

## PhD project in ASTROPHYSICS

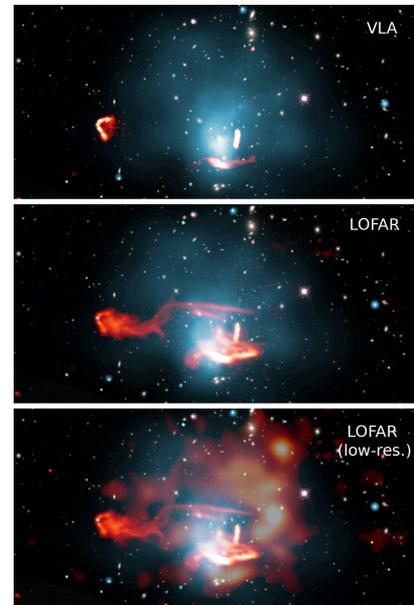
**Title of the Project:** The large scale structure of the Universe at ultra low radio frequencies

**Supervisor :** De Gasperin Francesco

### Scientific Case:

Within the cosmic web, enormous amounts of energy linked to the formation and growth of the largest structures of the Universe and the activity of active galactic nuclei (AGN) are dissipated through processes such as turbulence and shock waves. These processes have a fundamental impact on the evolution of galaxy clusters. Their most spectacular effect can be seen through the observation of radio sources that are as large as clusters themselves.

In particular, the ultra-low radio frequencies are unique probes to study these unique environments. In this regime, cluster-scale radio sources can be traced for hundreds of megayears, allowing us to explore their long-term impact in the cluster region. Furthermore, low-efficiency processes, invisible at higher frequencies, shine bright at these wavelengths. However, because of the complexity of the observations, the ultra low-frequencies are one of the last uncharted observational windows of the cosmic electromagnetic spectrum.



The radio emission in the galaxy cluster Abell 1033 at high (*upper panel*) and low frequencies (*lower panels*)

### Outline of the Project:

The candidate will use data from the Low Frequency Array (LOFAR; [www.lofar.org](http://www.lofar.org)) at ultra-low frequencies (<100 MHz or several metre wavelength) to study galaxy clusters and the large scale structure of the Universe. The student will work with massive amounts of data, developing advanced *data analysis* techniques and using supercomputers. A certain interest in coding and using novel technologies, such as machine learning, is an asset.

For the interpretation of the results, and depending on the candidate's attitude, the project can be tuned to leverage the observational (radio, X-ray), computational (MHD simulations) or theoretical (plasma physics and models of radio sources) part.

The candidate will be part of the LOFAR collaboration that includes >200 scientists from several European countries and of the UltraLowUniverse research group that includes 4 PhDs and 5 postdocs financed by a European ERC Grant. This grants the possibility of creating a large international network through visits and conferences as well as the access to state-of-the-art computing facilities. The possibility of spending one year of PhD at the University of Leiden (NL) can be discussed as well as earning a double PhD (UniBO and Leiden).

**Collaborators:** A. Bonafede, R. van Weeren (radio), F. Vazza (simulations) and G. Brunetti, R. Cassano (theory)

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