Bologna&Friends

1-2 March 2023
INAF/IRA Bologna

Report of Contributions

https://indico.ict.inaf.it/e/bolognandfriends

Contribution ID: **1** Type: **not specified**

WELCOME

Wednesday, March 1, 2023 2:00 PM (30 minutes)

Contribution ID: **2** Type: **not specified**

Elisabetta Liuzzo: Radio Galaxies with the Event Horizon Telescope

Wednesday, March 1, 2023 2:30 PM (20 minutes)

Event Horizon Telescope (EHT) represents an unique Earth-sized very long baseline interferometry (VLBI) array observing at 1.3 mm able to catch AGN black hole (BH) shadows. The angular resolution achieved by the EHT is unprecedented, being of the order of 25 microarcsec, and it allowed the first BH imaging at event horizon scales of the supermassive black hole M87*and Sgr A*. Total intensity and polarisation analysis are performed by EHT, providing direct evidence for the presence of supermassive black holes in centres of AGN and essential new information about structure of magnetic field lines near the event horizon. In addition to M87*and Sgr A*, EHT observations are also unveiling the launching and initial collimation region of extragalactic radio jets in nearby sources, such as Cen A and 3C 279, and NRAO 530 down to the unexplored 10-200 gravitational radii scales.
On behalf of the EHT Collaboration, I will review the published EHT results, highlighting the important astrophysical impact of these VLBI studies in the radio galaxies domain, from the possibility to explore gravity in its most extreme limit to putting tight constraints on the theoretical interpretations of the relativistic jet-launching processes.

Contribution ID: **3** Type: **not specified**

Paola Rossi: Simulations of jets: results and perspectives

Wednesday, March 1, 2023 2:50 PM (20 minutes)

Relativistic magnetohydrodynamical numerical simulations represent a fundamental tool for studying the dynamics of jets from their acceleration region, to the propagation and termination. We will discuss the main results for the different jet regions. We will illustrate the possible deceleration process from relativistic to subrelativistic velocities occurring in the inner region of low power radio jets. We will further discuss the following propagation on the kpc scale, emphasizing the role of magnetic field in determining the jet morphological properties.
One limitation of numerical simulations is that they cannot predict in a consistent way the jet non-thermal emission properties. Here we will discuss the results of an hybrid approach that tries to overcome this limitation. In this approach, we follow, along with dynamics of the thermal fluid, the evolution of the distribution function of a non-thermal relativistic particle population, by using a sub-grid approach for treating acceleration processes occurring in dissipative regions such as, for example, shocks. We will illustrate the potentialities of this approach with several examples.

Contribution ID: **4** Type: **not specified**

Loic Chantry: Two-component injection profile and FR0/FRI classification

Wednesday, March 1, 2023 3:10 PM (10 minutes)

The relationship between spine-jet and outer layer could play a role in the classification of FR0/FR1 radio galaxies. Using the asymptotic part of meridional self-solutions in Kerr metric models to describe the spine-jet, as well as an extension describing the outer layer, we are able to compute two-component injection profiles. In this injection model, the velocity ratio between the axial velocity of the spine and the outer layer is also the square of the ratio between jet's vorticity radius and the radius of the jet's electric current. For a given spine-jet, the profile of the outer layer depends on this velocity ratio and the ratio between the mass flux of the jet and the square of its magnetic flux. Profile evolution with these parameter indicate solutions more suited to FR0 profile for highest value of the mass flux to the square of magnetic ratio. On the contrary, lower values of this ratio produce injection profiles more suited to FR1.

Contribution ID: **5** Type: **not specified**

Mauro Dadina: Ultra-fast outflows in RQ and RL AGN

Wednesday, March 1, 2023 3:20 PM (15 minutes)

In the last twenty years, the study of ultra-fast outflows (UFOs) in AGNs has been recognized as a fundamental topic to be tackled in order to understand how the SMBH shaped the evolution of their host galaxies across cosmic times. Here I will focus on some basic aspects of our current knowledge of the astrophysics of the phenomenon with a comparison of what we learned from RQ and from RL objects. Finally I'll present some new theoretical results that indicate how the exploitation of new high resolution X-ray telescopes capability may help us in determining the launching mechanism of such winds.

Contribution ID: **6** Type: **not specified**

Cosimo Marconcini: MOKA3D: innovative approach to 3D AGN outflow kinematic modelling: accurate determination of outflow physical properties

Wednesday, March 1, 2023 3:35 PM (10 minutes)

The determination of outflow physical properties is important to assess the possible effects of Active Galactic Nuclei feedback on host galaxies and to compare observed outflow properties with model predictions. However, current estimates are based on simplified assumptions and do not take into account many observational aspects like projection effects and spatial resolution. I present MOKA3D , a novel method to model the kinematics and orientation of outflows, which is particularly successful in recovering the three-dimensional structure, even in the presence of observed clumpy emission and irregular kinematics. At variance with previous works, this model does not assume a distribution of the observed gas emission flux but uses a novel procedure to derive it directly from observations, reproducing a 3D distribution of the emitting clouds and providing accurate estimates of the outflows physical properties, e.g. the outflow and energy rate as a function of distance from the galaxy nucleus. I have successfully tested the performance of the method with both nearby Seyfert-II galaxies observed with the Multi Unit Spectroscopic Explorer at VLT and high redshift sources observed by JWST, showing that the very complex kinematical features observed can be ascribed to the clouds clumpiness in a very simple radial velocity field, accounted by a suitable geometry.

Contribution ID: **7** Type: **not specified**

Marisa Brienza: New insights into the duty cycle of radio galaxies

Wednesday, March 1, 2023 4:30 PM (25 minutes)

Jets in active galactic nuclei are episodic in nature, cycling through periods of activity and quiescence. The study of this duty cycle is essential for quantifying their energetic feedback on the host galaxy and surrounding environment, which is a key parameter in galaxy evolution models. However, how this duty cycle varies as a function of e.g. source type, environment, host, is still a matter of debate. In this talk I will present recent results obtained in this field, especially thanks to the advent of new-generation observations at low radio frequencies, which are sensitive to the oldest detectable radio plasma, and I will illustrate the prospects for extending these studies in the coming SKA era.

Contribution ID: **8** Type: **not specified**

Samantha Casadei: Characterization of 3C radio galaxies environment

Wednesday, March 1, 2023 4:55 PM (10 minutes)

The question whether the different classes of radio galaxies is influenced or, in turn, it influences the nearby environment is still an open issue. Previous studies concluded that the radio galaxies classified as BLO and HEG are mostly isolated galaxies, or at most in small groups, while LEGs tend to lie in a richer environment (i.e., groups or clusters). In this work, we studied a sample of 80 FR II radio galaxies included in the 3C catalog with $z < 0.3$. The sample includes a total of 22 LEGs, 31 HEGs and 16 BLOs and allows a statistical study of the various ambient they inhabit. The Red Sequence (RS) is a powerful tool to search for companion galaxies. We used the available photometric data of the Pan-STARRS survey DR2. The distribution of the number of sources included into the RS for the three classes are not statistically distinguishable. However, a slightly dissimilarity is highlighted by the median values of the distributions, due to a slight preference of LEGs to avoid very poor environments.

Contribution ID: **9** Type: **not specified**

Ivan Delvecchio: How not to get lost in the jungle of radio AGN: clues from their hosts

Wednesday, March 1, 2023 5:05 PM (20 minutes)

Radio-selected AGN are undoubtedly a great class of objects for studying BH duty cycle, AGN feedback and their long-term impact on galaxy evolution. However, radio AGN samples are highly heterogeneous, spanning several orders of magnitudes in size, obscuration, kinetic power and eddington ratio. In the local Universe, spatially resolved imaging, optical spectroscopy and radio morphologies have ascertained the wide diversity of the radio AGN population. Nevertheless, whether radio AGN activity is either as a natural byproduct of galaxy growth, or its internal sculptor, remains unclear. I will show how understanding this broad connection is further complicated by the huge variety of radio-AGN hosts, at fixed radio AGN power, observed at higher redshifts (z>0.5). I will discuss how marginalizing for stellar mass, host-galaxy type and redshift might help us (i) refining the “radio-loudness” criterion, and (ii) constraining the average BH accretion rate and kinetic power across the galaxy population.

Contribution ID: **10** Type: **not specified**

Giovanni Cresci: Bubbles and outflows: the novel JWST/NIRSpec view of the z=1.59 quasar XID2028

Thursday, March 2, 2023 9:15 AM (20 minutes)

Thanks to its existing extensive multi-wavelength coverage and to the massive and extended outflow detected both in the ionised and molecular components, XID2028 at z=1.6 represents a unique test case to study QSO feedback in action at the peak epoch of AGN-galaxy coevolution. This target was thus selected to be observed with the NIRSpec and MIRI IFU on board of JWST during the Cycle 0 Early Release Science (ERS) campaign.
In this talk I will focus on the NIRSpec integral field dataset, which is revealing a wealth of details hidden in the previous, seeing limited ground-based data thanks to the unprecedented sensitivity and resolution of JWST instrumentation. In particular, we found evidence of interaction between the QSO-driven radio jet, outflow and the ISM of the galaxy, which is producing an expanding hot bubble from which the fast and extended wind detected in previous observations is emerging. The new observations confirm the complex interplay between the AGN wind and the ISM of the host galaxy, resulting in a showcase of the new window opened by NIRSpec and JWST on the detailed study of feedback at high redshift.

Contribution ID: **11** Type: **not specified**

Lorenzo Ulivi: Outflows and feedback in jetted AGN

Thursday, March 2, 2023 9:35 AM (10 minutes)

Traditionally, AGN feedback is thought to operate through either kinetically powerful (>10^45 erg/s), extended (10s kpc) jets or massive gas outflows. Recent observational work and simulations suggest that also low-power (<10^45 erg/s) jets may play an important role, but little is known about their actual effect on their host galaxies.
We aim to investigate the relationship between radio jets and host galaxies in order to identify a new potential mechanism of AGN feedback. We extended the seminal work by Venturi et al., 2021 that found a turbulent, high velocity dispersion gas in the direction perpendicular to low-radio jet emission, at higher jet luminosities.
We selected four luminous type-II AGN with a moderate powerful radio jet (10^44 erg/s) observed with the Multi Unit Spectroscopic Explorer (MUSE) at the VLT, to analyze the properties of the extended ionized gas in these systems, employing the high spatial resolution of new generation integral field data. We detected ionized outflows extended over kiloparsec scales aligned with the direction of the jet. We also detected a strong enhancement in line-emission velocity dispersion perpendicular to the radio jets and found a correlation between the mass and the energetics of the high velocity dispersion gas and the power of the radio jet, supporting that jets may be responsible for the enhancement of turbulence and could represent a significant mechanism of AGN feedback in luminous sources. This phenomenon, being observed in a growing number of objects, could potentially represent an important additional channel of AGN feedback to be taken into account.

Contribution ID: **12** Type: **not specified**

Gianluca Castignani: AGN feedback in radio galaxies at mm wavelengths

Thursday, March 2, 2023 9:45 AM (15 minutes)

I will review some of the most recent results on AGN feedback in radio galaxies based on millimeter studies which rely on single dish (e.g., APEX, IRAM-30m, LMT) and interferometric (e.g., ALMA, NOEMA) observations. I will describe in particular how recent observations of cold molecular gas, which is the fuel of star formation, can give insights on both positive and negative radio-mode AGN feedback in radio galaxies over cosmic time. I will discuss how large scale structure environments of radio galaxies may play a role in the replenishment of molecular gas reservoirs, a process which is ultimately regulated by the radio mode AGN feedback.

Contribution ID: **13** Type: **not specified**

Francesco Ubertosi: AGN feedback from FR0, FRI, and FRII galaxy clusters

Thursday, March 2, 2023 10:00 AM (15 minutes)

When radio-loud active galactic nuclei (AGN) live in dense environments, we can obtain insights on their properties and lifecycle from the imprints they leave on the surrounding environment. In this talk I will present our recent results on the effects that radio galaxies can have on the gaseous atmospheres of their host galaxy groups or clusters. In particular, I will show how using X-ray observations (specifically Chandra) allows us, for instance, (a) to investigate the process of AGN feedback through the inflation of bubbles and the driving of shocks in the intracluster medium, and (b) to understand how different classes of radio galaxies may have varying effects on their environment. Regarding the last point, besides describing our work on the properties of the "canonical" FRI and FRII radio galaxies in clusters, I will also present our results on the emerging class of FR0 radio galaxies.

Contribution ID: **14** Type: **not specified**

Barbara Balmaverde: MURALES

Thursday, March 2, 2023 10:15 AM (20 minutes)

MURALES is a survey of tens of nearby radio galaxies up to z about 0.8 with the optical integral field spectrograph MUSE at VLT. The main aim is to explore the gas kinematics, its relationship with the relativistic outflows, and unveil jet-triggered star forming regions, enabling us to explore quantitatively the feedback process. In my review I will present the past and the state-of-art results of this project.

Contribution ID: **15** Type: **not specified**

Laura Di Gesu: Blazars from the new observational window of X-ray polarimetry: the first year of IXPE observations of blazars

Thursday, March 2, 2023 11:40 AM (20 minutes)

The NASA/ASI Imaging X-ray Polarimetry Explorer (IXPE) was launched on December 9, 2021 thereby opening the new observational window of X-ray polarimetry. Blazars, which are active galactic nuclei (AGN) where the jet is oriented towards the observer, are prime candidates for X-ray polarization observations. In particular, a high degree of X-ray polarization is expected from high energy peaked blazars (HBL) in the case of synchrotron radiation produced in an ordered magnetic field. Moreover, we expect different time variability patterns of the X-ray and radio/optical polarization properties depending on which physical mechanism energizes the particles in the jets, e.g. shock acceleration, magnetic reconnection in a kink unstable jet, or turbulence in the flow. We report on the first year of IXPE observations of HSP blazars and we discuss what X-ray polarimetry is teaching us about the inner physics of jets.

Contribution ID: **16** Type: **not specified**

Fabrizio Tavecchio: High-energy emission and particle acceleration in local radio-loud AGNs

Thursday, March 2, 2023 12:00 PM (20 minutes)

High-energy emission from local blazars and radio galaxies is usually explained in terms of particles accelerated at shocks in the relativistic jet. However, in recent years numerical simulations and theoretical studies enlarged the space of possible mechanisms at work. In particular, I will review recent developments on shear acceleration and jet recollimation processes and the potential applications to radio galaxies and extreme blazars.

Contribution ID: **17** Type: **not specified**

A. Costa/A. Sciaccaluga: Simulations of unstable recollimation shocks and Fermi-like particle acceleration

Thursday, March 2, 2023 12:20 PM (15 minutes)

Gli extreme TeV BL Lacs rappresentano una sifda ancora aperta per i modelli standard di emsissione. La Spectral Energy Distribution è caratterizzata da un secondo picco oltre 1 TeV, uno spettro sub-TeV molto ripido e una bassa variabilità temporale, proprietà difficilmente riproducibili utilizzando modelli basati su un singolo shock . Zech & Lemoine (2021) hanno proposto che una serie di shock obliqui, come nel caso di ricollimazione-riflessione in getti riconfinati dalla pressione esterna, possa accelerare gli elettroni ad energie sufficientemente elevate da giustificare l' estrema SED dei TeV blazars. Recenti simulazioni 3D hanno mostrato tuttavia che la nota serie di ricollimazione-riflessione può venire distrutta da una forma intrinsecamente tridimensionale dell' instabilità di Rayleigh-Taylor che si sviluppa a valle del primo shock di ricollimazione. L'instabilità può provocare forte turbolenza e la distruzione del getto stesso. Nonostante il campo magnetico possa sopprimere l'instabilità, questo accade per valori di magnetizzazione almeno superiori a 10^(-4), ben al di sopra di quelli ricavati per gli extreme blazars. Abbiamo dunque proposto in Tavecchio, Costa & Sciaccaluga un modello alternativo, in cui le particelle non termiche vengono prima accelerate dallo shock e in seguito energizzate ulteriormente dalla turbolenza. L'idea è stata testata in primo luogo senza considerare lo smorzamento della turbolenza, effetto incluso in un paper successivo, Sciaccaluga & Tavecchio. Attualmente il modello è stato testato con una sola sorgente, ma un prossimo obiettivo è il confronto con tutti gli spettri dei cataloghi attualmente esistenti attraverso l'implementazione di un algoritmo di fitting. Parallelamente, si sta svolgendo un programma di simulazioni 3D hybrid-relMHD con il codice PLUTO per studiare l'evoluzione dell' instabilità nel caso di getti di extreme blazars e caratterizzare consistentemente la prima fase dell' accelerazione e lo sviluppo della turbolenza in vista della possibile implementazione in PLUTO di un modulo accelerazione Fermi II.

Contribution ID: **18** Type: **not specified**

Gabriele Bruni: Glowing in the dark: gamma-ray emission from radio lobes, and the emerging population of high-energy radio galaxies

Thursday, March 2, 2023 12:35 PM (10 minutes)

The advent of new all-sky radio surveys such as VLASS, RACS, and LoTSS, performed with the latest generation radio telescopes, is opening new possibilities on the classification and study of extragalactic gamma-ray sources, specially the underrepresented ones like radio galaxies. I will discuss the recent discovery of new gamma-ray radio galaxies from the 4th Fermi/LAT catalogues, among which a FRII with hints of GeV emission from its lobes. Their classification, only possible thanks to new generation radio surveys, unveils an emerging population of radio galaxies in the gamma-ray sky, that could be studied in the next decade with SKA and ngVLA.

Contribution ID: **19** Type: **not specified**

Ettore Bronzini: Investigating the high-energy emission in the gamma-ray emitting CSO TXS1146+596

Thursday, March 2, 2023 12:45 PM (10 minutes)

Some of the most intriguing questions about the physics and the evolution of radio galaxies are related to the early stages of their life. The so-called Compacts Symmetric Objects (CSOs), defined to be those with radio lobe on both sides of an active nucleus and an overall size less than ~1 kpc, are thought to represent the first stage in the evolutionary path of radio galaxies. CSOs are considered a perfect test bench to study the accretion and ejection processes in the early-born radio galaxies and to investigate the interaction between the expanding radio source and the host galaxy. Unveiling the nature of X-ray emission is fundamental to constrain the physical parameters of these sources (i.e. accretion and ejection power), hence to predict their evolution. Moreover, X-rays are important to understand how these sources release energy in the surrounding medium, so to study the feedback between the central source and its host galaxy. Recent gamma-ray detection of a handful of young radio sources has provided the smoking gun of a non-thermal high-energy component, which can help in establishing the origin for the X-ray emission (X-rays from accretion disk or expanding radio jets). Here we present our broad-band X-ray results and multi-wavelength study of 1146+596, a gamma-ray emitter CSO. Starting from the analysis of Chandra and new proprietary Nustar data, we present the first SED model of 1146+596 to explain its broad-band emission from radio to gamma-rays.

Contribution ID: **20** Type: **not specified**

Marco Bondi: High-redshift radio galaxies with the International LOFAR Telescope

Thursday, March 2, 2023 2:30 PM (20 minutes)

During the past year the International LOFAR Telescope (ILT, aka LOFAR-VLBI) data analysis has been greatly improved and refined reaching sub-arcsec resolution imaging at 144 MHz with typical rms values of a few tens of microJy/beam (for an 8-hr observation). The improvement of about a factor of 20 in angular resolution (from 6" of LOFAR to 0".3 of ILT) is fundamental to study the bulk of radio sources detected in the deep fields which are located at redshift about or greater than 1. I will present some examples and preliminary results obtained from the analysis of the ILT observations in the Euclid Deep Field North.

Contribution ID: **21** Type: **not specified**

Alessandro Capetti: The quest for high-z radio galaxies

Thursday, March 2, 2023 2:50 PM (10 minutes)

High redshift radio galaxies (HzRGs) provide unique diagnostic tools about the conditions in the early Universe. While large samples of radio galaxies (RGs) at low redshift (z <1) are available and their properties have been studied in great detail, our knowledge of high redshift RGs is extremely limited: only a few tens of RGs are known. We recently started a project to select HzRGs candidates applying the dropout color technique. We selected flux-limited radio sources from the extragalactic GLEAM catalogue and we searched for the optical counterparts of the radio emission imaged at high resolution in the VLASS survey. We selected u-dropout radio galaxies candidates (z~ 3) from The Kilo-Degree Survey (KiDS) and g-drop candidates (z~4) from the Hyper Suprime-Cam Subaru Strategic Program survey (HSC-SSP). We have already obtained observational time at the 3.6 meters New Technology Telescope (NTT) to spectroscopically confirm the u-dropout selected candidates.

Contribution ID: **22** Type: **not specified**

Tullia Sbarrato: Jets from (cosmic) dawn to noon: how to find the hidden young jets

Thursday, March 2, 2023 3:00 PM (20 minutes)

Radio-loud Active Galactic Nuclei represent about one tenth of the known active supermassive black hole population. The most luminous among them are visible up to extremely high-redshift, thanks to their intrinsic bright and strongly beamed emission. They are generally considered 1:1 tracers of the jetted AGN population, but in the last years this identity revealed to be not always true. The two extremes of the jetted population in terms of power are in fact interestingly different than expected: both the lowest and the highest power relativistic jets can hide among radio-quiet AGN, under different conditions. Particularly at the highest redshifts, the occurrence of relativistic jets appears to be larger than in the local Universe, without affecting the radio-loud fraction. Radio-loudness as a tracer of jet presence can be faulty, and other approaches are needed at high redshift. We will explore this issue, and evaluate if other viable jet tracers can be considered.

Contribution ID: **23** Type: **not specified**

Cristiana Spingola: The radio VLBI view of the outstanding gamma-ray flare of the lensed blazar PKS 1830-211

Thursday, March 2, 2023 3:20 PM (10 minutes)

We present results from a dense VLBI monitoring of the brightest lensed blazar PKS 1830-211 (z=2.5). Time delays are a primary manifestation of gravitational lensing and they provide one of the most powerful methods to spatially locate the multi-band emitting regions in AGN at high redshift: a difference between the measured radio and the gamma-ray time delays directly implies that the two regions are separated in the source plane. We monitored PKS 1830-211 for three months at 15, 24 and 43 GHz with the VLBA during its most extreme gamma-ray flare detected by the Fermi-LAT. We do not find evidence for a knot ejection at sub-mas resolution and we obtain a new precise VLBI-derived time delay measurement. Additional single-dish OVRO observations confirm our result and reveal an additional value for the time delay, likely related to the central lensed image. We discuss the implication of our findings and prospects for this kind of study with the future time-domain surveys.

Contribution ID: **24** Type: **not specified**

CONCLUDING REMARKS (Gabriele Giovannini)

Thursday, March 2, 2023 4:05 PM (10 minutes)