Magnetic field amplification by shocks in galaxy clusters

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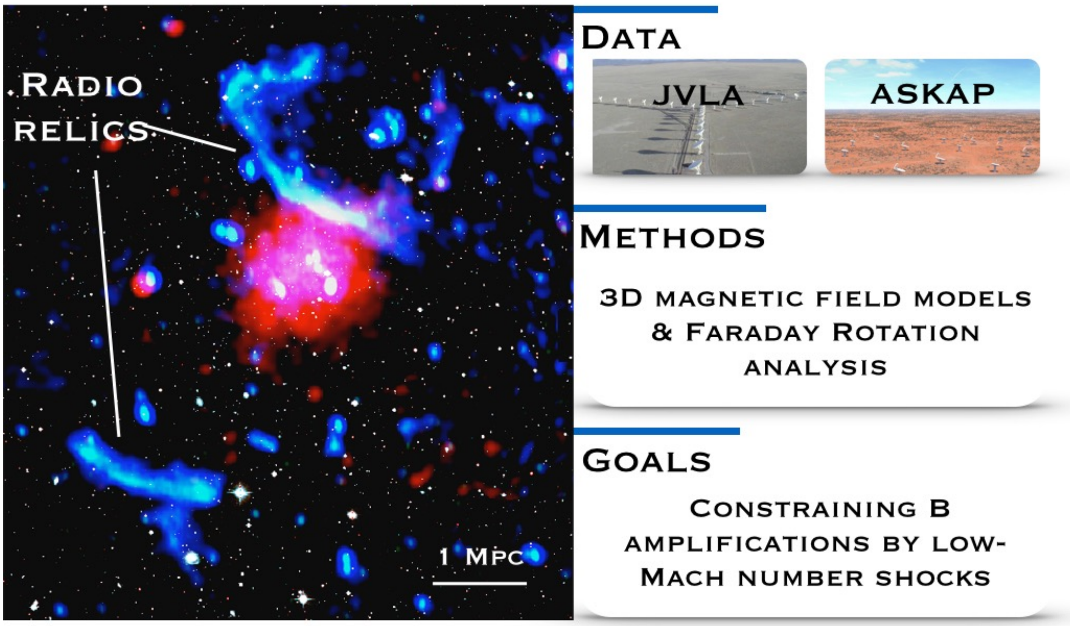
Galaxy clusters are massive and gravitationally bound objects that form by accretion of less massive clusters and groups. Mergers between clusters are the most energetic events in the Universe, with up to 10^{64} erg released in the intra-duster medium (ICM). Cosmological simulations show that shock waves develop during mergers travel through the ICM and propagate outwards. In the outskirts of some merging clusters, radio observations show Mpc-size sources that originate form the ICM. These sources are called "radio relics" and emit via synchrotron, probing the existence of magnetic fields on Mpc scale.



The origin of radio relics is still unknown. Theoretical models suggest that shock waves amplify the magnetic field in the ICM and accelerate particles, giving origin to synchrotron radio emission. Although this process could be similar to the one in Supernova remnants, shock waves in the ICM have low Mach number (<4), and it is a big challenge to understand how particle can be accelerated. Recent models have focussed on the role of magnetic fields, that in certain configurations could allow the shock wave to accelerate electrons. Hence, it is now crucial to constrain the properties of magnetic fields at cluster shocks. **With this project, we aim at performing the first systematic study of magnetic field in radio relics, i.e. in regions crossed by low Mach-number shocks.** The goal of the project is to constrain the magnetic field strength and structure in a well defined sample of clusters, where shock waves and radio relics have been detected. The results of the project are important not only for the galaxy cluster science, but have a larger impact on plasma physics, as we will be able to i) understand if relics originate from shock waves ii) constrain the efficiency of particle acceleration in low Mach number shocks.

Data and methods:

This project will use new data taken with the cutting-edge facility Jansky Very Large Array and from the SKA pathfinder ASKAP. The PhD candidate will learn how to prepare, reduce and analyse radio observations, using the most updated tools. To constrain the magnetic field properties, the PhD candidate will use and develop numerical techniques, starting from an existing numerical tool developed by the supervisor in the last years.

Scientific context:

The PhD thesis is part of a larger project DRANOEL (*Deciphering RAdio NOn-Thermal Emission on the Largest-scale*) financed by the European Research Council (ERC-2016-STG 71425). The PhD candidate will work in close contacts with the other group members and will be involved in international working groups (SKA-pathfinders working groups). Travels to visit collaborators in the USA and Australia are planned.