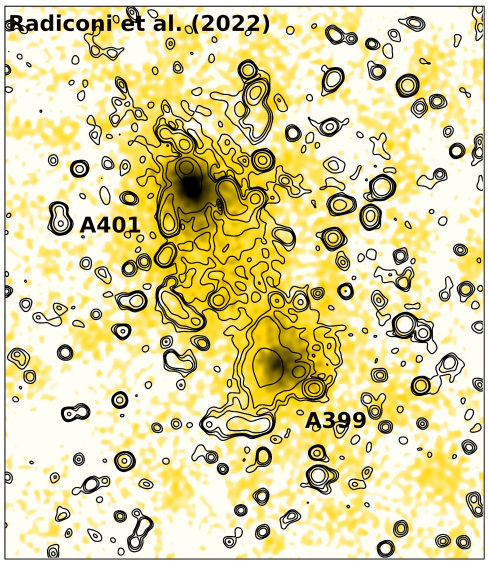
Uncovering the link between thermal and non-thermal components in galaxy clusters



SUMMARY.
A growing number of galaxy clusters shows the presence of radio halos, low-surface brightness diffuse radio emission on Mpc scales located at the cluster centre [1]. Galaxy clusters hosting radio halos show a correlation between the integrated radio power over the entire cluster volume (non-thermal components) and the integrated X-ray and Sunyaev–Zeldovich (SZ) signal (thermal component) [2,3]. In some systems, a local radio-X and radio-SZ correlation has also been found see, e.g., [4,5]. The link between thermal and non-thermal properties provides precious insights about the still mysterious non-thermal components in galaxy cluster. The student will learn the current status on this topic and will contribute to this research field by analyzing multi-wavelenght detailed and sensitive data of galaxy clusters.

OBJECTIVES

The student will learn about

- *emission mechanisms;*
- *galaxy clusters and their non-thermal components;*
- *how to conduct from start to end a research project.*

The student will learn to do

- *radio data reduction;*
- *multi-wavelenght data analysis and interpretation;*
- *write python fitting and plot scripts.*

INSTITUTE

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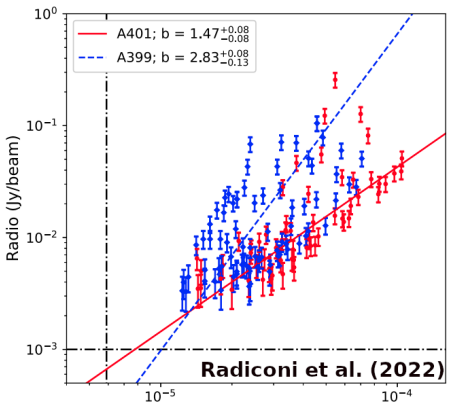
THEORY

Radio halos witness the presence of ultra-relativistic electrons and μG magnetic fields in galaxy clusters. The properties and origin of these non-thermal components are still under investigation. The emerging evidences suggest a mixed leptonic-hadronic scenario for the origin of ultra-relativistic electrons [6]. The magnetic field strenght appear to be linked to the thermal gas density of the system [7], however the right scaling is not known yet.

APPLICATIONS

The student will look for the presence of a local correlation between radio emission, X-ray and SZ signal in galaxy clusters (the figure below shows an example of local radio-SZ correlation in two galaxy clusters). The student will discuss these correlations in the context of the different scenarios for the emitting radio electrons origin. By combining the information from these three frequencies, the student will derive the magnetic field dependence on thermal gas density in these systems based on proper modelling of these quantities. The student will compare the results to the literature and provide an interpretation in light of this. Keen students will have the additional chance to learn about radio data reduction.



MAIN PROGRESSION STEPS

- `Week 1-2`: Introduction, initial setup and study of theory;
- `Week 3-6`: Data reduction and analysis
- `Weeks 7`: Preparation of the written report;
- `Weeks 8`: Preparation of the final oral presentation.

EVALUATION

- `Theory grade [30%]`
  - Written report
- `Practice grade [30%]`
  - Oral presentation;
  - Initiative, progress, analysis;
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

[1] van Weeren et al. (2019)
[2] Giovannini & Feretti (2000)
[3] Basu et al. (2012)
[4] Govoni et al. (2001)
[5] Radiconi et al. (2022)
[6] Zandanel et al. (2014)
[7] Govoni et al. (2017)

CONTACT

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