PhD project in ASTROPHYSICS

Title of the Project: Magnetic fields and particle acceleration on the largest scales

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Scientific Case:

LOFAR and MeerKAT are the most important pathfinder and precursor of the SKA. Thanks to their unprecedented sensitivity and capability to recover extended diffuse radio emission, they have opened a new parameter space in the study of non-thermal phenomena in galaxy clusters and large-scale structure, with implications on our understanding of the particle acceleration mechanisms on Mpc-scales, magnetogenesis, and the formation and evolution of galaxy clusters themselves.

Outline of the Project:

Recently, LOFAR and MeerKAT carried out very sensitive observations of numerous galaxy clusters. In particular, LOFAR performed the deepest observations to date on two local galaxy clusters: Abell 2255 and Coma. Shallower observations of these systems have already revealed the presence of very large-scale emission coming from the cluster outskirts and possibly from the cosmic web (Figure). The PhD candidate will use these deep radio observations to investigate the properties of the newly discovered features and of the cluster magnetic fields on very large scales. LOFAR is a unique instruments to detect low magnetic fields in low density environments, hence the deep field data are unique to explore the magnetic field properties in the uncharted territory of far cluster outskirts. On the other hand, MeerKAT observations are now enabling the detection of several polarized sources in the direction of galaxy clusters that can be used as Faraday rotation probes to study the intra-cluster medium magnetic field. The PhD candidate will thus work also on a selected sample of clusters observed with MeerKAT to constrain the magnetic field properties inside, outside, and in-between galaxy clusters. The origin of cosmic magnetism is one of the big unaddressed questions in astrophysics, and probing the magnetization of the large-scale structure constitutes a fundamental test for the models of magnetogenesis, allowing to discriminate between primordial and astrophysical scenarios. The results obtained during this PhD will thus represent an important step in this direction. Data will be used in combination with numerical simulations and theoretical models to determine the properties of magnetic fields, the allowed scenarios for cosmic magneto genesis, and the particle-acceleration mechanisms.
The PhD student will be part of the LOFAR collaboration and have access to the most recent analysis technique. The PhD student will also be involved in international working groups, and travels to visit collaborators in the Netherlands and Germany are planned.

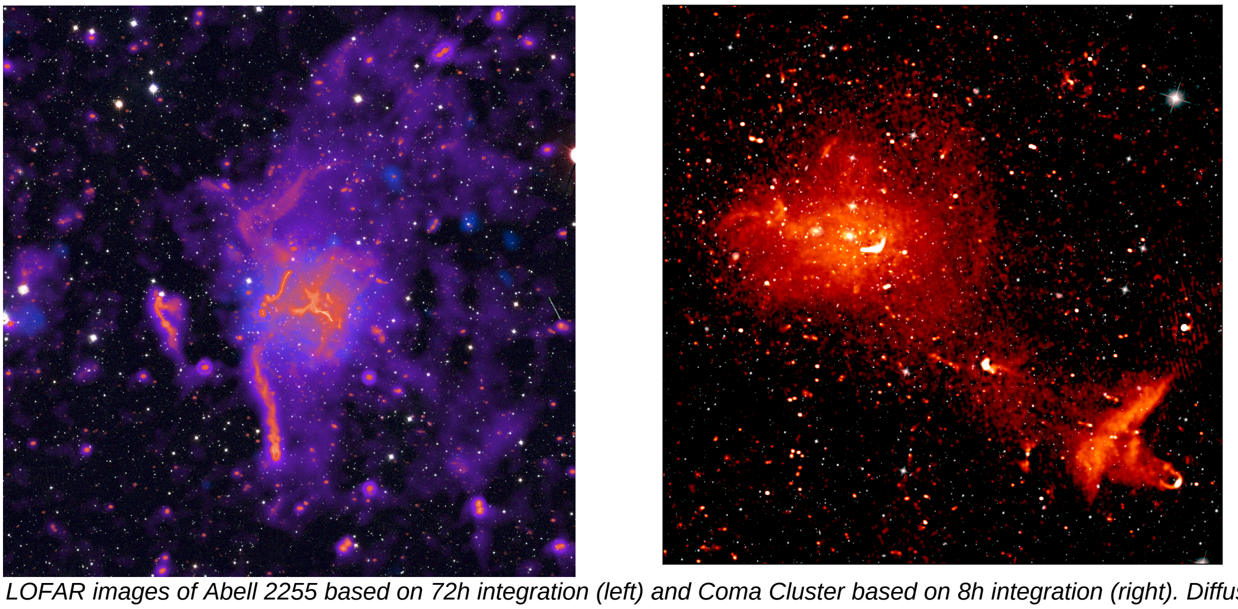

Figure: LOFAR images of Abell 2255 based on 72h integration (left) and Coma Cluster based on 8h integration (right). Diffuse radio emission (in reddish/purplish color) spans projected scales of 3-5 Mpc. From Botteon et al. (2022) and Bonafede et al. (2022).