Master 2 Internship and Thesis Topic

Diffuse and extended radio emission in galaxy clusters : how to detect it ?

Kind of work : data analysis

Requested background knowledge : general overview of extra-galactic astronomy. Some informatics skills (in particular a basic knowledge of Unix commands)

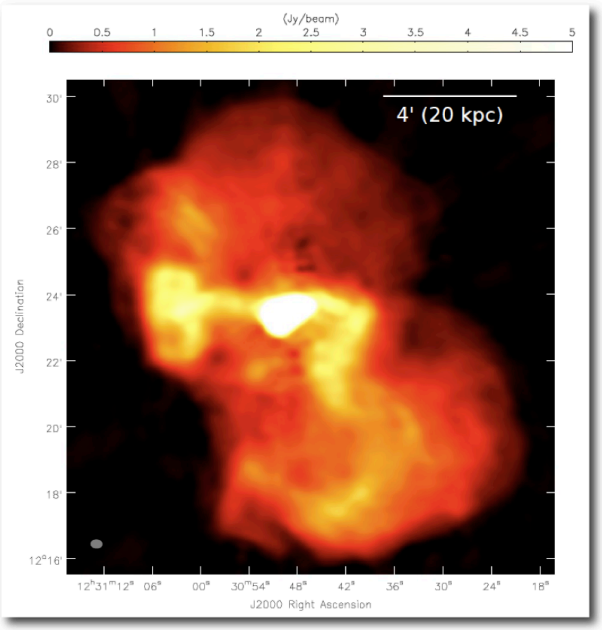
Beginning date - Duration : 21/01/2013 - 5 to 6 months

Supervisor's name (e-mail) : Dr. Chiara FERRARI (chiara.ferrari@oca.eu)

Co-supervisor's name (e-mail) : Dr. Giulia MACARIO (giulia.macario@oca.eu)

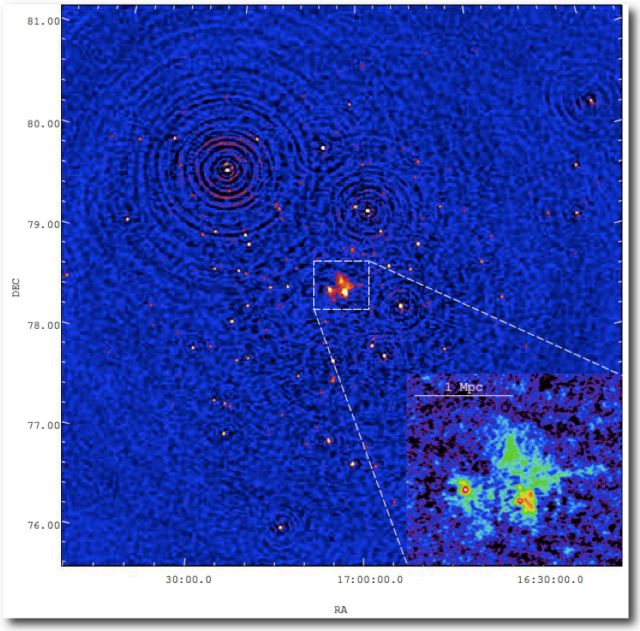
Funding : ~ allocated

Complementary information : a research stay at ASTRON (The Netherlands) is expected during the M2 thesis period



M87, the radio galaxy at the center of the Virgo cluster, observed by LOFAR at meter wavelengths

(de Gasperin et al. 2012)



Diffuse radio emission in the galaxy cluster Abell 2256, as observed by LOFAR

(van Weeren et al. 2012)

The radio sky has been surveyed in the last years at different frequencies with typical resolutions of several tens of arc-seconds. Radio surveys characterized by higher sensitivity and better angular resolution will be available in the next decades thanks to incoming and future radio facilities, such as the Low Frequency Array (LOFAR, Europe), the Long Wavelength Array (LWA, U.S.), the Australian Square Kilometre Array Pathfinder (ASKAP, Australia) and the Karoo Array Telescope (MeerKAT, South Africa). These new revolutionary radio-telescopes, operating in a wide region of the electromagnetic spectrum (from 10 MHz to 15 GHz), are the technical and scientific pathfinders of the Square Kilometre Array (SKA), that, with its total collecting area of one square kilometer, will be the largest telescope ever built (~2020).

Deep radio observations of the sky have revealed the presence of diffuse and extended radio sources in about 10% of known galaxy clusters, the largest gravitationally bound structures in the Universe. Their diffuse radio emission, with typical extensions of the order of 1 Mpc[1], is not associated to single galaxies, but to the presence of a non-thermal component (cosmic rays and magnetic fields) in the volume in between cluster galaxies. One of the main open questions of current cluster studies is to understand how this non-thermal component originates and affects the thermo-dynamical evolution of galaxy clusters.

We are now living in the "golden age" for non-thermal cluster studies, since radio emission from galaxy clusters is more easily detectable at the low-frequencies observed by the new-generation of radio telescopes, and in particular by the International LOFAR Telescope (ILT). This instrument has shown its capability in the detection of diffuse cluster emission already in its early observational phase (van Weeren et al. 2012; de Gasperin et al. 2012; see also above images). The ILT will allow to map diffuse radio emission in clusters through on-going shallow and future deep surveys (MSSS, P.I. G. Heald/ASTRON ; Extra-galactic Surveys, P.I. H. Röttgering/Leiden) .

The main aim of this master work is to collaborate in the development of tools for the automatic detection and physical characterization of diffuse cluster sources from new all-sky radio surveys. This will be an essential step to build a statistical sample of diffuse cluster radio sources, necessary to constrain the different models of intra-cluster cosmic ray acceleration. After an initial and essential bibliographic work, the student will focus on two main research points:

i) a statistical characterization of the observational properties (size, distance from the cluster centre, morphological parameters, ...) of extended cluster radio sources. This part of the work will mostly consist on a detailed literature research ;

ii) a multi-band association of both diffuse and compact sources in interesting fields covered by currently on-going LOFAR survey (MSSS). The student will then analyze the results, in particular for extended sources, at the light of results obtained at point i) .

The work is intended to be developed in collaboration with ASTRON researchers in The Netherlands, with a possible work visit to develop the analysis of MSSS data. Discussions within the Galaxies & Cosmology group at OCA will be strongly encouraged to have an overview of the extra-galactic work developed in Lagrange laboratory.

[1] 1 Mpc ~ 3×10^{22} m