[2]Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile

[3]NAOJ Fellow

email: chat.hull@nao.ac.jp

Abstract. We present 21 cm (L-band) JVLA observations of the Perseus Cluster, comprising data from all four array configurations. The resulting images are nearly an order of magnitude deeper than any other image made of NGC 1275 and its environs at this frequency.

Keywords. galaxies: clusters: individual (Perseus), (galaxies:) cooling flows, (galaxies:) intergalactic medium, galaxies: ISM

1. Summary

The center of the Perseus galaxy cluster displays a spectacular array of intricate, filamentary nebulae. These filaments typically lie between 10 and 50 kpc from the center of the cluster, with lengths $\lesssim 10$ kpc. First discovered in H_α by Minkowski (1957), they have now been studied extensively in the radio (Salomé *et al.* 2008a, 2008b), infrared (Werner *et al.* 2013), optical (McDonald *et al.* 2010), UV (Canning *et al.* 2010), and soft x-ray (Sparks *et al.* 2009), as well as in hydrodynamic and magnetohydrodynamic simulations (e.g., Revaz *et al.* 2008; Sharma *et al.* 2010).

Despite more than five decades of study, however, several features of the filaments are extremely difficult to explain. Though immersed in the $\sim 10^8$ K intracluster medium (ICM), these filaments emit strongly in H_α, indicating an internal temperature $\lesssim 10^4$ K. In some filaments, the detection of molecular CO and HCN suggests even lower internal temperatures $\lesssim 2000$ K. Thus, these nebulae have temperatures orders of magnitude lower than the surrounding ICM, yet have radii smaller than the mean free path of ICM electrons of ~ 100 pc. If thermal conduction is not suppressed by the local magnetic field, the timescale for such thin filaments to evaporate could be as short as 100 years!

HST observations of the filaments show that some, but not all, of the filaments, are actively forming stars, representing a unique case of star formation taking place outside of a galaxy. A by-product of star formation in star forming galaxies is synchrotron emission, produced through the ejection of cosmic ray electrons into the ISM by supernovae, which then interact with the intergalactic magnetic field.

Measuring the synchrotron emission from the filaments would yield information about the cosmic ray population and would confirm the presence of a strong magnetic field. Comparing the synchrotron flux to existing far-infrared (FIR) observations would also probe the universality of star formation.

This study is still in progress, and involves making the highest-ever-dynamic-range L-band (1.4 GHz) image of the cD galaxy of the Perseus cluster, NGC 1275. The data involved are from all four (A, B, C, D) configurations of the Karl G. Jansky Very Large

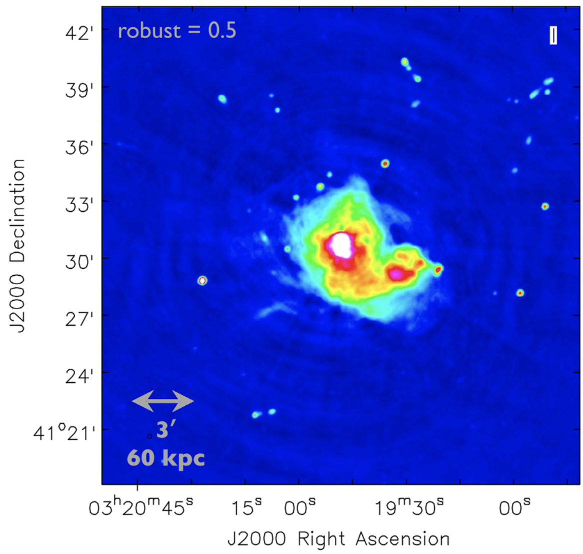

Figure 1. L-band (1.4 GHz) image of NGC 1275 made using a combination of C and D-configuration data from the VLA. The central extended source is the famous "mini-halo" surrounding NGC 1275. A wealth of background sources and intricate structure can be seen in this high-dynamic-range image; these structures will become clearer upon combination with the higher-resolution A and B-configuration data.

Array (VLA), and are revealing intricate structures in the galaxy itself, as well as a wealth of intriguing background sources. A preliminary C+D-configuration image can be seen in Figure 1. These data will be combined with A and B-configuration data to make the best possible image of the region.

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