Research theses INAF Institute for Radioastronomy (IRA): your friendly neighbour

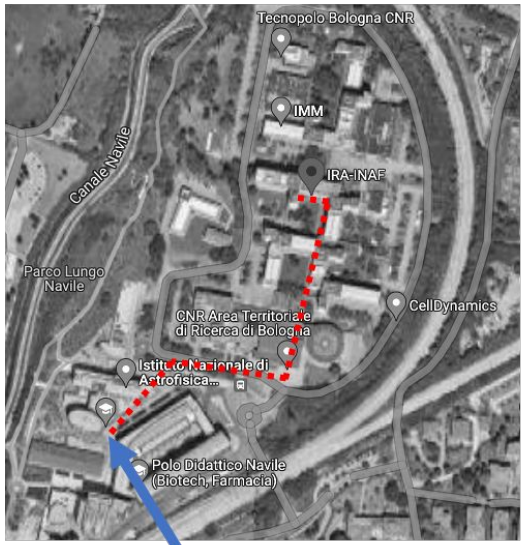
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

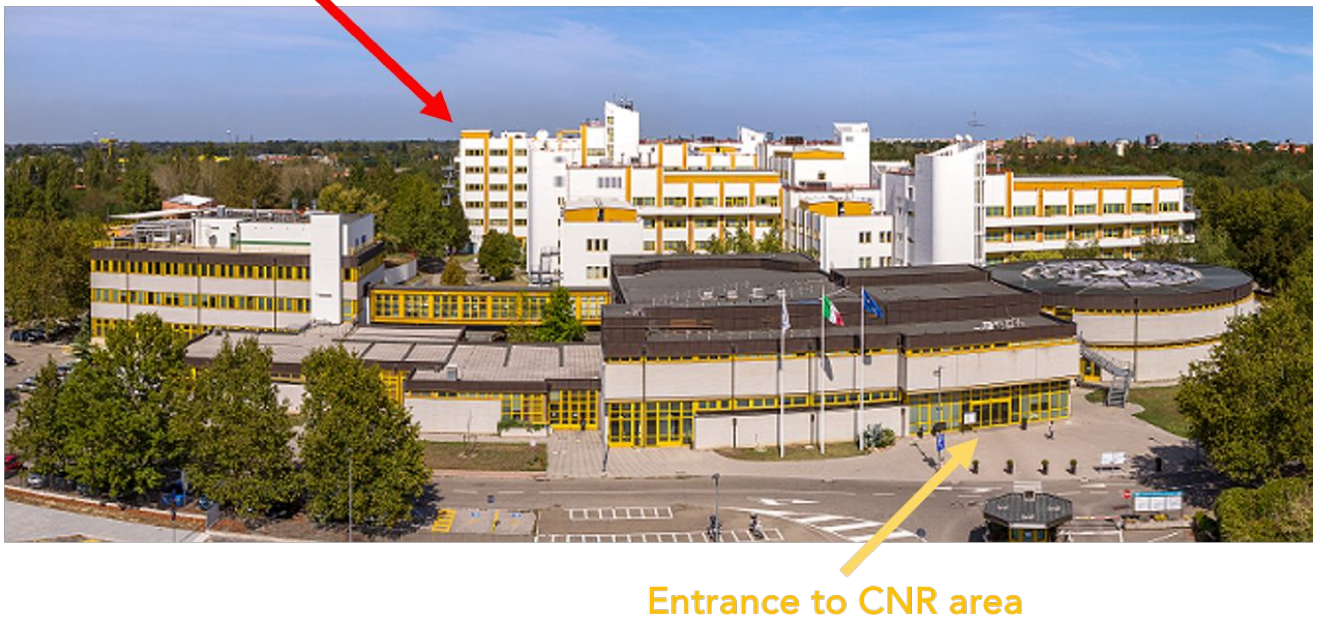
"Thesis day" - Feb 5th, 2024

Matteo Bonato, Andrea Botteon
Rocco Lico, Cristiana Spingola

Where are we?

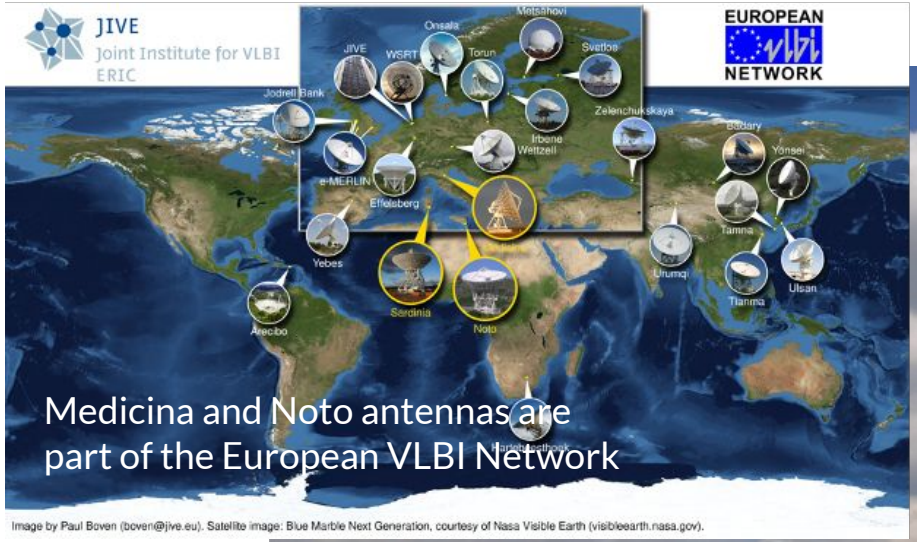
Where you did (or will do) the ALMA data analysis for the
«MULTIWAVELENGTH ASTROPHYSICS LABORATORY» course (2nd year of MSc)





https://info.ira.inaf.it/studio-e-lavoro/tesi-di-laurea/

Radio telescopes handled by INAF-IRA



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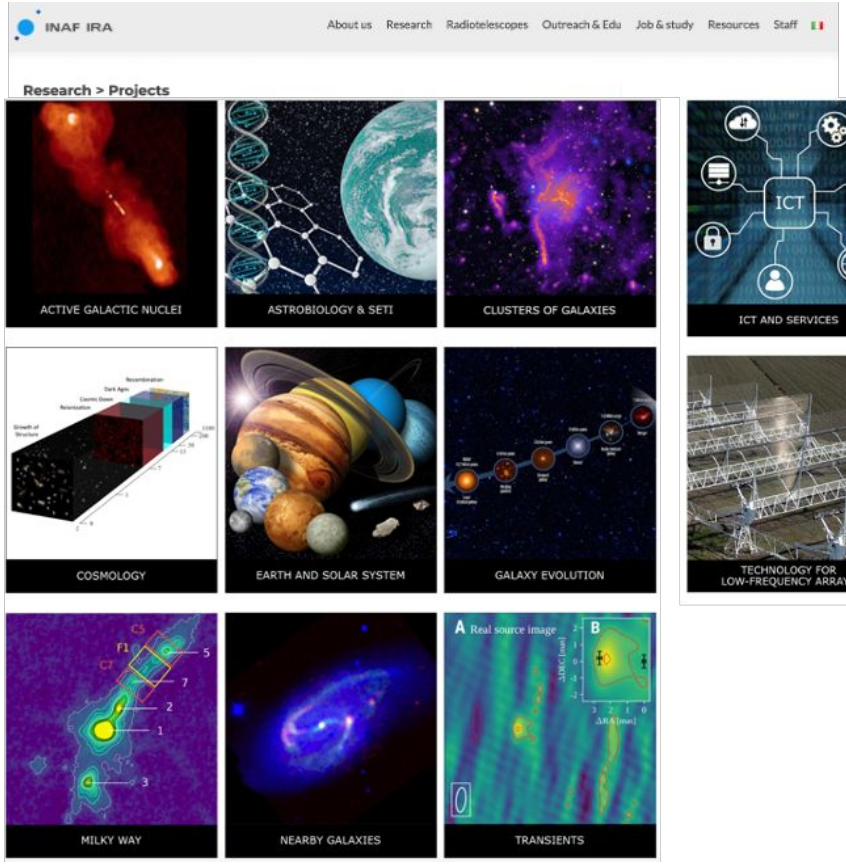
Research areas

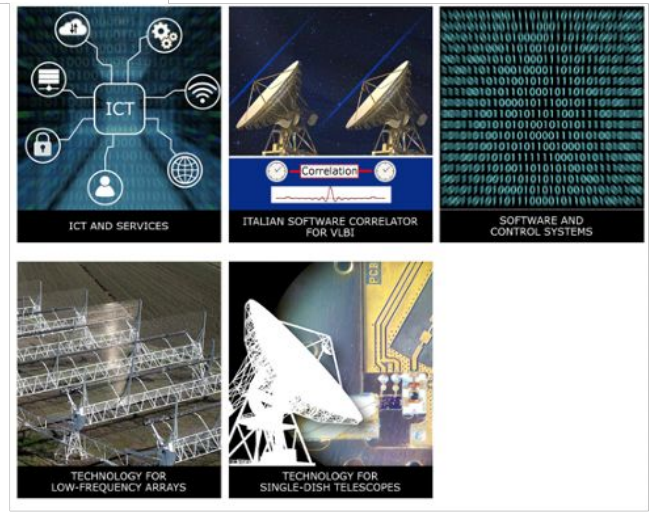
Science & Technology

https://info.ira.inaf.it/en/research/

Answering big questions

- What triggers AGN activity in the local and ancient Universe?
- When did the first galaxies form?
- And how do they evolve?
- What is dark matter?
- How are particle accelerated in the largest structures in the Universe?
- Why are cosmic magnetic fields important?





co-organisation of JAC and seminars

dedicated IRA seminars on
FRIDAYS AT 11:30 at IV floor

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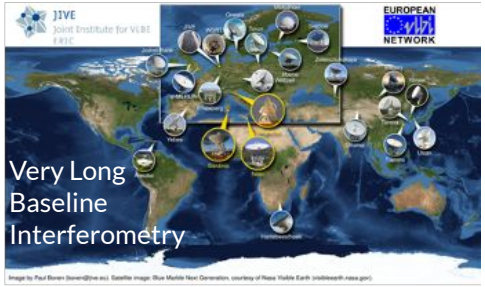
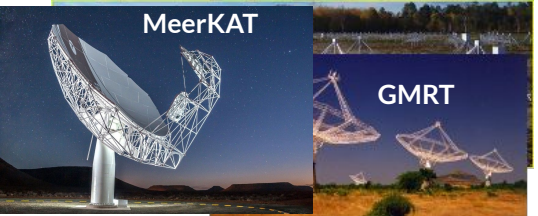
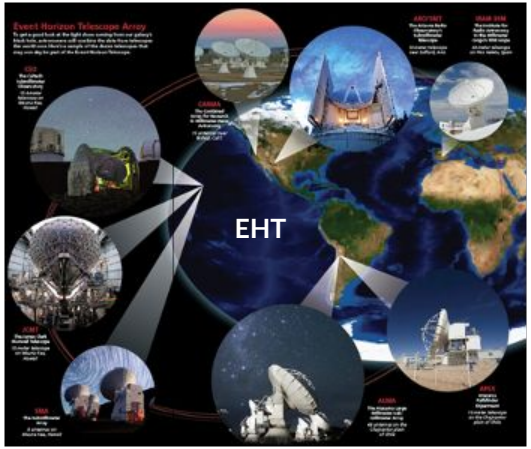
Telescopes in our research (precursors)

Radio (m - cm)

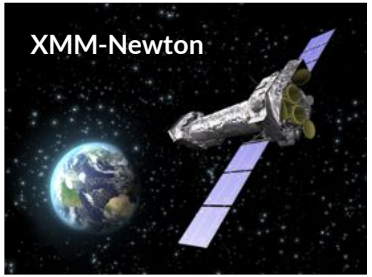




Microwave (mm - submm)
ALMA Regional Center



X-rays



Gamma-rays

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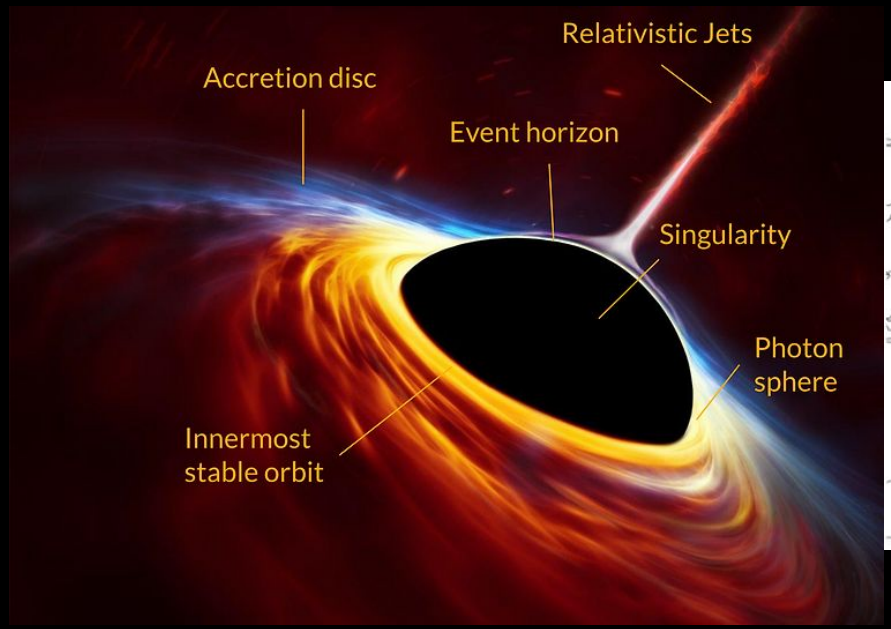
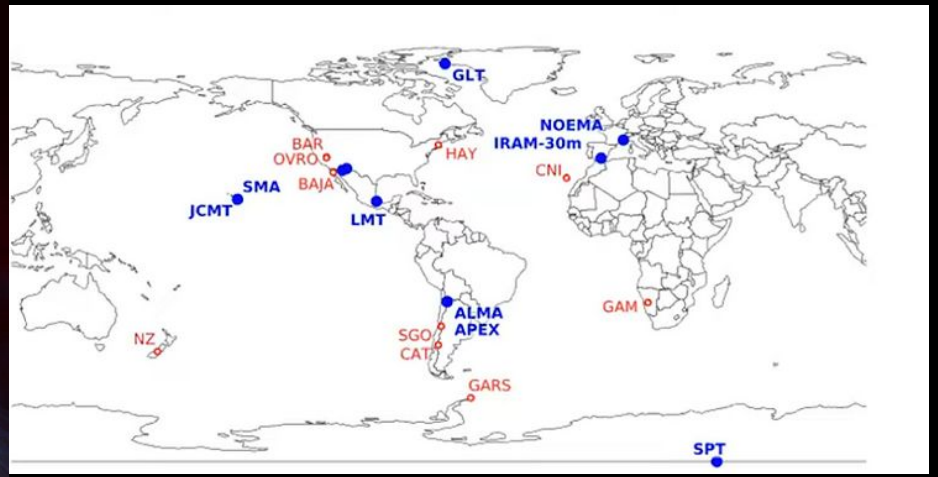
Telescopes in our research
Involvement in next generation of observatories



Next generation of EHT



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Telescopes in our research
Involvement in next generation of observatories

ngvla

Next Generation Very Large Array

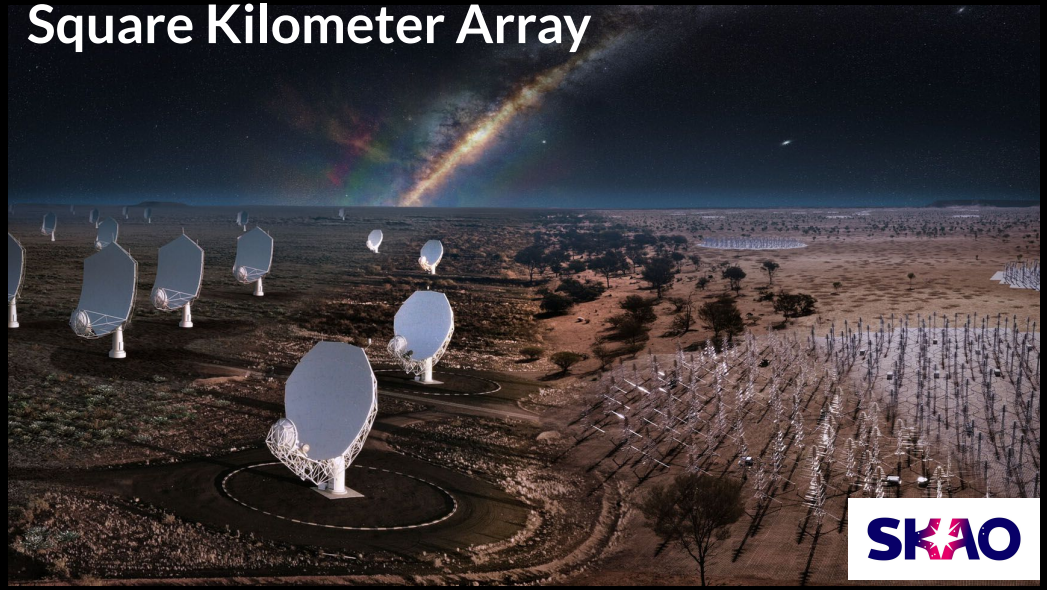
Construction expected in 2028
Early science in 2031

INAF-IRA is involved in 4 science cases <u>with leadership</u>
(and many others as collaborators)

Theses on simulations of ngVLA observations available!

Telescopes in our research
Involvement in next generation of observatories

Square Kilometer Array



First SKA1-mid antenna built!

Science commissioning expected to start in 2024
Key Science Projects in 2026
PI proposals in 2028

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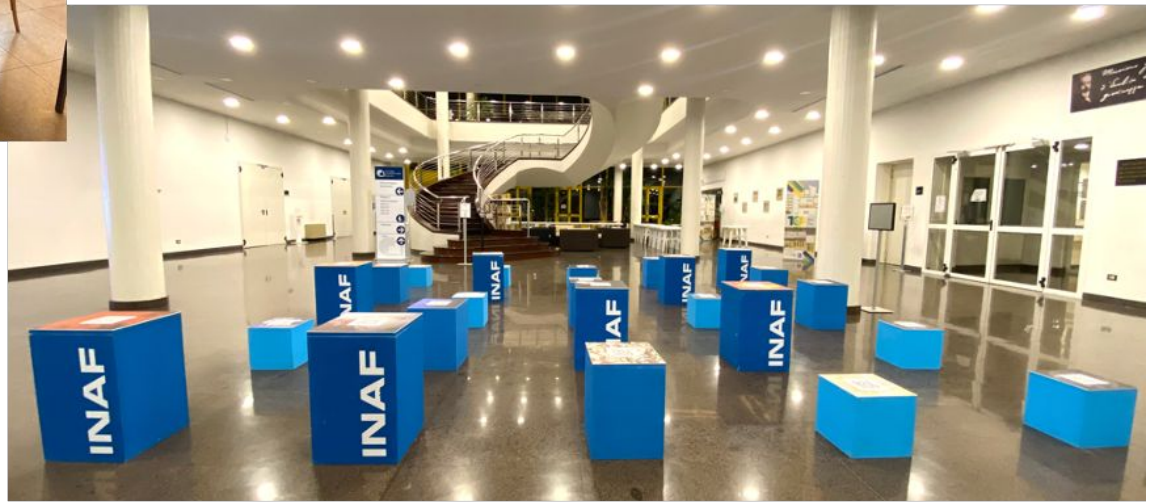
MSc thesis (and PhD) at INAF-IRA

Always MSc and PhDs + strong connection with other international institutes (hence good networking for possible PhD abroad)

Publication of thesis in refereed journals

Our contact information: https://info.ira.inaf.it/en/about/contacts/



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Our research groups and proposed theses

Cosmology: the team

Gianni Bernardi

Carlo Burigana

Ettore Carretti

Tiziana Trombetti

Matteo Bonato

Marcella Massardi

Vincenzo Galluzzi

"Contact person" @
DIFA: Lauro Moscardini

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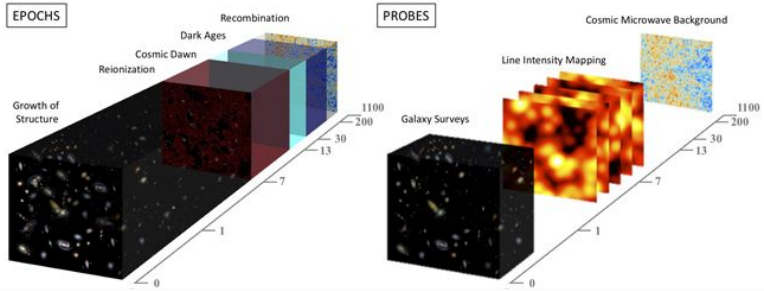
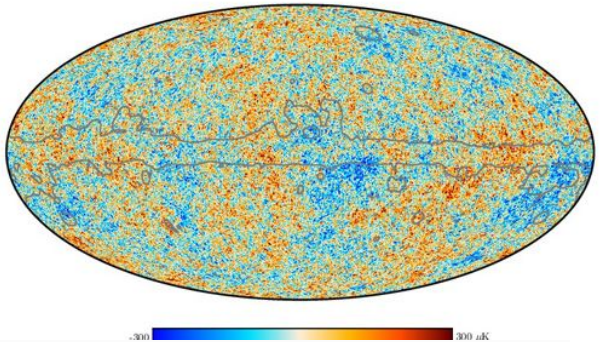
Cosmology



Various epochs in cosmic history and probes from different types of cosmological surveys
(Delabrouille et al., 2021)

Cosmic backgrounds and large scale structure

- imprints expected from the early phases of the Universe to the reionization age
- non-equilibrium phenomena
- background signal from source population



All-sky map of the temperature anisotropies of the CMB
(Planck Collaboration 2020)

Observational cosmology

-cosmological surveys of the diffuse backgrounds and of the galaxies distributions (LOFAR, ATCA, JVLA, Euclid…)

Cosmology

From the dark ages to the cosmological reionization

-21 cm line science

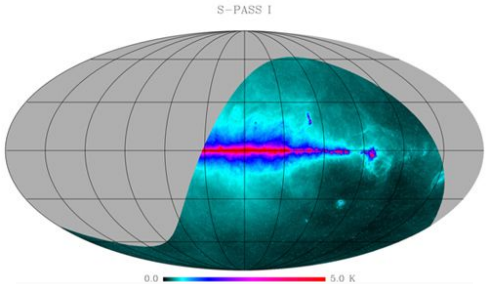
-Involved in projects: LEDA, HERA, REACH, LOFAR, SKA, Planck and future CMB missions

Astrophysical foregrounds

- Galactic synchrotron and free-free radio emissions (e.g. GMIMS and S-PASS surveys)

-Galactic dust and Zodiacal light emissions (COBE, IRAS, WMAP, SMEI and Planck)

- extragalactic sources and galaxy clusters: Sunyaev-Zel'dovich effect



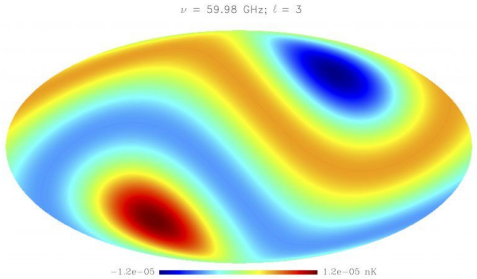
S-PASS map of the total intensity at 2.3 GHz (Carretti et al. 2019)

Methods

-theoretical forecasts and modeling

- simulations of the sky signals and of instrumental and observational effects

-analysis of simulated and real data



Prediction of the anisotropy induced by the Solar System barycentre motion in the presence of spectral distortions (Trombetti et al., 2021)

Galaxy evolution: the team

Isabella Prandoni

Tiziana Venturi

Viviana Casasola

Rosita Paladino

Marcella Massardi

and Marco Bondi

PhD & Post-Doc @ IRA:
Bisigello, Giulietti, Trobbiani, Belfiori, De Rubeis, Tailor

Ranieri Baldi

Matteo Bonato

Cristiana Spingola

Francesco De Gasperin

"Contact people" @ DIFA: Cristian Vignali, Francesca Pozzi, Margherita Talia

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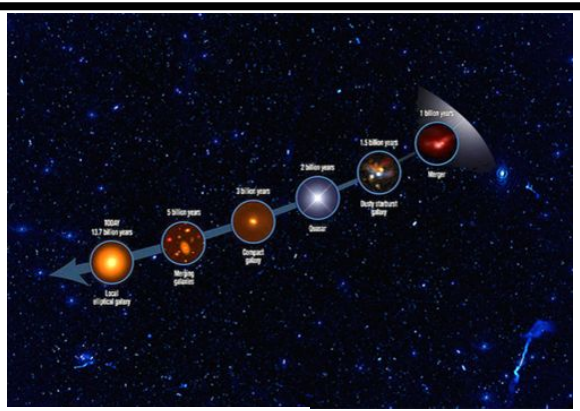
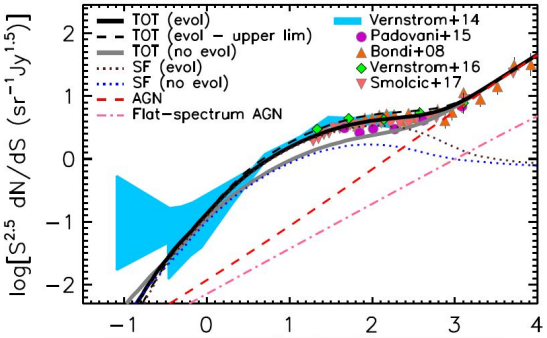
Galaxy evolution



Zoom in of the Lockman Hole of the LOFAR 150 MHz Survey Tier 2 fields. Superimposed is a graphic showing the evolutionary sequence in the growth of massive elliptical galaxies over 13 billion years (LoTSS collaboration)

Tracing the evolution of galaxies and AGN

- Galaxy/AGN (co-)evolution (models and observations)
- From the Local Universe to high-z
- Radio-continuum surveys with SKA pathfinders and precursors (LOFAR, ASKAP and MeerKAT)
- Statistical properties of different populations of galaxies and AGN
- Physical properties of galaxies and AGN (e.g fueling/feedback cycle in radio galaxies)
- Resolved local galaxies (e.g. Dustpedia project)
- Star formation history
- Multi-frequency approach



Theoretical and observational number counts (Bonato et al., 2017)

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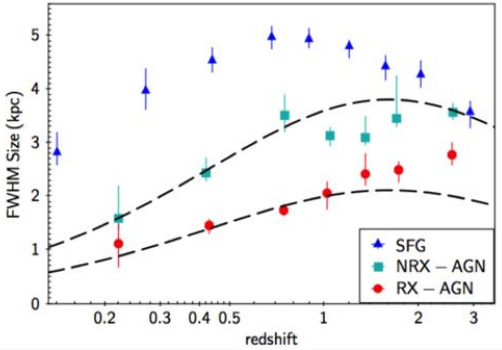
Galaxy evolution

Physical properties of faint radio AGN

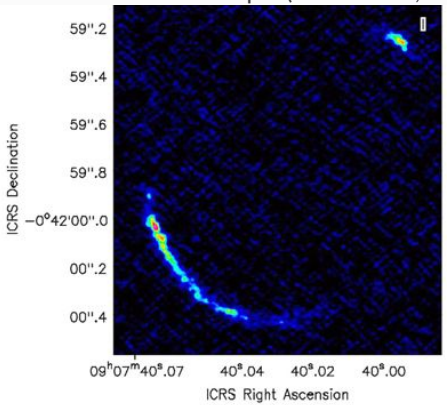
- Studying faint and compact radio AGN with VLBI and multi-band observations



Evolution of the linear size with redshift of sources in the VLA-COSMOS 3 GHz sample (Bondi et al., 2018)

Interplay between star formation and nuclear activity at high-z

- AGN feedback in high-z strongly lensed galaxies (sub-arc resolution with VLBI and ALMA observations)



ALMA 1.3-mm high-resolution continuum image of the strongly lensed galaxy SDP.9 at z~1.6 (Massardi et al., 2018)

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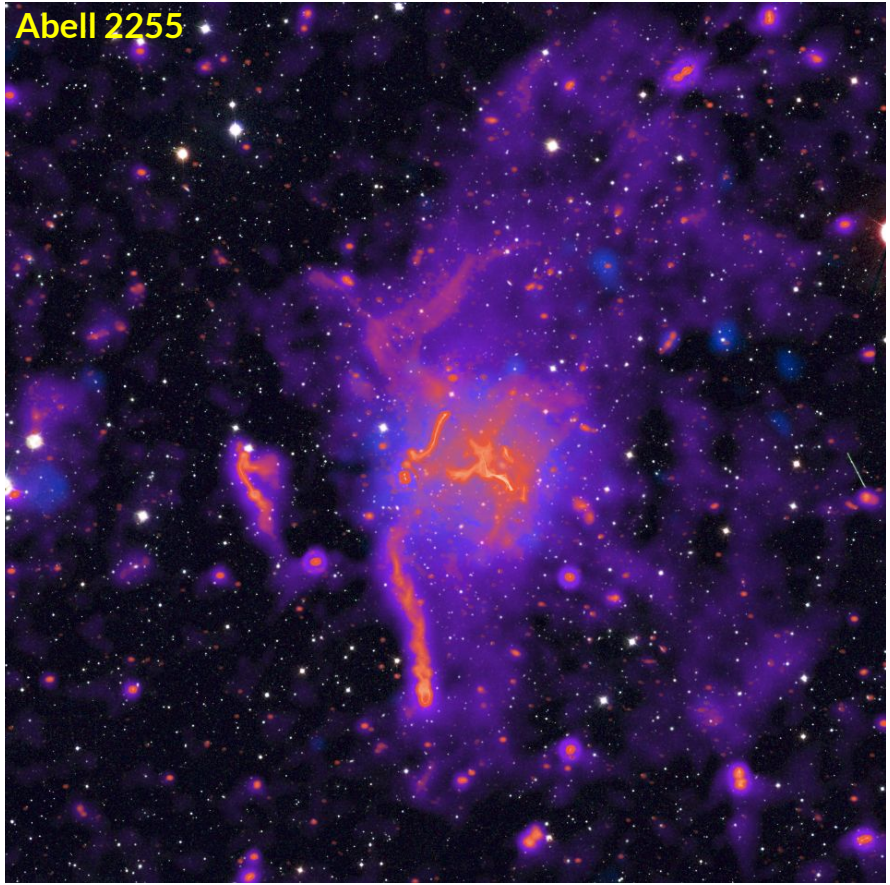
Galaxy clusters



Background: optical image (SDSS)
Blue: X-ray image (ROSAT)
Orange+purple: radio image (LOFAR)

Research interests:
-diffuse radio emission from galaxy groups, clusters, and large-scale structure (e.g. radio halos and relics)
-particle acceleration mechanisms
-magnetic fields
-radio galaxies in clusters (e.g. tailed AGN, BCG)

LOFAR, MeeKAT, uGMRT, JVLA, ASKAP, XMM-Newton, Chandra

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Galaxy clusters: the team

Tiziana Venturi

Gianfranco Brunetti

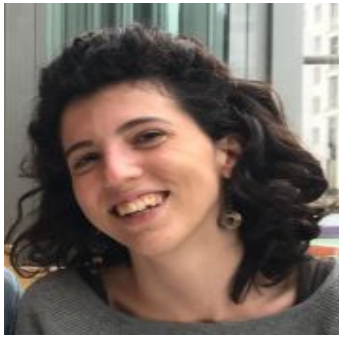
Rossella Cassano

Gianni Bernardi

Strong connections with groups in Germany, Netherlands, US, India, South Africa, and more

Andrea Botteon

Francesco De Gasperin



Chiara Stuardi

PhD & Post-Doc @ IRA:
Benati, Bruno, De Rubeis, Pasini, Srikanth

“Contact points” @ DIFA:
Bonafede, Dallacasa, Gitti, Vazza

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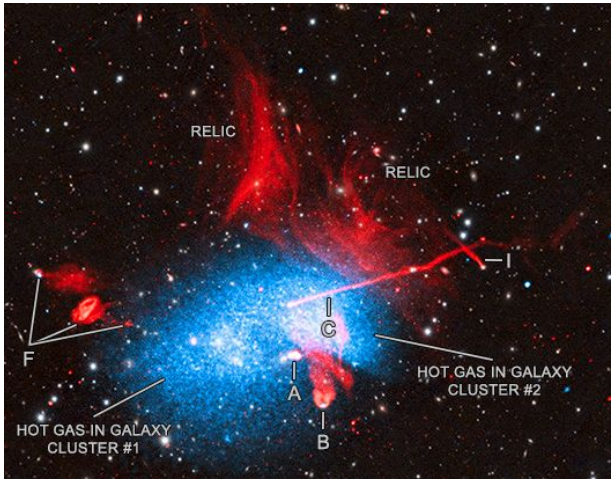
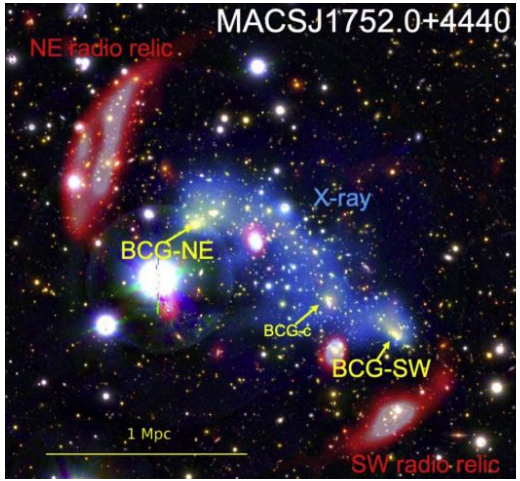
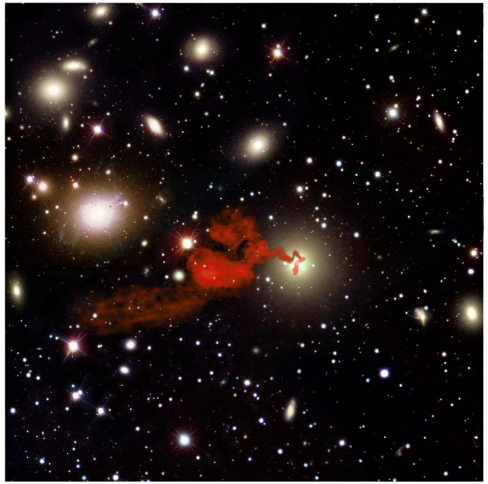
Galaxy clusters: diffuse sources

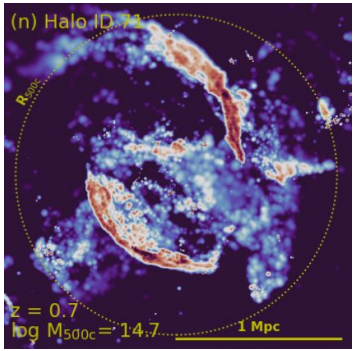
Bonafede, Botteon, Dallacasa, De Gasperin, Gitti, Stuardi, Venturi

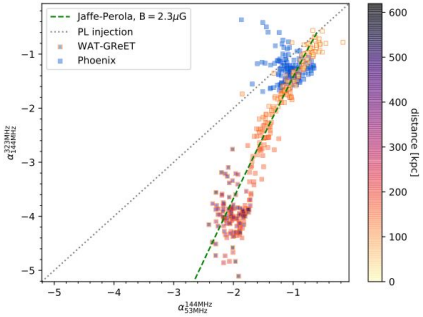






- Radio halos, mini-halos, relics, bridges, filaments!
- Head-tail radio galaxies
- Connection between radio galaxies and diffuse sources
- LOFAR+MeerKAT+uGMRT+JVLA+ASKAP
- Multifrequency radio analysis -> spectral modeling
- Comparison with models/simulations
- Interaction with the ICM (Chandra+XMM)
- Thesis : "special "selected targets





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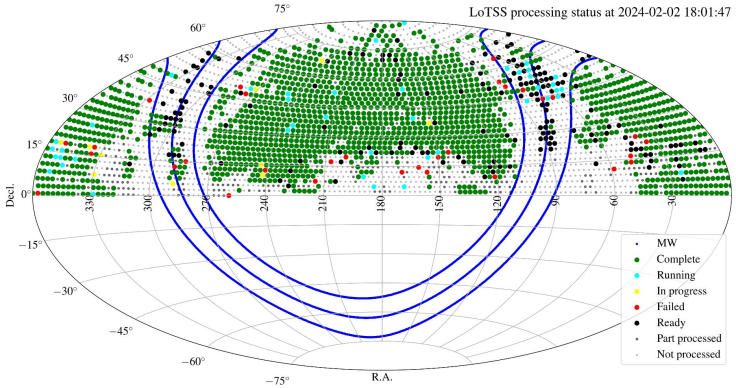
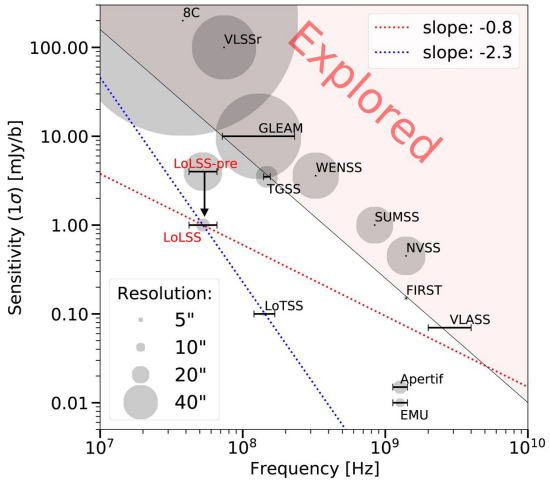
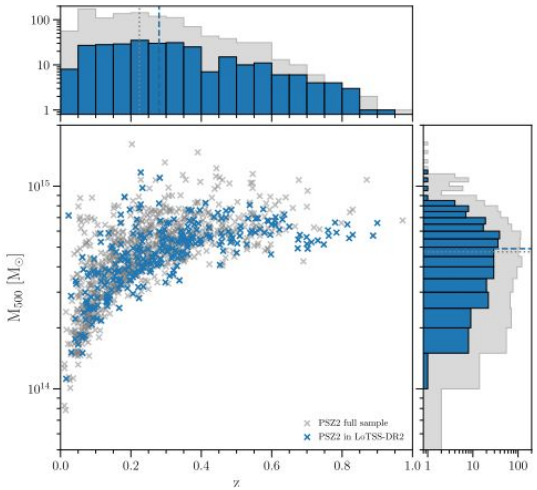
Galaxy clusters: statistical samples

Bonafede, Botteon, Dallacasa, Brunetti, Cassano, De Gasperin, Venturi



https://lofar-surveys.org/planck_dr2.html





The Planck clusters in the LOFAR sky

In this page, we collect the results from the analysis of the galaxy clusters covered by the second LOFAR Two-metre Sky Survey Data Release (LoTSS-DR2) that belong to the second Planck catalog of Sunyaev-Zel'dovich sources (PSZ2). With 309 objects, the LoTSS-DR2/PSZ2 sample represents the largest statistical sample of galaxy clusters observed with highly sensitive low frequency observations that has been ever used to search for and study diffuse synchrotron emission in the intra-cluster medium. The results of this work are presented in the series of papers entitled "The Planck clusters in the LOFAR sky", as listed below.

Papers

- Paper I (Botteon et al.): LoTSS-DR2: new detections and sample overview
- Paper II (Bruno et al.): LoTSS-DR2: Recovering diffuse extended emission with LOFAR
- Paper III (Zhang et al.): LoTSS-DR2: X-ray properties of clusters with Chandra and XMM-Newton
- Paper IV (Cassano et al.): LoTSS-DR2: Statistics of radio halos and re-acceleration models
- Paper V (Cuciti et al.): LoTSS-DR2: Mass-radio halo power correlation at low frequency
- Paper VI (Jones et al.): LoTSS-DR2: Properties of radio relics

- ❑ Unexplored frequency window!
- ❑ Unprecedented statistics halos/relics
- ❑ Halos/relics new regimes (z, mass)
- ❑ Large number of tailed AGN
- ❑ Test/comparison with models
- ❑ Spectral studies
- ❑ Thesis : selected subsamples

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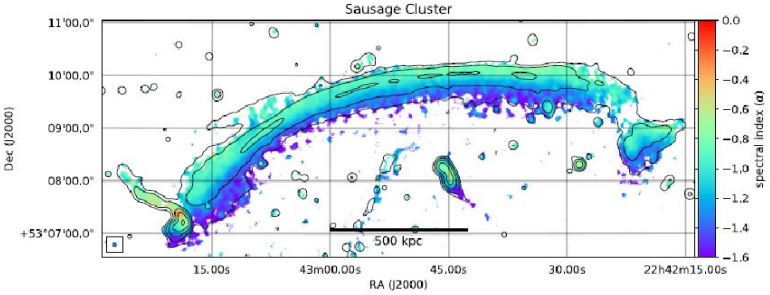
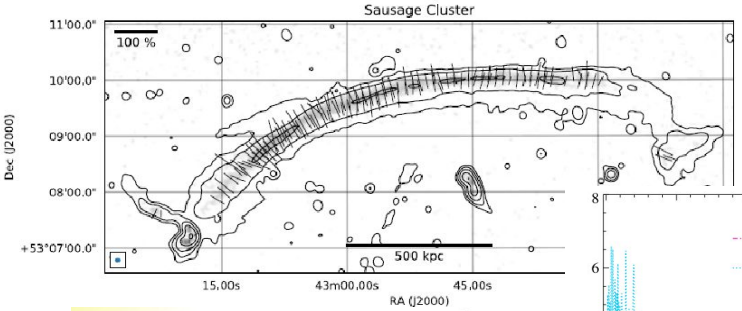
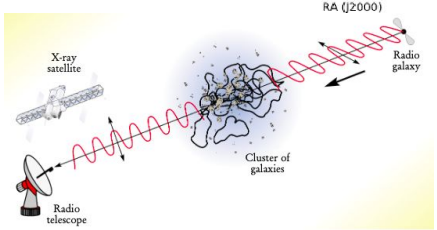
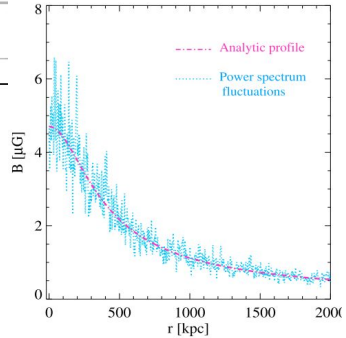
Galaxy clusters: magnetic fields

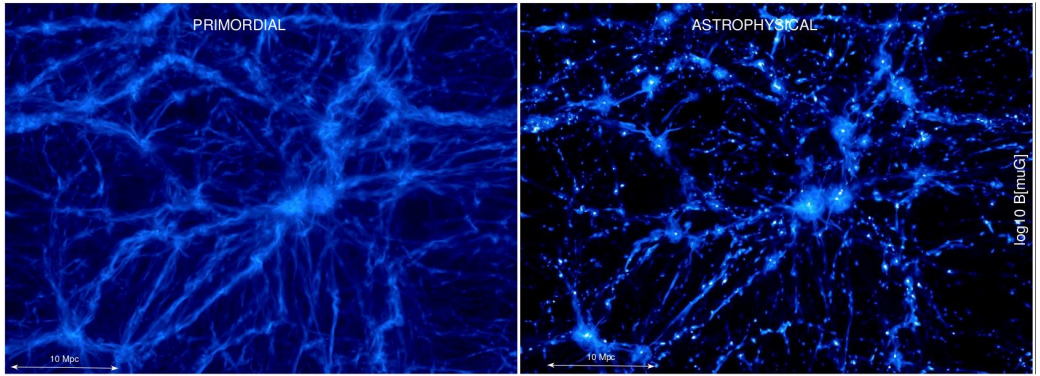
Bernardi, Bonafede, Dallacasa,
Stuardi, Venturi, Vazza











- What is the origin of cosmic magnetism?
- What are the properties on B in the ICM?
- How is B amplified?
- Polarization
- Faraday rotation synthesis
- LOFAR+MeerKAT+JVLA
- Comparison with models/simulations
- Thesis : Stokes U and Q

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Galaxy clusters: theory + simulations

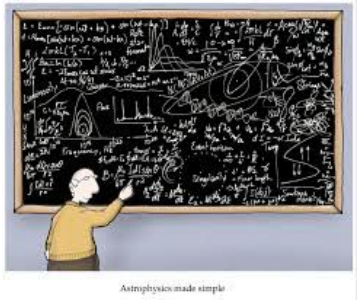
Brunetti, Cassano, Vazza

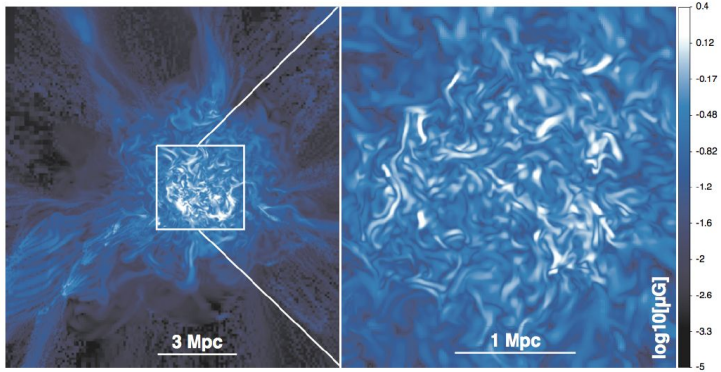
- What are the acceleration mechanisms in the ICM ?
  (origin of radio halos, relics, bridges)
- How CRs are transported / diffuse in the ICM ?
- How magnetic field is amplified in the ICM ?
- Non-thermal SED of GCs & the observational tests
- How plasma physics & kinetic effects affect the physics of the ICM & non-thermal components?

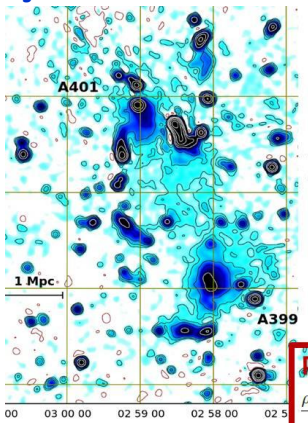
$$\frac{\partial N_e(p,t)}{\partial t} = \frac{\partial}{\partial p}\left(N_e(p,t)\left[\left(\frac{dp}{dt}\right)_{rad+i} - \frac{2}{p}D_{pp} - \frac{p}{3}(\nabla\cdot V)\right]\right) + \frac{\partial}{\partial p}\left(D_{pp}\frac{\partial N_e(p,t)}{\partial p}\right) + Q_e(p,t) \quad (77)$$

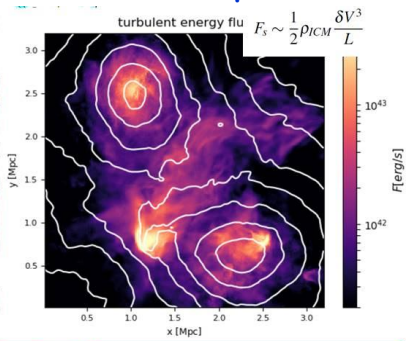
$$\frac{\partial N_p(p,t)}{\partial t} = \frac{\partial}{\partial p}\left(N_p(p,t)\left[\left(\frac{dp}{dt}\right)_{i} - \frac{2}{p}D_{pp} - \frac{p}{3}(\nabla\cdot V)\right]\right) + \frac{\partial}{\partial p}\left(D_{pp}\frac{\partial N_p(p,t)}{\partial p}\right) - \frac{N_p(p,t)}{\tau_{pp}} \quad (78)$$

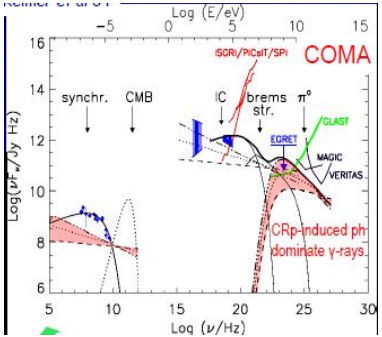
$$\frac{\partial \mathcal{W}(k,t)}{\partial t} = \frac{\partial}{\partial k}\left(k^2 D_{kk}\frac{\partial}{\partial k}\left(\frac{\mathcal{W}(k,t)}{k^2}\right)\right) - \sum_i \Gamma_i(k,t)\mathcal{W}(k,t) + I(k,t) \quad (79)$$









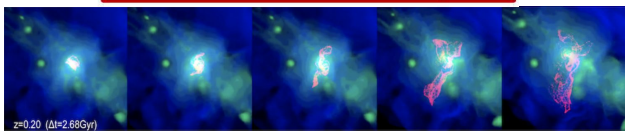


Pturb ~ 10^5 x Pr (A399+401)

$$\frac{\rho_{ICM}\delta V^3}{L}\eta_{CRe} \sim \int d^3pE\frac{\partial f_e}{\partial t}$$

Radiation: Syn + ICS

- Calculations on the expected properties of the radio emission
- MHD simulations (traces)
- Thesis : Predictions



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VLBI / High-energy group

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Gabriele Giovannini
(collaborator)

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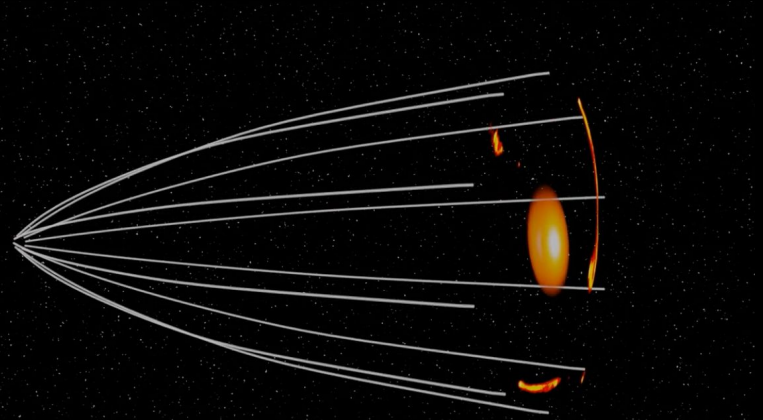
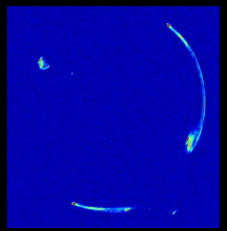
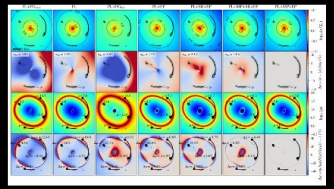
Spingola, Migliori, Giroletti

AGN as cosmological probes







AGN jets at extremely high-z (z > 6)

Spingola+ 2020c

Incl. Migliori, Giroletti, Orienti, Dallacasa (UniBO)

collaborators at INAF-Brera and MPIA (Heidelberg)

Strong lensing to test ΛCDM framework

Spingola+ 2018, 2022

Collaboration with G. Despali (UniBO)

and collaborators in Europe and South Africa

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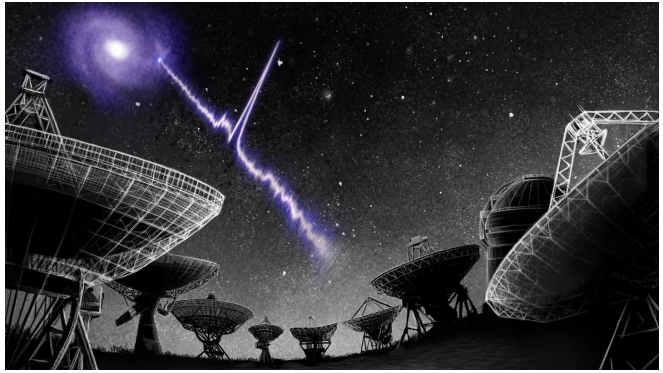
Transients: gamma ray bursts, fast radio bursts and many others

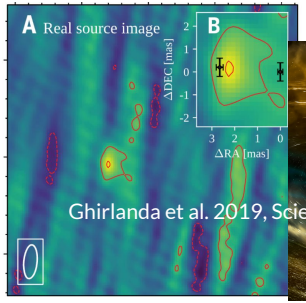
Pelliciari, Bernardi, Giarratana, Giroletti, Lico, Migliori

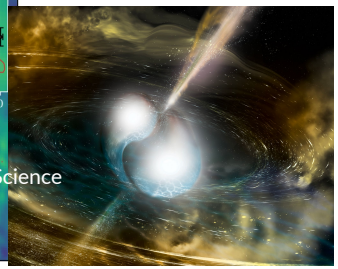
FRBs



Giroletti, Bernardi, Pelliciari

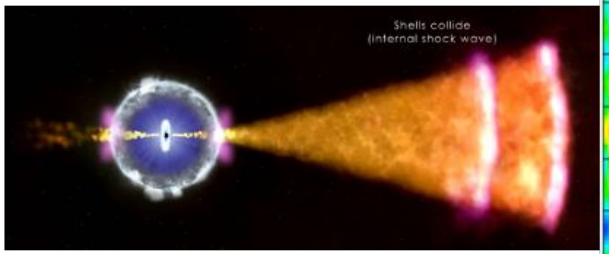
Localisation of Gravitational Waves

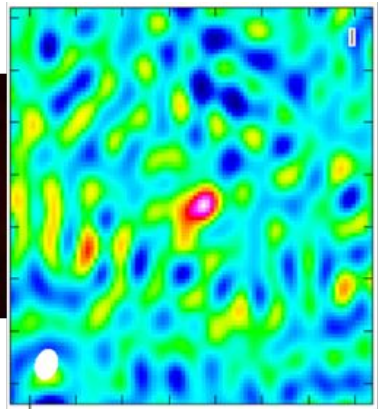




Contact person: Marcello Giroletti

GRBs





Giarratana+ 2022, 2023a, b

Jets from GRBs to test different evolution models

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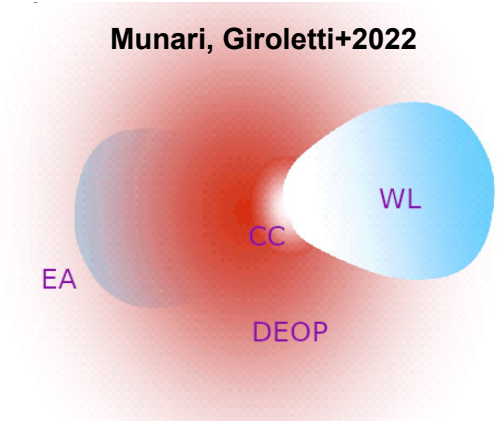
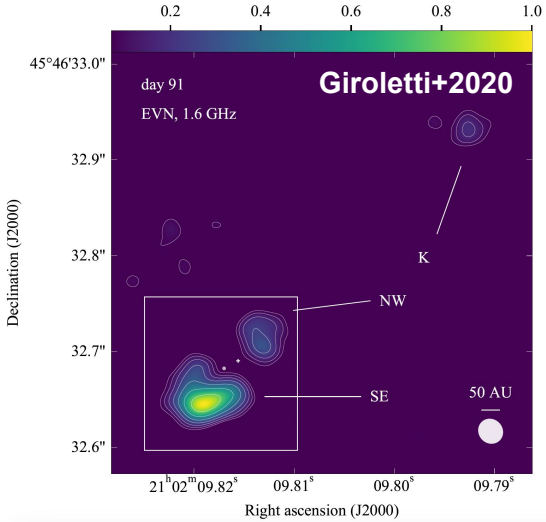
Transients: novae

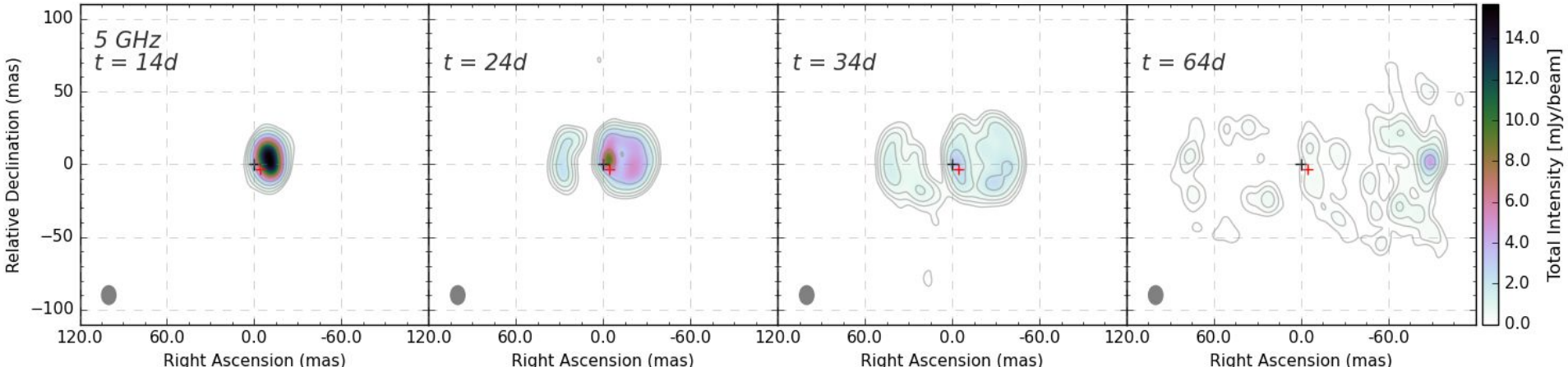
Giroletti, Lico, Orienti, D'Ammando, Spingola, Migliori

- RS Ophiuchi
- V407 Cygni
- T CrB





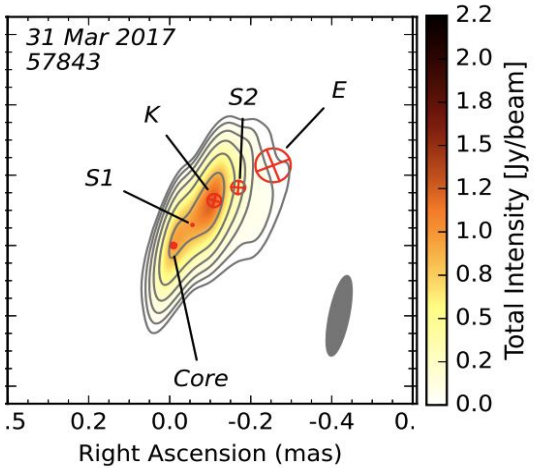
Lico, Giroletti+in prep.



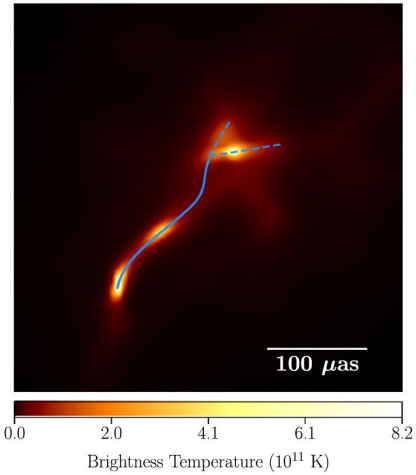
AGN physics in the era of mm-VLBI: OJ287

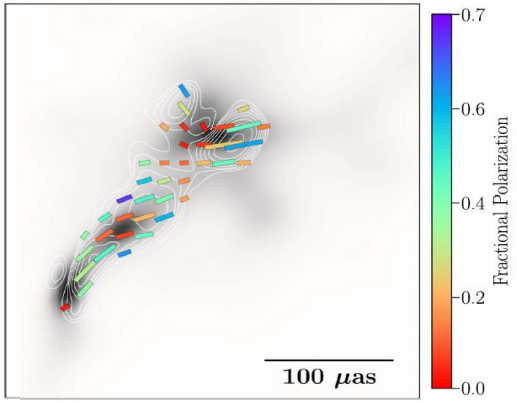
Giroletti, Lico, Orienti, D'Ammando, Spingola, Migliori, Giovannini, Baldi.

3 mm GMVA (Lico+2022)

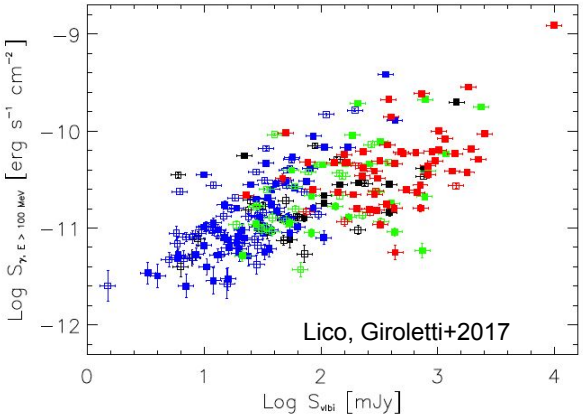


3 mm GMVA+ALMA (Zhao+2022)



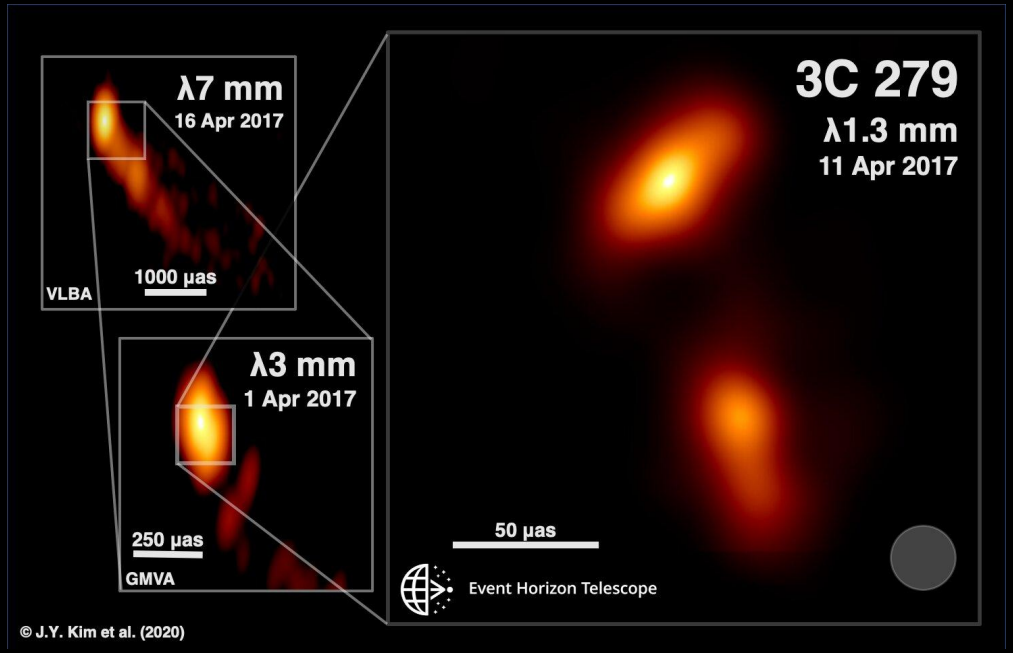


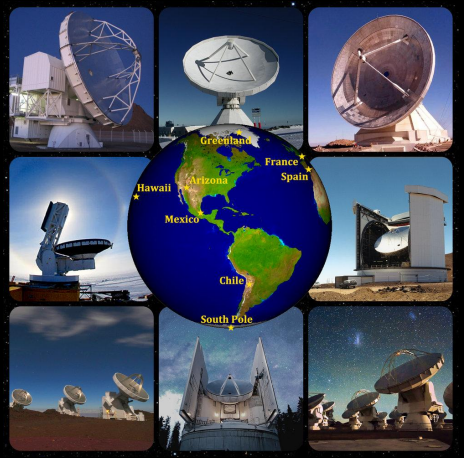
- Magnetic fields
- Jet formation & collimation
- High-energy emission
- GWs and Neutrinos
- population studies

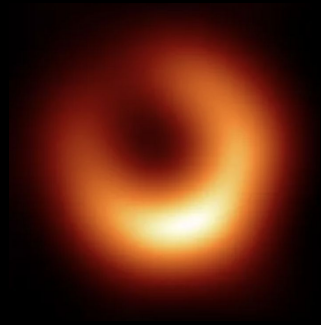


Giroletti, Lico, Nanci, Migliori, Orienti,
D'Ammando, Marchili, Giovannini.

AGN physics in the era of mm-VLBI







M87* EHTC 2024

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Some examples of MSc theses

For a more complete list see
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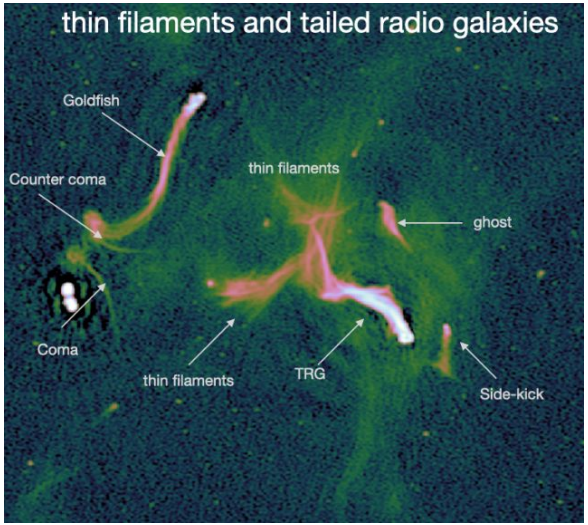
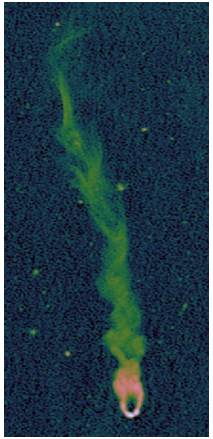
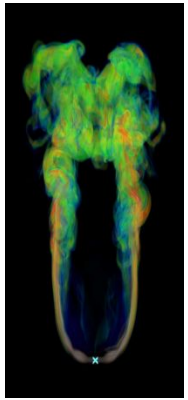
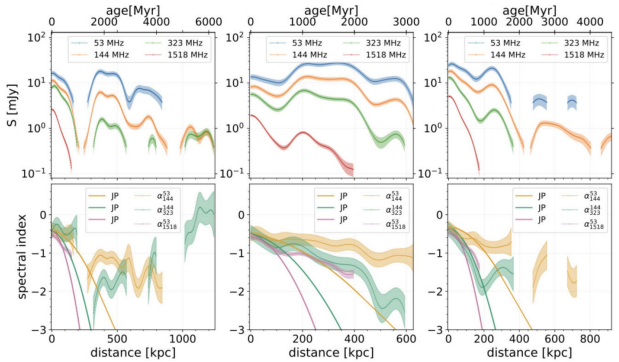
Contact us if you have other ideas!
We can find the best project for you

Particle re-acceleration in the head-tail radio galaxies in Abell 2255









Coordinators Dr. Andrea Botteon (andrea.botteon@inaf.it), Prof. Daniele Dallacasa (daniele.dallacasa@unibo.it)

Duration 6-8 months

Description Tailed radio galaxies are extended sources found in galaxy clusters that can show very peculiar morphologies. The most extreme class of these sources is represented by “head-tail” radio galaxies, that are generated when the host galaxy is moving at high velocity (up to 10^3 km/s) in the cluster. Owing to the ram-pressure from the intra-cluster medium (ICM), the radio jets of these sources are strongly curved, resulting in elongated trails of relativistic electrons and magnetic fields extended up to Mpc-scale.

The aim of the thesis work is to use very deep multi-frequency observations performed with LOFAR, uGMRT, and VLA to study the morphological and spectral properties of the head-tail radio galaxies in Abell 2255. The analysis will allow the student to determine how magnetic fields and relativistic electrons evolve from the active black hole up to large distances from the host galaxy. By comparing these results with spectral aging models, the student will constrain the role of re-acceleration processes triggered by the interaction between the non-thermal components in the jets and the surrounding ICM.

References Pizzo & de Bruyn 2009, A&A, 507, 639; Botteon et al. 2020, ApJ, 897, 93; Botteon et al. 2022, Science Advances, 8, eabq7623

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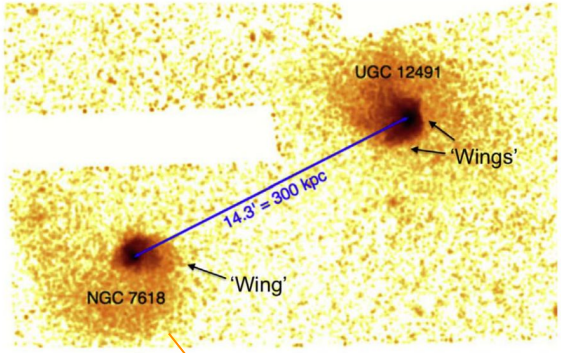
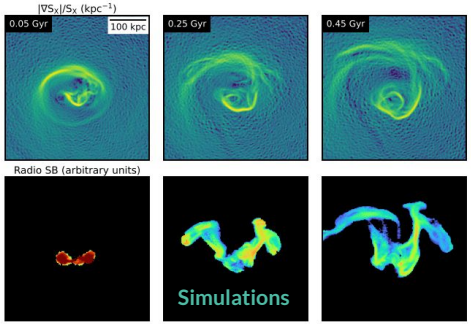
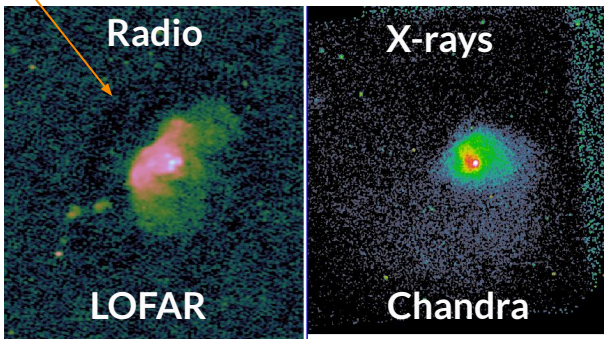
The interplay between relativistic plasma and thermal gas in a galaxy group







Coordinators Dr. Andrea Botteon (andrea.botteon@inaf.it)

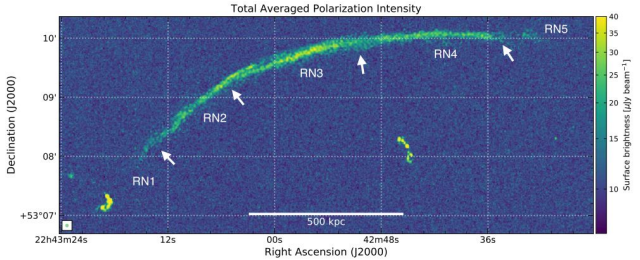
Duration 6-8 months

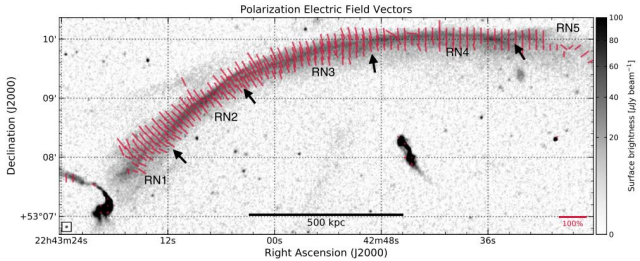
Description NGC7618/UGC12491 represents a rare case of a major group merger in the local Universe. This system has been intensively studied in the X-rays, revealing a plethora of complex features, yet it lacks a detailed investigation in the radio band. Compared to massive galaxy clusters, radio emission from galaxy groups is poorly explored. Nonetheless, the group regime is increasingly gaining interest in the community as new instruments now allow for the first time to probe non-thermal phenomena in these systems, making a multi-band study of NGC7618/UGC12491 very timely.

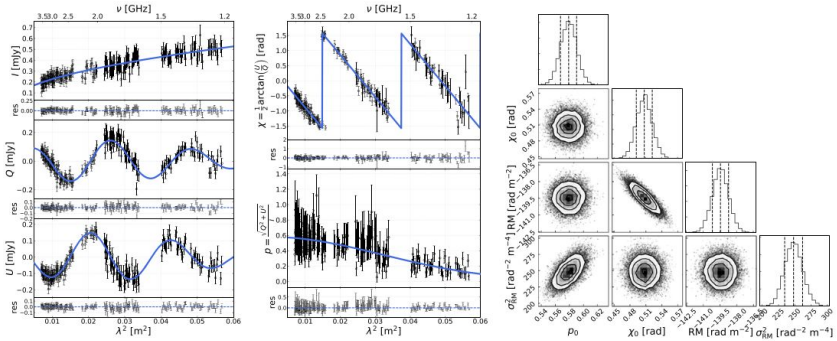
The thesis work is focused on the analysis of multi-frequency observations obtained with LOFAR and GMRT. Preliminary images show the presence of diffuse radio emission at the center of NGC7618, whose nature is ambiguous. An intriguing possibility is that it traces material ejected by an AGN which is being distributed by sloshing motions. By combining radio and X-ray data, the student will aim to shed light on the origin of this newly discovered source.

References Kraft et al., 2006, 640, 762; Roediger et al., 2012, 754, 147; Machacek et al., 2023, 958, 93

Modeling the magnetic field in the CIZA J2242.8+5301 galaxy cluster







Coordinators Prof. Annalisa Bonafede (annalisa.bonafede@unibo.it), Dr. Gabriella Di Gennaro (Hamburg University), Dr. Chiara Stuardi (ccstuardi@gmail.com)

Duration 6-8 months – available from January 2024

Description Galaxy clusters are permeated with magnetic fields and ultra-relativistic particles, which are revealed by the presence of diffuse Mpc-size synchrotron emission in the radio band (namely, radio halos and relics). Currently, very little is known about the topology and the strength of the magnetic field on these Mpc scales. Polarization and Faraday rotation properties of sources embedded within galaxy clusters bring fundamental information about the magnetic fields that permeate the intra-cluster medium. Comparing these observational probes with the ones obtained from simulations allows us to enlighten our knowledge of large-scale magnetic fields in galaxy clusters.

The student will use 1-4 GHz observations of the CIZA J2242.8+5301, the famous cluster hosting the Sausage radio relic, performed with the Jansky Very Large Array (JVLA). The total intensity and polarized emission of cluster radio galaxies will be modeled using the QU-fitting and the RM-synthesis approach. Subsequently, the obtained information will be compared with semi-analytical and/or cosmological simulations of galaxy clusters in order to derive the magnetic field properties for this famous galaxy cluster. The student will develop important coding skills using different programming languages (python and IDL) and will have the opportunity to work and visit collaborators based in Hamburg (Germany).

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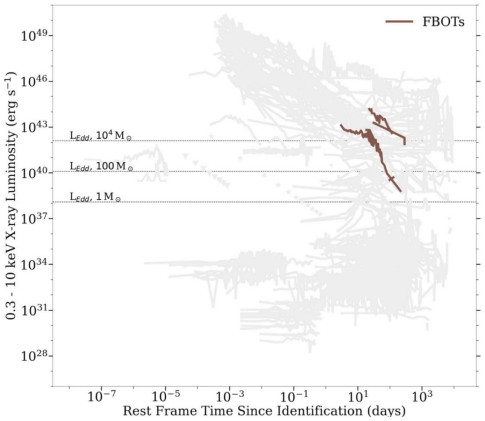
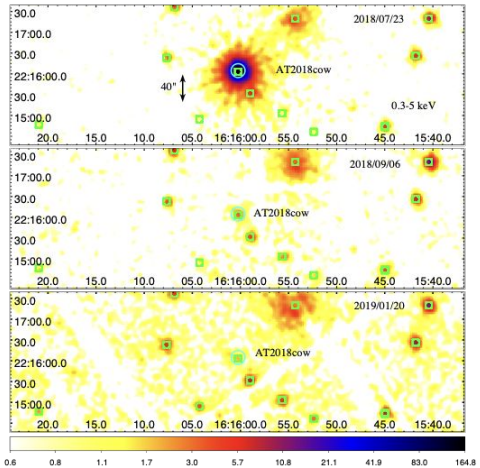
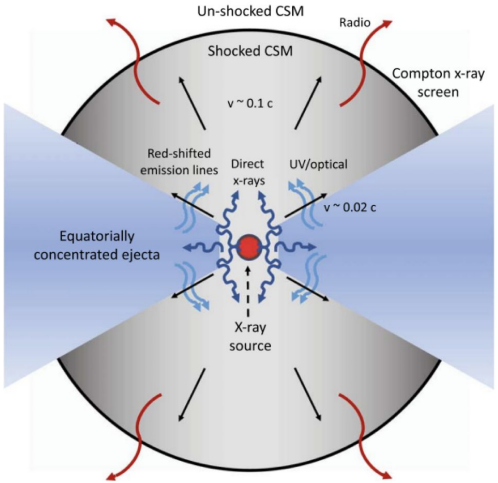
Investigating the late-time X-ray emission of the enigmatic transient AT2018cow







Coordinator Prof. Cristian Vignali (DIFA, cristian.vignali@unibo.it), Dr. G. Migliori (INAF-IRA, giulia.migliori@inaf.it), Prof. R. Margutti (University of California)

Duration 6-9 months - available from May 2024

Description Fast Blue Optical Transients (FBOTs) are a new class of transients with luminosities and time scales that challenge traditional Supernovae models. They are characterized by an extremely rapid rise to maximum light (L>10^44 erg/s) over timescales as short as only a few days and, in some cases, luminous radio and X-ray emission. The intrinsic nature of their energy source is unknown but might be connected to the presence of a central engine, for example in the form of accretion on a black hole (BH) similar to Gamma-Ray Bursts (GRBs) or tidal disruption events (TDEs).
This thesis project focuses on FBOT AT2018cow, which is thus far the nearest (60 Mpc) and best studied target with a rich multi-wavelength dataset. In particular, the student will work on a new deep X-ray observation taken about 6 yr after the transient discovery, with the goal to: (i) map the long-term evolution and spectrum in X-rays of this enigmatic source and (i) shed light on the possible connection of FBOTs with manifestations of super-Eddington accretion on BHs.

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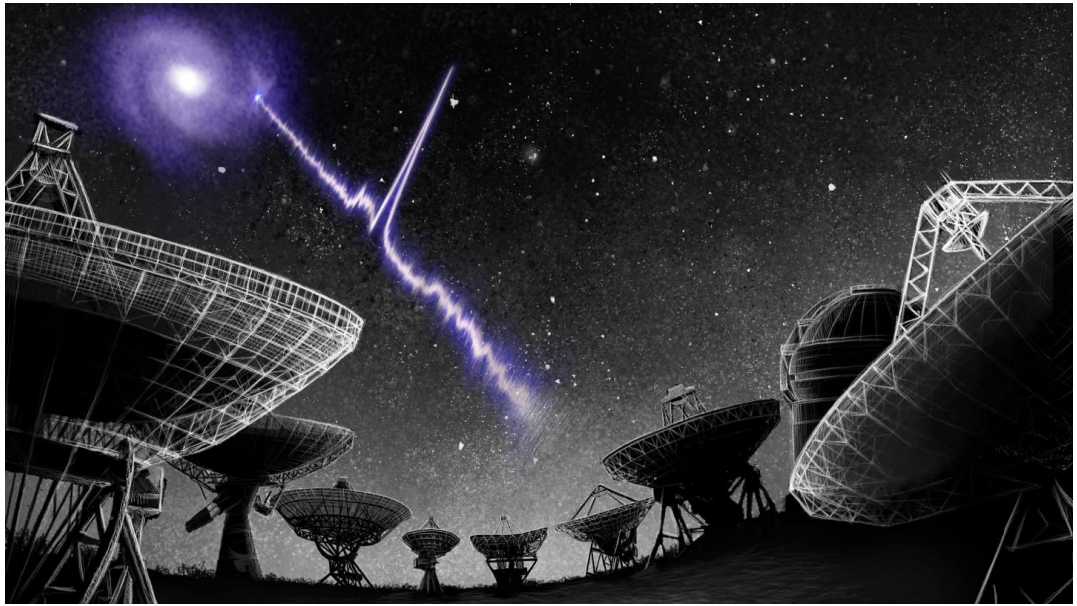
Observations and characterization of FRBs



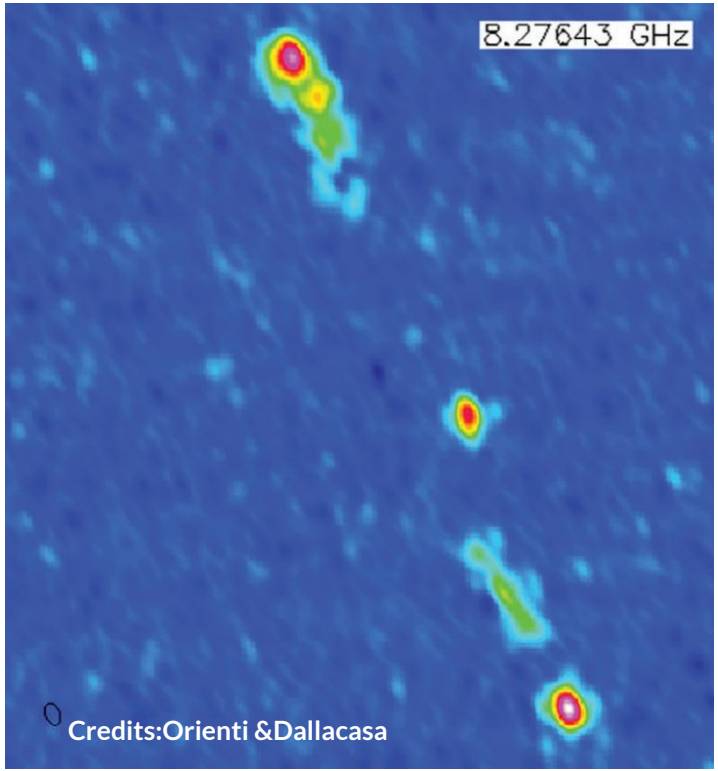
Coordinators Prof. Daniele Dallacasa (daniele.dallacasa@unibo.it), Dr. Gianni Bernardi (gianni.bernardi@inaf.it), Dr. Maura Pilia (maura.pilia@inaf.it)

Duration 6-8 months - available from Feb 2024

Description

Fast Radio Bursts (FRBs) are bright (> 1 Jy at 1.4 GHz), extremely short (a few ms) radio bursts whose nature is still largely unknown. They originate at cosmological distances and are largely believed to be associated with magnetars, i.e. young and energetic neutron stars with magnetic fields three orders of magnitude (or more) larger than standard neutron stars. The physical mechanism that generate such energetic bursts is still debated with various models existing in the literature. One way to constrain their emission models is to observe FRB events at multiple frequencies, characterizing their spectrum. The student will work on simultaneous observations of repeating FRB sources at multiple frequencies, between 300 MHz and 5 GHz, taken with the Northern Cross radio telescope, the Sardinia Radio Telescope, and the two 32-m dishes located at Medicina and Noto. The thesis goal will be to analyze the observations, characterize the burst properties and compare the results with theoretical models in order to shed light on the physical mechanism that powers FRBs.

Structural evolution of two young radio sources



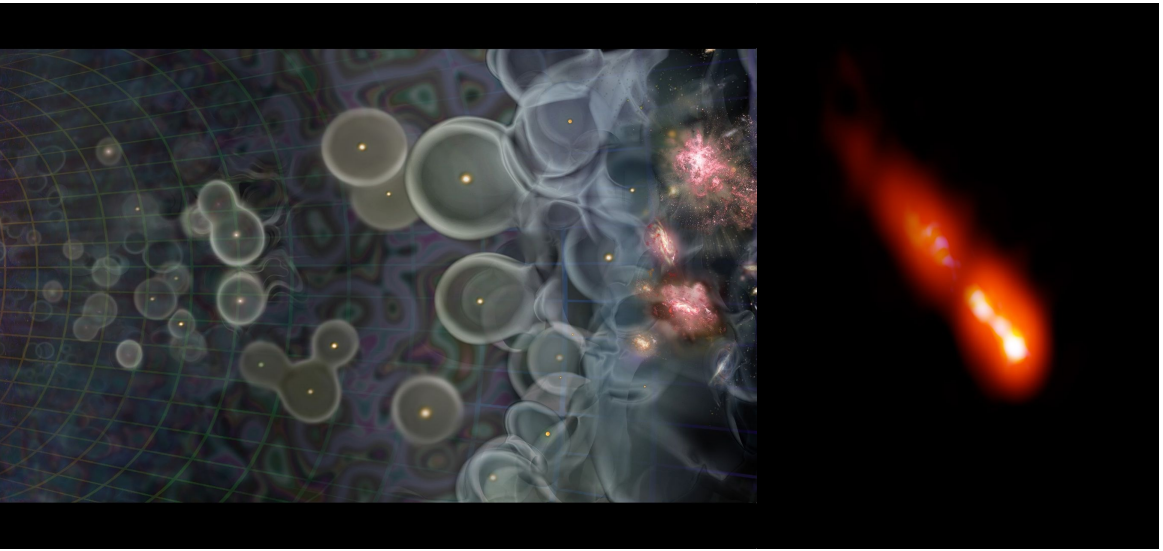
Coordinators Prof. Daniele Dallacasa (daniele.dallacasa@unibo.it), Dr. Marcello Giroletti (marcello.giroletti@inaf.it)

Duration 6-8 months - available from Feb 2024

Description

The superior angular resolution of Very Long Baseline Interferometry is the only tool that can directly probe structural changes in extragalactic sources. This has provided evidence for the youth scenario (i.e. compact sources are compact because they have just started their evolutionary path) thanks to the estimate of advance velocities of features in VLBI images. However, only few such measurements have been obtained, and any additional observing epoch will greatly improve our constraints on these estimates, providing fundamental constraints for the jet evolution and its impact (feedback) on the host galaxy. In this project, the analysis of VLBI data obtained at high frequency for two radio galaxies in different stages of evolution (a young and a restarted source) will be analysed and compared with previous epochs for a general interpretation of the kinematics.

Zooming into a jetted AGN at the end of cosmic re-ionisation with VLBI observations

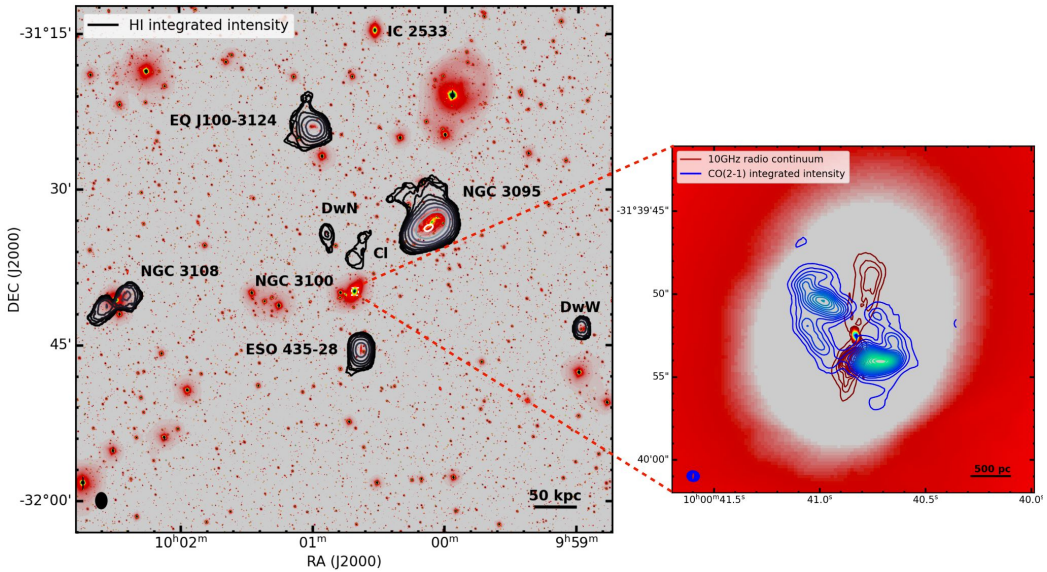


Coordinators
Prof. Daniele Dallacasa (ddallaca@ira.inaf.it), Dr. G. Migliori (giulia.migliori@inaf.it), Dr. C. Spingola (cristiana.spingola@inaf.it)

Duration 6-9 months - available from Sep 2024

Description
Little is known observationally above redshift z = 6, at time when the Universe was young and the first sources (including AGN) ionised their surrounding gas in the period called *cosmic reionisation*. The high masses of the few AGN detected at these cosmological distances challenge the standard formation models of supermassive black holes. The presence of jets can be a viable theoretical justification of such large masses. In this project the student will analyze state-of-the-art multi-frequency VLBI observations at mas angular resolution of a jetted AGN at z = 6.18. With the plethora of ancillary observations in hand, it will be possible to fully determine the physical properties of this distant jetted AGN. Moreover, the student can investigate its variability in flux density and morphology over 13 years, providing important new information on this elusive (but crucial) SMBH population. The detection of proper motions, could also be used to infer q0, hence directly testing the current cosmological model.

The fueling/feedback cycle in radio galaxies



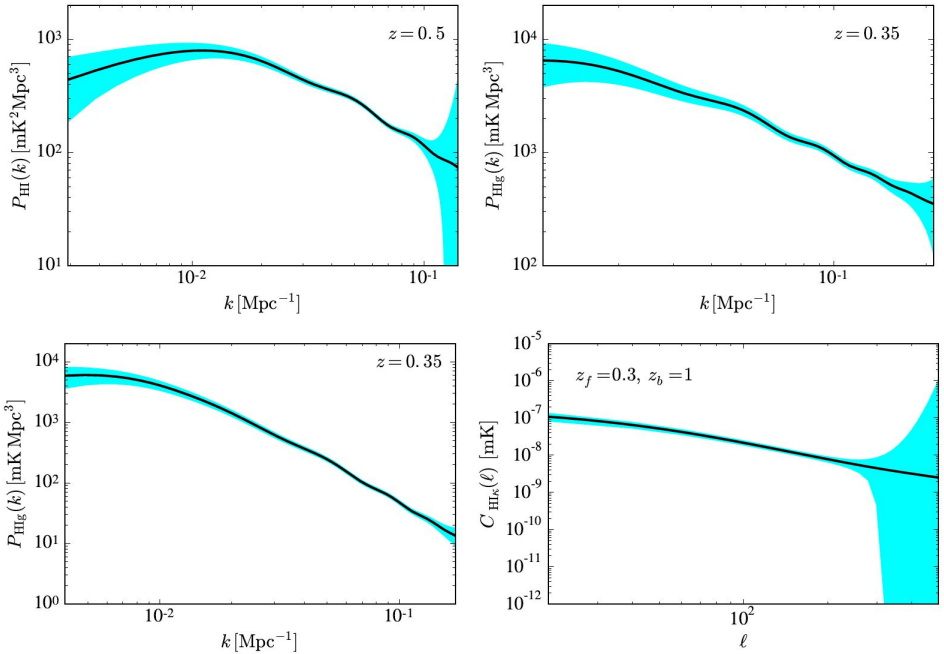
Multi-wavelength view of the group of NGC 3100 and of its circum-nuclear regions (Maccagni et al., 2023)

Coordinator
Dr. Isabella Prandoni (prandoni@ira.inaf.it)

Duration 6 months

Description
Local radio galaxies (RG) are preferentially hosted by massive early-type galaxies (ETG). Their study can then provide a better understanding of the AGN fuelling/feedback cycle in ETGs, enabling us to isolate its role in the overall formation and evolution of massive spheroids. The powering mechanism of such RGs, however, is not fully understood. It has been proposed that they are powered by inefficient accretion from the hot phase of the inter-galactic medium (IGM), through e.g. chaotic cold accretion (CCA). An alternative scenario could be external accretion through galaxy interactions or minor mergers. We are conducting the first systematic, spatially-resolved, multi- component (stars, warm/cold gas, dust, jets) investigation of the cores of a representative sample of RG in the local Universe, using ALMA and integral-field optical spectroscopy (IFS). Our ALMA data clearly show that sizeable amounts of molecular gas are confined in rotating discs in the inner (sub-)kpc scales of these RGs. Such discs may be an essential link in the feeding/feedback cycles of local RGs. Our multi-wavelength analysis strongly supports an external origin of the observed discs, at least for some of our sources. However external accretion cannot be fully established with the ALMA/IFS data, which are limited to the inner regions of our sources. For this reason we have asked and obtained wide-field neutral Hydrogen (HI) data and wide field optical images (with the ESO VST telescope). Such data allow us to directly probe the presence of interactions with nearby galaxies and test the external accretion scenario. So far we have analysed one of the targets (see Maccagni et al. 2023) finding a first clear evidence of external accretion. The student will analyse one or more of the remaining sources.

Mapping the large scale structure of the Universe with 21 cm Intensity Mapping



HI detection with MeerKLASS (Santos et al., 2017)

Coordinators
Prof. Lauro Moscardini (lauro.moscardini@unibo.it); Dr. Gianni Bernardi (gianni.bernardi@inaf.it); Dr. Marta Spinelli (spinemart@gmail.com)

Duration 6-8 Months – available from September 2024

Description
Intensity Mapping (IM) of the redshifted 21 cm line from neutral hydrogen is a promising technique to construct three-dimensional maps of the large-scale structure of the Universe in the post-reionization era, complementary to galaxy surveys. The central idea of IM is to measure the integrated 21 cm line emission from all galaxies that fall into a single resolution element (i.e. beam) without the need to resolve them individually. IM, therefore, allows the detection of the 21 cm emission at higher redshifts compared to standard observations of individual galaxies. As IM observations trace the underlying matter distribution of the Universe on large scales, a 21 cm detection would place tight constraints on cosmological parameters. The student will take an active part in the MeerKLASS IM survey of the MeerKAT radio telescope. The MeerKLASS data cover a 300~deg^2 sky patch with the goal to observe IM up to z ~ 0.4 and new data will be available soon. Thesis activities will include (but not necessarily limited to) data analysis, foreground separation, and simulations of the expected cosmological signal.

https://info.ira.inaf.it/studio-e-lavoro/tesi-di-laurea/