June 14-18, 2021

# EXTRA-GALACTIC JETS AT ALL SCALES

## LAUNCHING, PROPAGATION, TERMINATION

MPIA, Heidelberg, Germany - Online
https://www2.mpia-hd.mpg.de/jets2021/

## INVITED SPEAKERS

Sara Buson
Judith Croston
Jason Dexter
Christian Fromm
Dimitrios Giannios
Kazuhiro Hada
Talvikki Hovatta
Matthias Kadler
Yuri Kovalev
Robert Laing
Greg Madejski
Dipanjan Mukherjee
Maria Petropoulou
Alexander Tchekhovskoy

## TOPICS

Jet Launching GR-MHD Simulations
Jet Stability & Variability
Jet Energetics - Heating, Dissipation
Jet Termination - AGN Feedback and ICM Heating
Emission & Polarization - Observed & Simulated
Particle Acceleration Mechanisms
Essential Observational Input for Theory
Universality of Jet Properties

## DATES

| Registration Opens | Abstract Submission and Registration Deadline | Registration Fee Payment Deadline |
|---|---|---|
| **Nov. 15, 2020** | **April 1, 2021** | **May 15, 2021** |

A workshop jointly organized by MPIA & IIT Indore

Email : jets2021@mpia.de

/jets_2021

# About

## Rationale

Energetic and collimated beams of plasma launched from the centre of galaxies have fascinated the community for a century. In spite of the advancement in observational and theoretical modelling techniques, many aspects regarding the detailed physics of extra-galactic jets remain not fully understood. This conference aims to push forward our understanding of extra-galactic jets bringing together experts from theory and observations.

The main focus shall be on the theoretical side. One major aim of this conference is to demonstrate recent advances in the multi-scale numerical modeling of jets and to discuss strategies for how to better constrain simulations with multi-wavelength and high-resolution observational data. Another focus shall be the universality of jet properties and understand what we can learn from other jets sources such as non-relativistic jets or GRBs.

In particular we would appreciate contributions on the following topics:
1. Jet launching GR-MHD simulations
2. Jet stability and variability
3. Jet energetics : heating, dissipation, feedback
4. Emission and Polarization - observed and simulated
5. Particle Acceleration Mechanisms
6. Essential observational inputs for theory
7. Universality of jet properties

## Scientific Organizing Committee (SOC)

| | | |
|---|---|---|
| Keiichi Asada | Markus Boettcher | Christian Fendt (Co-Chair) |
| Sebastian Heinz | Rony Keppens | Preeti Kharb |
| Thomas Krichbaum | Karl Mannheim | Andrea Mignone |
| Eileen Meyer | Raffaella Morganti | Oliver Porth |
| Bhargav Vaidya (Co-Chair) | Diana Worrall | |

## Virtual Organizing Committee (VOC)

| | |
|---|---|
| Indu Kalpa Dihingia | Giancarlo Mattia |
| Christian Fendt | Bhargav Vaidya |

# Schedule

*RT: Review Talk (20 + 10) min, IT: Invited Talk (15 + 5) min, CT: Contributed Talk (7 + 3) min, Poster.*

## Monday, 14th of June

### Session I [Propagation], 12.00 - 14.50, Chair: Karl Mannheim

| | | | |
|---|---|---|---|
| 12:00–12:20 | **Welcome remarks** | | |
| 12:20–12:50 | RT | **Robert Laing**<br>UK | Jets from the Event Horizon to Cluster Scales |
| 12:50–13:00 | CT01 | **Ivan Agudo**<br>Spain | POLAMI: Polarization Monitoring of AGN at Millimeter Wavelengths with the IRAM 30m Telescope. First results and impact on AGN science |
| 13:00–13:10 | CT02 | **Alexander Pushkarev**<br>Russia | Magnetic fields of parsec-scale AGN jets from multi-epoch VLBA linear polarization imaging |
| 13:10–13:25 | **Coffee break** | | |
| 13:25–13:35 | CT03 | **Markus Boettcher**<br>South Africa | Prospects for High-Energy Polarimetry of Blazars |
| 13:35–13:45 | CT04 | **Ioannis Liodakis**<br>Finland | Understanding high-energy emission processes in blazar jets through X-ray Polarization |
| 13:45–13:55 | CT05 | **Sebastian Kiehlmann**<br>Greece | Critical aspects of identifying and analysing optical EVPA rotations |
| 13:55–14:35 | **Discussion round S-I** | | |
| 14:35–14:50 | **Coffee break** | | |

### Session II [Launching], 14.50 - 18.00, Chair: Rony Keppens

| | | | |
|---|---|---|---|
| 14:50–15:10 | IT01 | **Kazuhiro Hada**<br>Japan | High-resolution view of collimation and acceleration regions of M87 and nearby AGN jets |
| 15:10–15:20 | CT06 | **Nick Seymour**<br>Australia | GLEAMing the Powerful Jets at the Highest Redshifts |
| 15:20–15:30 | CT07 | **Anne-Kathrin Baczko**<br>Germany | Jet collimation in NGC1052 from 1.5GHz to 86GHz |
| 15:30–15:40 | CT08 | **Christoph Wendel**<br>Germany | Gamma-ray emission from pair cascades at the border of broad line regions |
| 15:40–15:50 | **Coffee break** | | |
| 15:50–16:30 | **Poster session I : Posters P01-P12** | | |
| 16:30–16:50 | IT02 | **Alexander Tchekovskoy**<br>USA | Simulating lives and deaths of astrophysical jets |
| 16:50–17:00 | CT09 | **Bart Ripperda**<br>USA | Magnetic reconnection and plasmoid formation in black hole accretion flows |
| 17:00–17:10 | CT10 | **Elizabete de Gouveia Dal Pino**<br>Brazil | Particle Acceleration to Ultra High Energies by Magnetic Reconnection in Relativistic Jets and the Origin of the Very High Energy Emission |
| 17:10–17:20 | CT11 | **Koushik Chatterjee**<br>USA | Imaging plasmoids, warps and distortions in black hole jets using next-generation 3D GRMHD simulations |
| 17:20–18:00 | **Discussion round S-II** | | |

# Tuesday, 15th of June

## Session III [Termination], 12.00 - 14.50, Chair: Raffaella Morganti

| | | | |
|---|---|---|---|
| 12:00–12:20 | IT03 | **Judith Croston**<br>UK | The LOFAR and X-ray view of extragalactic jet populations |
| 12:20–12:30 | CT12 | **Giulia Migliori**<br>Italy | Fermi tutti? Unveiling particle acceleration and high-energy emission processes in hotspots |
| 12:30–12:40 | CT13 | **Marisa Brienza**<br>Italy | A unique snapshot of the oldest AGN feedback phases |
| 12:40–12:50 | CT14 | **Ranieri Baldi**<br>Italy | The multi-band properties of FR0 radio galaxies |
| 12:50–13:00 | CT15 | **Giacomo Venturi**<br>Chile | The effect of low-power, compact AGN jets on their host galaxies as seen by VLT/MUSE |
| 13:00–13:10 | CT16 | **Izak van der Westhuizen**<br>South Africa | Modelling the synchrotron emission and self-absorption from AGN jets simulations using the particle hybrid module for the PLUTO Code |
| 13:10–13:25 | **Coffee break** | | |
| 13:25–13:35 | CT17 | **Rony Keppens**<br>Belgium | AGN jet simulations for double-double radio galaxies |
| 13:35–13:45 | CT18 | **Rainer Weinberger**<br>USA | The impact of jets on galaxy clusters: a simulation perspective |
| 13:45–13:55 | CT19 | **Forrest Glines**<br>USA | Simulations of Magnetic AGN Feedback in Galaxy Clusters |
| 13:55–14:35 | **Discussion round S-III** | | |
| 14:35–14:50 | **Coffee break** | | |

## Session IV [Propagation], 14.50 - 18.00, Chair: Eileen Meyer

| | | | |
|---|---|---|---|
| 14:50–15:10 | IT04 | **Talvikki Hovatta**<br>Finland | Blazar magnetic fields from launch to termination |
| 15:10–15:20 | CT20 | **James Matthews**<br>UK | Particle acceleration in radio galaxies with flickering jets: GeV electrons to ultrahigh energy cosmic rays |
| 15:20–15:30 | CT21 | **Evgeniya Kravchenko**<br>Russia | The zoo of brightness temperature distribution in parsec-scale AGN jets |
| 15:30–15:40 | CT22 | **Alice Pasetto**<br>Mexico | Can we finally map the magnetic field in extragalactic jets? |
| 15:40–15:50 | **Coffee break** | | |
| 15:50–16:30 | **Poster session II : Posters P13-P25** | | |
| 16:30–16:50 | IT05 | **Dimitrios Giannios**<br>USA | SBlazar jets from the black hole to the radiation zone |
| 16:50–17:00 | CT23 | **Li Hui**<br>USA | Particle Acceleration by Instabilities and Reconnection with Turbulence in Jets and Implications for Their Polarized Emissions |
| 17:00–17:10 | CT24 | **Amit Shukla**<br>India | Gamma-ray flares from relativistic magnetic reconnection in the jet of the quasar 3C 279 |
| 17:10–17:20 | CT25 | **Jenni Jormanainen**<br>Finland | Confronting observations of VHE gamma-ray blazar flares with reconnection models |
| 17:20–18:00 | **Discussion round S-IV** | | |

# Wednesday, 16th of June

### Session V [Termination], 12.00 - 14.50, Chair: Preeti Kharb

| | | | |
|---|---|---|---|
| 12:00–12:20 | IT06 | **Dipanjan Mukherjee**<br>India | Simulating the impact of jet-driven outflows on different scales |
| 12:20–12:30 | CT26 | **Manel Perucho**<br>USA | The role of stars on FRI jet deceleration. |
| 12:30–12:40 | CT27 | **Christoph Pfrommer**<br>Germany | AGN jet feedback in galaxy clusters: the case for cosmic-ray heating |
| 12:40–12:50 | CT28 | **Takumi Ohmura**<br>Japan | Magnetohydrodynamic simulations of the interaction between the jet and the intra-cluster magnetic filed |
| 12:50–13:00 | CT29 | **Arthur Charlet**<br>France | Impact of thermal radiative losses on microquasar jets |
| 13:00–13:10 | CT30 | **Kristian Ehlert**<br>Germany | AGN jet heating with cosmic rays in magnetized, turbulent galaxy clusters |
| 13:10–13:25 | **Coffee break** | | |
| 13:25–13:35 | CT31 | **Eileen Meyer**<br>USA | The Relativistic Jet Dichotomy and the End of the Blazar Sequence |
| 13:35–13:45 | CT32 | **Lawrence Rudnick**<br>USA | Unanticipated Jets: the view from MeerKAT |
| 13:45–13:55 | CT33 | **Kristina Nyland**<br>USA | Young Quasar Jets Revealed by Dynamic Radio Surveys |
| 13:55–14:35 | **Discussion round S-V** | | |
| 14:35–14:50 | **Coffee break** | | |

## Session VI [Launching], 14.50 - 18.00, Chair: Thomas Krichbaum

| | | | |
|---|---|---|---|
| 14:50–15:10 | IT07 | **Jason Dexter**<br>USA | Strong magnetic fields from a polarized black hole image of M87 |
| 15:10–15:20 | CT34 | **Dominik Schleicher**<br>Chile | Signatures of jets and accretion for the EHT |
| 15:20–15:30 | CT35 | **Stefania Kerasioti**<br>Greece | Modeling the Polarized Synchrotron Radiation from Magnetohydrodynamic Jets |
| 15:30–15:40 | CT36 | **Sebastiaan Selvi**<br>Netherlands | On the microphysics of resistivity in relativistic flows |
| 15:40–15:50 | **Coffee break** | | |
| 15:50–16:30 | **Poster session III : Posters P26-P37** | | |
| 16:30–16:50 | IT08 | **Yuri Kovalev**<br>Russia | Physics of nuclei in active galaxies as revealed by high resolution radio and optical studies |
| 16:50–17:00 | CT37 | **Niel Brandt**<br>USA | The Nature of the X-ray Emission from Typical Radio-Loud Quasars: Jets vs. Coronae |
| 17:00–17:10 | CT38 | **Ruth Daly**<br>USA | Black Hole Spin Determinations for over 750 Sources |
| 17:10–17:20 | CT39 | **Bidisha Bandyopadhyay**<br>Chile | Ray-tracing of GRMHD simulations with strong winds and jets and their implication for the observation with ng-EHT |
| 16:20–18:00 | **Discussion round S-IV** | | |

# Thursday, 17th of June

### Session VIIA [Propagation], 12.00 - 14.50, Chair: Markus Boettcher

| | | | |
|---|---|---|---|
| 12:00–12:20 | IT09 | **Sara Buson**<br>Germany | High-energy view of jetted active galaxies |
| 12:20–12:30 | CT40 | **Elina Lindfors**<br>Finland | Association of IceCube neutrinos with radio sources observed at Owens Valley and Metsähovi Radio Observatories |
| 12:30–12:40 | CT41 | **Silvestri Stefano**<br>Austria | Inter Galactic Magnetic field constraints through the gamma ray observations of the Extreme High-frequency-peaked BL Lac candidate HESS 1943+213 |
| 12:40–12:50 | CT42 | **Tigran Arshakian**<br>Armenia | Dynamics and emission model of the recollimation shock in BL Lacertae |
| 12:50–13:00 | CT43 | **Ioannis Myserlis**<br>Spain | F-GAMMA / QUIVER : Full-Stokes, multi-frequency radio monitoring of Fermi blazars |
| 13:00–13:10 | CT44 | **Arti Goyal**<br>Poland | Timing analysis of blazar sources: all the colors of noise |
| 13:10–13:25 | **Coffee break** | | |
| 13:25–13:35 | CT45 | **Nicholas MacDonald**<br>Germany | Full Stokes Polarized Radiative Transfer In 3D Relativistic Jet Simulations: Application of the TRISTAN, PLUTO, and RADMC-3D Codes |
| 13:35–13:45 | CT46 | **Gaëtan Fichet de Clairfontaine**<br>France | Flux variability from ejecta in structured relativistic jets with large-scale magnetic fields |
| 13:45–13:55 | CT47 | **Sriyasriti Acharya**<br>India | MHD Instabilities and its impact on the emission signatures of AGN jets |
| 13:55–14:35 | **Discussion round S-VIIA** | | |
| 14:15–14:30 | **Coffee break** | | |

### Session VIIB [Propagation], 14.50 - 18.00, Chair: Diana Worrall

| | | | |
|---|---|---|---|
| 14:50–15:10 | IT10 | **Maria Petropoulou**<br>Greece | High-energy neutrinos from blazars: lessons & puzzles from recent IceCube observations |
| 15:10–15:20 | CT48 | **Abhishek Desai**<br>USA | Testing the AGN Radio and Neutrino correlation |
| 15:20–15:30 | CT49 | **Michael Zacharias**<br>France | The imprint of protons on the emission of extended blazar jets |
| 15:30–15:40 | CT50 | **Alexander Plavin**<br>Russia | High-energy neutrinos from central parsecs of AGNs |
| 15:40–15:50 | **Coffee break** | | |
| 15:50–16:30 | **Poster session IV : Posters P38-P49** | | |
| 16:30–16:50 | IT11 | **Greg Madejski**<br>USA | Content of relativistic jets in blazars, and implications on jet structure inferred from future X-ray polarization observations |
| 16:50–17:00 | CT51 | **Venkatessh Ramakrishnan**<br>Chile | Millimetre and X-ray correlated variability of the jet in Centaurus A |
| 17:00–17:10 | CT52 | **Manel Errando**<br>USA | Systematic differences in radiative cooling between blazar classes revealed by gamma-ray observations in the time domain |
| 17:10–17:20 | CT53 | **Olivier Hervet**<br>USA | TeV flares of radiogalaxies, the case of the great flare of NGC 1275 on January 1st 2017 |
| 17:20–18:00 | **Discussion round S-VIIB** | | |

# Friday, 18th of June

## Session VIII [Launching], 12.00 - 14.50, Chair: Oliver Porth

| | | | |
|---|---|---|---|
| 12:00–12:20 | IT12 | **Christian Fromm**<br>Germany | Radiative signatures of GRMHD jets |
| 12:20–12:30 | CT54 | **Yosuke Mizuno**<br>China | Comparison of the ion-to-electron temperature ratio prescription: two-temperature GRMHD simulations |
| 12:30–12:40 | CT55 | **Indu Kalpa Dihingia**<br>India | Jets, disc-winds, and oscillations around Kerr black hole |
| 12:40–12:50 | CT56 | **Rosemary Talbot**<br>UK | Blandford-Znajek jets in galaxy formation simulations |
| 12:50–13:00 | CT57 | **Elena Nokhrina**<br>Russia | AGN jet boundary shape break – what can we learn? |
| 13:00–13:10 | CT58 | **Gibwa Musoke**<br>Netherlands | Quasi-periodic oscillations in GRMHD simulations of tilted accretion disks |
| 13:10–13:25 | **Coffee break** | | |
| 13:25–13:35 | CT59 | **Giancarlo Mattia**<br>Heidelberg | Astrophysical jets from strongly magnetized systems- A non isotropic accretion disk dynamo |
| 13:35–13:45 | CT60 | **Mayur Shende**<br>India | Disk-Jet Connection in Black Hole Sources |
| 13:45–13:55 | CT61 | **Paola Grandi**<br>Italy | Jet-accretion system in the nearby mJy Radio Galaxies |
| 13:55–14:35 | **Discussion round S-IX** | | |
| 14:35–14:50 | **Coffee break** | | |

## Session IX [Termination], 14.50 - 16.30, Chair: Sebastian Heinz

| | | | |
|---|---|---|---|
| 14:50–15:10 | IT13 | **Matthias Kadler**<br>Australia | Radio observations of candidate neutrino blazars with single-dish and VLBI techniques |
| 15:10–15:20 | CT62 | **Tom Jones**<br>USA | AGN Jets as Probes of Intracluster Media Dynamics and Physics |
| 15:20–15:30 | CT63 | **Irina Zhuravleva**<br>USA | Energy transfer from jets to the ICM from the analysis of density fluctuations on various spatial scales |
| 15:30–15:40 | CT64 | **Ting-Wen Lan**<br>USA | Probing the Environments of Giant Radio Galaxies |
| 15:40–15:50 | **Coffee break** | | |
| 15:50–16:30 | **Poster session V : Posters P50-P63** | | |

## Session X [Other Jets], 16.30 - 18.00, Chair: Christian Fendt

| | | | |
|---|---|---|---|
| 16:30–16:40 | CT65 | **Carlos Carrasco-Gonzalez**<br>USA | Observational constraints on launching and collimation in Protostellar Jets |
| 16:40–16:50 | CT66 | **Yuji Urata**<br>Taiwan | GRB jet energetics and structure |
| 16:50–17:00 | CT67 | **Emanuele Sobacchi**<br>USA | Radiative turbulence in magnetically-dominated jets |
| 17:00–17:10 | CT68 | **Shifu Zhu**<br>USA | Investigating the X-ray enhancements of highly radio-loud quasars at $z > 4$ |
| 17.10–17:50 | **Discussion round S-IX & S-X** | | |
| 17.50–18:00 | **Summary & Goodbye** | | |

# List of Abstracts – Invited and Review Talks

## Jets from the Event Horizon to Cluster Scales

***Robert Laing*** RT

SKA, UK

Jets – fast, highly-collimated, bipolar outflows – are inextricably linked to the processes of accretion and collapse onto compact astrophysical objects. Not only can jets be the primary channel of energy loss from accreting supermassive black holes, but they also have a major impact on their surroundings and the evolution of their host galaxies and clusters. Jet-related particle acceleration also produces the most energetic photons and (perhaps) hadrons we observe. I will sketch the subject of AGN jets primarily from the perspective of a radio astronomer, but also drawing on results from across the electromagnetic spectrum and from observations of neutrinos and cosmic rays. I will conclude with future prospects for radio imaging of AGN, emphasising sub-mm VLBI (EHT) and high sensitivity (SKA).

## High-energy view of jetted active galaxies

***Sara Buson*** IT09

Wurzberg, Germany

During the past decade our knowledge of jetted active galaxies has received a huge boost thanks to the advent of sensitive gamma-ray observations enabled by satellite instruments, such as the Fermi Gamma-ray Space Telescope and the Gamma-ray Imaging Detector AGILE, and the synergy with IACTs observatories. Besides incrementing tremendously the number of objects detected at gamma rays and opening the window to the discovery of new populations, the long-time and broad-multiwavelength coverage of the available observations allowed us with an unprecedented study of the timing and spectral properties of these sources. As well as has opened new perspectives for jetted galaxies in the context of the multimessenger field. In this talk I will review some of the most interesting and recent results on high-energy jetted galaxies, some of which have strongly put into question theoretical assumptions and predictions on the jet physics and emission mechanisms of these objects.

## The LOFAR and X-ray view of extragalactic jet populations


***Judith Croston***

IT03

Open University, UK


The relationship between large-scale radio-galaxy structures, jet launching and environmental feedback has been a subject of long-standing debate. I will first discuss how X-ray observations demonstrate an important link between radio morphology and internal conditions, with implications for feedback behaviour. I will then summarise how the very large and diverse radio-galaxy populations emerging from LOFAR surveys work are changing our understanding, with particular focus on the link between accretion behaviour, radio appearance, and feedback roles.

## Strong magnetic fields from a polarized black hole image of M87


***Jason Dexter***

IT07

University of Colorado, US


Magnetic fields have long been thought to play key roles in driving accretion onto black holes and launching their relativistic jets. I will show how horizon scale polarized black hole images can be used to map out magnetic fields in the region where accretion energy is released and jets are launched. I will discuss the interpretation of the polarized black hole image of M87, and argue that the magnetic fields in the jet launching region are dynamically important.

## Radiative signatures of GRMHD jets


***Christian Fromm***

IT12

Uni Frankfurt, Germany


Relativistic jets are launched in the vicinity of the black holes and emit powerful radiation across the electromagnetic spectrum. According to our current understanding relativistic jets are launched by directly tapping the rotational energy of spinning black holes via the so-called Blandford-Znajek process. In addition to the spin of the black hole, numerical simulations showed the amount of accreted magnetised flux has a major impact on the formation of relativistic jets.We investigate the radiative signatures of self-consistently launched relativistic jets using 3D general relativistic magneto-hydrodynamical (GRMHD) simulations and general relativistic radiative transfer (GRRT) calculations. To compare our results with current and future very long baseline interferometric (VLBI) observations we generate synthetic data taking into account realistic array configurations and image reconstruction algorithms.

## Blazar jets from the black hole to the radiation zone

***Dimitrios Giannios***

**IT05**

Purdue, USA

Relativistic jets are a common manifestation of accreting black holes. Blazars are jets from supermassive black holes moving close to our line of sight. A common hypothesis for jet formation is that they are launched by powerful magnetic fields that thread the black hole. After reviewing our ideas of how the magnetic fields make it to the black hole, I discuss the trip of the jet from the central engine to the much larger scales where it radiates. I argue that the jet emission is result of MHD instabilities that result in dissipation in the jet through the process of magnetic reconnection. I will review our latest understanding of the physics of magnetic reconnection and show that it could naturally produce the emitting blobs commonly invoked when modeling the blazar flares. Finally, I will discuss that the magnetic dissipation process may be very gradual resulting in blazars been accelerated to their terminal speed out to  100 pc scales.

## High-resolution view of collimation and acceleration regions of M87 and nearby AGN jets

***Kazuhiro Hada***

**IT01**

Mizusawa VLBI Observatory, NAOJ, Japan

Over the past decade, significant progress has been made in our observational/theoretical understanding of jets in active galactic nuclei (AGN) thanks the advent of multi-wavelengths instruments and advance in numerical/GRMHD simulations. Nevertheless, it is still challenging to observationally resolve the regions of jet launching, collimation and acceleration since the relevant spatial scales are tiny. Observations with very long baseline interferometry (VLBI) are currently the only way to directly access such compact scales. Here I overview recent progress of VLBI studies of AGN jets. In particular I will highlight the progress on the analysis of jet collimation and acceleration zone in M87 and nearby AGN jets.

## Blazar magnetic fields from launch to termination

***Talviki Hovatta***

**IT04**

University of Turku, Finland

Magnetic fields are thought to play a crucial role in both launching and collimation of blazar jets. In my talk, I will discuss how polarization observations in the radio, millimeter, and optical bands can be used to constrain the magnetic field structure in parsec- and kiloparsec- scale jets of blazars. I will use the archetypal blazar 3C273 as an example, and present new results from ALMA millimeter wavelength observations of the central region and the termination hotspot.

## Radio observations of candidate neutrino blazars with single-dish and VLBI techniques

*Matthias Kadler*

IT13

JMU Würzburg, Germany

High-energy cosmic neutrinos have observationally been associated with blazars but it is currently not clear how large the contribution of blazars to the total all-sky diffuse neutrino flux is. Recent results suggest a key role of the radio band in the correct interpretation of neutrino-telescope observational data. Unlike other wavebands, radio observations can probe scales of parsecs and smaller via spatially resolved imaging in both total intensity and polarized emission. Radio spectral monitoring and Very-Long-Baseline interferometric (VLBI) imaging have the potential to reveal characteristic conditions that might have to be met in blazar jets in order to cause sufficiently bright neutrino emissions for detections with existing neutrino telescopes. We present recent results from radio single-dish and high-resolution VLBI observations of selected blazars that have been associated with high-energy neutrinos. We will put a focus on the possible connection between bright and long-lasting (=radio- flaring) jet emission and neutrino detections and on radio observational evidence for structured jets.

## Physics of nuclei in active galaxies as revealed by high resolution radio and optical studies

*Yuri Kovalev*

IT08

Lebedev Physical Institute, Russia

Observational studies of collimation in jets in active galactic nuclei (AGNs) are a key to understanding their formation and acceleration processes. We have found ten nearby jets at redshifts $z < 0.07$ with a transition from a parabolic to conical shape in a large sample of AGNs observed by VLBI. We conclude that the geometry transition may be a common effect in AGN jets. The break occurs at $10^5 - 10^6$ gravitational radii from the nucleus, which is the typical Bondi radius distance. We suggest that the jet shape transition happens when the bulk plasma kinetic energy flux becomes equal to the Poynting energy flux, while the ambient medium pressure is assumed to be governed by Bondi accretion. Adding astrometric data into the analysis, we have found that VLBI-Gaia positional offsets are not entirely random, but have a preferable direction along the VLBI jet. This anisotropy is interpreted as a manifestation of long and bright parsec-scale optical jets co-spatial to radio jets. Adding information on optical classes, color and polarization into analysis, we were able to separate AGN with dominant disk and jet emission. They show opposite offset directions. These observations open a new window of opportunity to study the black hole - disk - jet system at the sub-parsec and parsec scales for hundreds of AGN.

## Content of relativistic jets in blazars, and implications on jet structure inferred from future X-ray polarization observations

***Greg Madejski***

IT11

Standford, US

Relativistic jets in blazars carry a tremendous amount of energy, but we don't have a complete picture of the jet content. In order to escape the intense radiation field of the material accreting onto the black hole, in the early phase, the jet mass-energy content cannot be dominated by leptons, and is likely dominated by Poynting flux. At some point, at larger distances from its origin, in the so-called "blazar zone" - where the observed radiation is produced - the jet must become mass-loaded, since all viable radiation processes require appreciable particle content. Still, it is not clear whether the jet particle content in the blazar zone is mainly electron-positron, or electron-proton plasma. We argue that at least in one case, the interpretation of broad-band spectrum and variability of a BL Lac type blazar strongly suggests e+/e- plasma. We also briefly discuss the prospects on the new insights into the blazar jet structure which will be gleaned from the data collected by the X-ray - sensitive polarimeter mission IXPE, slated for launch by NASA late in 2021

## Simulating the impact of jet-driven outflows on different scales

***Dipanjan Mukherjee***

IT06

IUCAA, India

It has been well established that feedback from the central super-massive black holes plays an essential role in the evolution of massive galaxies. Large scale cosmological simulations have identified AGN feedback as a key ingredient to regulate the mass assembly and star formation rates in galaxies. However, how exactly such outflows affect the gas both within the host galaxy and its nearby environment, over what spatial and temporal scales, remain an open question. AGN feedback occurs in two modes: local outflows within the galaxy and heating the extra-galactic gas through large scale jets. In recent years numerical simulations of AGN driven winds and jets have been performed that resolve the impact of these different physical processes. The simulations are able to capture interaction of these outflows with the turbulent clumpy interstellar medium of the host and as well as the circumgalactic gas. They explore in detail the energetics of the outflows, the difference in behaviour between the early phase when they are trapped within the galaxy and post break out heating of the galactic halo. I will review the current state of simulations addressing such feedback processes and highlight recent developments, with a focus on the impact on the galactic environments and what these simulations predict in terms of observable signatures.

## High-energy neutrinos from blazars: lessons  puzzles from recent IceCube observations

***Maria Petropoulou***

IT10

National & Kapodistrian University of Athens, Greece

High-energy astrophysical neutrinos, which are produced by inelastic collisions of relativistic protons or heavier nuclei with radiation or matter, can be used to trace the elusive sources of cosmic rays and to shed light on the underlying particle acceleration mechanisms. Blazars – active galaxies with relativistic jets pointing toward the observer – have long been discussed as some of the most likely sources of high-energy neutrinos and cosmic rays mostly because of their powerful relativistic jets and large electromagnetic outputs. The detection of a high-energy neutrino (IC-170922A) coincident with an electromagnetic flare from blazar TXS 0506+056 in 2017 opened a new window in the study of these powerful extragalactic sources with multiple messengers (i.e., photons and neutrinos). In July 2019, IceCube detected another high-energy astrophysical neutrino candidate, IC-190730, in whose uncertainty region of arrival direction lies the flat spectrum radio quasar (FSRQ) PKS 1502+106; this is one of the 50 brightest sources in the LAT 8-year Source Catalog. Even more recently, the extreme blazar 3HSP J095507.9+355101 was also tentatively associated with IceCube-200107A while undergoing a hard X-ray flare. In this talk, I will present results of physical models trying to explain the aforementioned associations. I will review the lessons learned about blazar jets and the new puzzles created from these recent IceCube observations.

## Simulating lives and deaths of astrophysical jets

***Alexander Tchekovskoy***

IT02

Northwestern, US

Tightly collimated relativistic outflows, known as jets, are ubiquitous across a wide range of astrophysical phenomena including accreting neutron stars and stellar-mass black holes, active galactic nuclei, collisions of neutron stars, and deaths of massive stars. How jets emerge near the black hole and survive long-range propagation through the surrounding medium is not understood. In this talk, I will discuss the insights into these processes coming from first-principles simulations of black hole accretion. Namely, using general relativistic magnetohydrodynamic simulations, which describe the motion of magnetized gas on a curved space-time of a spinning black hole, I will report on the crucial roles that disk–black-hole misalignment, dynamically-important magnetic fields, radiation feedback, and the interaction with the ambient medium play in jet lives.

# List of Abstracts – Contributed Talks

## MHD Instabilities and its impact on the emission signatures of AGN jets

***Sriyasriti Acharya*** **CT47**

Indian Institue of Technology Indore, India

AGN jets exhibit a broadband non-thermal spectrum extending from radio to gamma-rays. Blazar, a special class of AGN jets, shows multi-timescale variability and optical polarisation angle swings correlated with gamma-ray flares. These relativistically beamed jets pointing towards our line of sight make them an ideal laboratory to understand the underlying physics responsible for jet radiation and variability. This is achieved through high-resolution numerical simulations and subsequent emission modeling. In particular, I will present our recent results from a parametric survey of 3D simulations of plasma columns prone to Kink and Kelvin-Helmholtz mode instability. The goal of this work would be to discuss the effect of MHD instability on the SEDs of AGN jets and to provide a connection between the dynamics of the plasma column with its time-varying emission features. I will also present the implications of relativistic kink mode on long-term variability in the context of the twisting inhomogeneous jet model. In addition, I will discuss the effects of shocks on the multi-wavelength emission obtained using the hybrid Eulerian-Lagrangian framework using PLUTO code.

## POLAMI: Polarization Monitoring of AGN at Millimeter Wavelengths with the IRAM 30m Telescope. First results and impact on AGN science

***Ivan Agudo*** **CT01**

IIA-CSIT, Spain

A long term program at the IRAM 30m Telescope called POLAMI observes, with a time sampling of $\sim 2$ weeks, the four Stokes parameters of the 3.5 and 1.3 mm emission of a sample of the 40 brighter sources in the northern sky. This contribution outlines the most salient scientific results obtained from the first detailed analysis of the data that has recently published in a series of three papers. In particular, we find that circular polarization seems to be present in most blazars at mm wavelengths at levels of $\sim 2\%$ or larger, shorter mm emission is found to come from smaller regions with progressively better magnetic field order, one- zone models are definitely excluded by the general properties of mm polarization of blazars, and blazar jets are not compatible with axisimmetric geometries in general on which regards to their polarization emission.

## Dynamics and emission model of the recollimation shock in BL Lacertae

***Tigran Arshakian*** **CT42**

Byurakan Astrophysical Observatory, Armenia

We present studies of the relativistic jet of BL Lacertae based on 121 epochs (over 17 years) of high-resolution VLBA observations at 15 GHz, which is capable to zoom in the sub-parsec scales of the innermost quasi-stationary feature (or recollimation shock) of the jet. The study of its kinematics and dynamics reveals that trajectories of the recollimation shock are asymmetric in direction of the jet axis, which is interpreted in terms of the core displacement. We develop a statistical method that allows us to distinguish the core shift and intrinsic motion of the recollimation shock. We find that the on-sky brightness distribution of the recollimation shock is asymmetric along and transverse to the jet axis. Modelling the brightness distribution reveals that the twisted velocity field formed at the recollimation shock can explain the observed brightness asymmetry. In this model, the recollimation shock behaves like a jet nozzle, which drags the jet stream in a swinging motion. I will discuss how simulations can be used to constrain parameters of a recollimation shock.

## Jet collimation in NGC1052 from 1.5GHz to 86GHz

***Anne-Kathrin Baczko*** **CT07**

Max-Planck-Institut fuer Radioastronomie, Germany

I will summaries the status of our observational campaign of NGC1052 including VLBA, RadioAstron, GMVA, and EHT data over several frequencies from 2016 and 2017. Based on our VLBA images from 1.4GHz to 43GHz the jets show a change of their collimation profile at around 10000 Schwarzschild radii. However, free-free absorption blocks our view onto the innermost region at frequencies below 43GHz. Hence, to image the region of jet formation and acceleration, and to obtain width measurements closer to the central engine mm-VLBI is decisive. Our GMVA image from 2004 suggests a gap between a central bright feature and both jets, which may be explained by an ADAF or a blend of both jet bases. Until now it was not possible to favor one model over the other.

## The multi-band properties of FR0 radio galaxies

***Ranieri Baldi*** **CT14**

Institute of Radio Astronomy, Italy

Radio galaxies (RGs) are active galactic nuclei (AGN) able to launch relativistic jets, the most energetic phenomena in the Universe which can have a large impact on galaxy evolution. RGs are typically associated with red giant elliptical galaxies hosting the most massive black holes ($> 10^8$ solar masses). In the local Universe (z<0.3) the optical classifications of AGN reflect a clearer separation of the local population of RGs (LERGs/HERGs) in terms of nuclear and host properties than that based on the radio morphology (FRI/FRII). However, a different pitcure is emerging from recent large-area high-sensitivity radio-optical surveys, which have allowed us to explore the very low end of the RG luminosity function, where low-power FRI (LERGs) were expected to dominate. This has instead unearthed a large population of RGs which differ from classical FRI/IIs, by showing 'compact' radio structures and more heterogeneous host properties: the FR0s, which lack of large scale ($> 10$ kpc) radio emission. Considering their multi-band properties and environment, I will speculate about the possible origins of FR0s and the possible cosmological scenarios they imply.

## Ray-tracing of GRMHD simulations with strong winds and jets and their implication for the observation with ng-EHT

***Bidisha Bandyopadhyay*** **CT39**

Universidad de Concepcion, Chile

In 2019, the Event Horizon Telescope Collaboration (EHTC) has published the first image of a supermassive black hole (SMBH) obtained via the Very Large Baseline Interferometry (VLBI) technique. In the future, it is expected that additional and more sensitive VLBI observations will be pursued for other nearby Active Galactic Nuclei (AGN), and it is therefore important to understand which possible features can be expected in such images. In this paper, we post-process General Relativistic Magneto-Hydrodynamical (GR-MHD) simulations which include resistivity, thus providing a self-consistent jet formation model (with resistive mass loading) launched from a thin disc. The ray-tracing is done using the General Relativistic Ray-Tracing code GRTRANS assuming synchrotron emission. We study the appearance of the black hole environment including the accretion disc, winds and jets under a large range of condition, varying black hole mass, accretion rate, spin, inclination angle, disc parameters and observed frequency. When we adopt M87-like parameters, we show that we can reproduce a ring-like feature (similar as observed by the EHT) for some of our simulations. The latter suggests that such thin disc models are thus likely consistent with the observed results. Depending on their masses, accretion rates, spin and other parameters, we note that other SMBHs may show additional features like winds and jets depending on the sensitivity that can be reached in the observations.

## Prospects for High-Energy Polarimetry of Blazars

***Markus Boettcher*** **CT03**

Centre of Space Research, North-West University, Potchefstroom, South Africa

This talk summarizes recent progress in theoretical models for multi-wavelength (and, in particular, high-energy) polarization from blazars. We point out the potential of high-energy polarimetry to distinguish between leptonic and hadronic high-energy emission processes. Time-dependent simulations of polarized radiation transport coupled to relativistic MHD simulations may reveal distinctive high-energy polarization variability features akin to polarization-angle swings as repeatedly observed in the optical. Such simulations have the potential to identify both the dominant particle acceleration and radiation mechanisms.

## The Nature of the X-ray Emission from Typical Radio-Loud Quasars: Jets vs. Coronae

***Niel Brandt*** **CT37**

Penn State University, USA

Radio-loud quasars (RLQs) are typically more X-ray luminous, by a factor of $2-20$, than matched radio-quiet quasars (RQQs). This excess X-ray emission has generally been attributed to small-scale jets. To determine the nature of this excess X-ray emission, we have constructed a large uniform sample of 729 optically selected RLQs with high fractions of X-ray detections and radio- slope measurements. We investigate correlations between X-ray, optical/UV, and radio luminosities. Strikingly, we find that steep- spectrum RLQs (SSRQs) follow a quantitatively similar relation between X-ray vs. optical luminosities as RQQs, suggesting a common accretion-disk corona origin for the X-ray emission of both classes. However, the intercept for SSRQs is larger than that for RQQs and increases with radio loudness, suggesting a connection between the radio jets and the accretion-flow configuration. Flat-spectrum RLQs also generally appear to have corona-dominated X-ray emission, though in some cases jets make large contributions. Formal statistical model selection supports these conclusions. The observed corona-jet connection implies that small-scale processes in the vicinity of black holes, probably associated with the magnetic flux/topology, are controlling quasar radio loudness.

## A unique snapshot of the oldest AGN feedback phases

***Marisa Brienza*** **CT13**

University of Bologna-IRA, INAF, Italy

Jetted Active Galactic Nuclei (AGN) inflate lobes of relativistic plasma and magnetic fields, which rise buoyantly as light bubbles into the intracluster medium (ICM) counterbalancing its spontaneous cooling. While the impact of jetted-AGN feedback is clear on energetic grounds, the exact physical mechanism that converts the bubble mechanical power into heat is not assessed yet. One way to investigate this aspect is through the study of radio bubbles at late stages of their evolution, when the plasma starts getting mixed with the ICM. However, up to now these have been very challenging to identify. Here I report the discovery of a spectacular group of galaxies showing radio emission extending up to hundreds of kpc-scales, with very complex, filamentary morphology. Our study of the system, based on LOFAR and uGMRT radio observations combined with eRosita 0.5-2 keV observations, suggests that the radio emission is related to multiple episodes of the central AGN jet activity. Our results show that the bubble buoyancy power (equal to $\sim 10^{42}$ erg/s) can efficiently offset the radiative cooling of the ICM. Most interestingly though, we have detected for the first time at radio frequencies some very old AGN-driven bubbles, which have first transformed into toroidal ('mushroom-shaped') structures - similar to what observed in M87 - and are now getting shredded into a multitude of filamentary substructures. This system clearly demonstrates how, over timescales of hundreds of millions of years, the plasma released by the intermittent AGN-jet activity can disperse up to spatial scales of hundreds of kpc without being completely mixed with the surrounding ICM. This will surely provide new useful constraints to theoretical models describing the late phases of the AGN feedback process.

## Observational constraints on launching and collimation in Protostellar Jets

***Carlos Carrasco-Gonzalez*** **CT65**

IRyA-UNAM, Mexico

Protostellar jets are usually considered as a less energetic manifestation of the most powerful relativistic jets. It is usually accepted that similar physical mechanisms are acting in all kind of astrophysical jets. If that is true, then the study of protostellar jets should be considered as a complementary to the study of relativistic jets in order to understand the universal phenomenon. Protostellar jets offer advantages with respect to their extragalactic siblings; they are located close to the Earth allowing to observe them at very small physical scales, and they are not relativistic, simplifying the estimation of several important parameters. The problem with protostellar jets is their weakness at useful observable wavelengths. Despite that their systematic study at radio wavelengths started in the 90s, we still do not know whatś the launching and collimation mechanism in protostellar jets. However, the recent improvements in radio interferometric observatories allows now to impose the highest constraint ever. In this talk, I will report some of the most recent results obtained from radio interferometric observations of protostellar jets driven by low- and high-mass protostars. We are starting to study the role of the magnetic field in the large scale collimation by observations of the polarized synchrotron emission, and we are taking advantage of the improved angular resolution of instruments such as the EVLA to zoom into the collimation zone.

## Impact of thermal radiative losses on microquasar jets

***Arthur Charlet*** **CT29**

CRAL ENS de Lyon/LUPM, France

Relativistic jets in high-mass microquasars are source of leptonic radiation through different processes: Bremsstrahlung, synchrotron and inverse Compton (IC) scattering. We present simulations of hydrodynamical jets and their propagation through their companion's stellar wind while accounting for radiative losses effect over the jet dynamics. We apply our model to archetypal sources: Cygnus X-1 and Cygnus X-3. We discuss the consequences of such losses on the jet's structure and propagation as well as the instabilities which develop within the jet and its cocoon during the early phases (outburst and steady state-like propagation) of its evolution. The jet first propagates in a dense environment where the wind is at its strongest where synchrotron losses are dominant. In this region, the cocoon presents a large asymmetry due to the wind's ram pressure before being blown away by the wind. On larger scales, the increasing distance to the companion star and the cocoon's expansion changes the relative importance of the various processes.

## Imaging plasmoids, warps and distortions in black hole jets using next-generation 3D GRMHD simulations

***Koushik Chatterjee*** **CT11**

Harvard University, USA

Over the previous two decades, general relativistic magneto-hydrodynamic (GRMHD) simulations have contributed immensely towards understanding the evolution of black hole accretion disks and relativistic jet launching. Advanced numerical algorithms that fully utilise the boom in computational resources over recent years have played a vital role in enabling simulations to resolve disk turbulence and jet dynamics. I will be presenting my work on two such important advancements: the warping of jets by a spinning black hole, and the formation of small magnetised blobs, or plasmoids, crucial for understanding the jet morphology of M87 as well as the flaring state of our own supermassive black hole, Sagittarius A* or Sgr A*, both of which are Event Horizon Telescope (EHT) targets. Using our group's in-house developed state of the art GPU- accelerated GRMHD code H-AMR, I will show that the misalignment of black hole spin and disk rotational axes, which is naturally expected, substantially affects the jet's morphology and, thus, needs to be accounted for when interpreting the horizon-scale images of M87*. Next, with one of the highest resolution GRMHD simulations ever produced, I will show how capturing the small scale physics of plasmoids could potentially revolutionise our understanding of nIR and X- ray variability in Sgr A*. Further, we are able to resolve jet boundary instabilities with such simulations that could provide an explanation as to the origin of the spine-sheath configuration of jets, and hold important implications for multi-wavelength observations of AGN jets.

## Black Hole Spin Determinations for over 750 Sources

***Ruth Daly*** **CT38**

Pennsylvania State University, USA

The new method of determining black hole spin using the properties of highly collimated outflows from supermassive and stellar-mass black holes will be presented. Results obtained for three different categories of AGN, for a total of 753 spin values, and 4 stellar-mass black hole systems will be presented and discussed.

## Particle Acceleration to Ultra High Energies by Magnetic Reconnection in Relativistic Jets and the Origin of the Very High Energy Emission

***Elizabete de Gouveia Dal Pino*** **CT10**

IAG-USP, Universidade de S$\ddot{a}$o Paulo, Brazil

Relativistic jets are born magnetically dominated. Ultra and very-high energy cosmic rays can be efficiently accelerated by magnetic reconnection in these sources. We here demonstrate this by means of three-dimensional relativistic magnetohydrodynamical (3D-RMHD) simulations, injecting thousands of initially low-energy particles in the transition region of the relativistic jet from magnetically to kinetically dominated, where its magnetization parameter sigma $\sim 1$. In this region, there is strong magnetic energy dissipation by fast magnetic reconnection which is naturally induced by current-driven-kink instability (CDKI) in the initial helical magnetic field configuration of the jet. Our results show that particles are accelerated up to energies $E \sim 10^{18}$ eV for background magnetic fields B 0.1 G, and $E \sim 10^{20}$ eV for $\sim 10$ G. We have also obtained that the acceleration time due to magnetic reconnection has a dependence on the particles energy, $t_acc \propto E^{0.1}$. The energy spectrum of the accelerated particles develops a power-law tail with spectral index $p \sim -1.2$. Our results can explain observed variable emission patterns, specially at very high energies and the associated neutrino emission recently detected in blazars.

## Testing the AGN Radio and Neutrino correlation

***Abhishek Desai*** **CT48**

University of Wisconsin Madison (WIPAC), United States

On 22 September 2017 IceCube reported a high-energy neutrino event which was found to be coincident with a flaring blazar, TXS 0506+056. This first multi-messenger observation hinted at blazars being sources of observed high-energy astrophysical neutrinos and raised a need for extensive correlation studies. Recent work shows that the internal interactions of gamma rays and their external absorption in the extragalactic background will cause a lack of energetic gamma- ray and neutrino correlation while hinting towards a correlation between neutrinos and lower photon energy observations in the X-ray and radio bands. Studies based on published IceCube alerts and radio observations report a possible radio-neutrino correlation in both gamma-ray bright and gamma-ray dim active galactic nuclei (AGN). However, they have marginal statistical significance due analysis limitations. We present results of a correlation analysis between radio-bright AGN reported in the MOJAVE XV catalog and 10 years of IceCube detector data.

## Jets, disc-winds, and oscillations around Kerr black hole

*Indu Kalpa Dihingia* **CT55**

IIT Indore, India

Relativistic jets and disc-winds are typically observed in BH-XRBs and AGNs. However, many physical details of jet launching and the driving of disc winds from the underlying accretion disc (AD) are still not fully understood. This study will investigate the role of the magnetic field strength and structure in launching jets and driving disc-winds. We will also explore the connection between jet, wind, and the AD around the central black hole. We have performed axisymmetric GRMHD simulations of the accretion-ejection system using AMR. Essentially, our simulations were initiated with a thin AD in equilibrium. We will present results from our extensive parametric study with different combinations of initial magnetic field strength and inclination parameter (m). Our study has found relativistic jets and disc-wind driven by the Blandford & Znajek and Blandford & Payne mechanism, respectively. We have also found that plasmoids are formed due to the reconnection events, and these plasmoids advect with disc- winds. Consequently, the enhanced magnetic tension force results in disc truncation and oscillation in the inner part of the AD. The plasma-beta and m play crucial roles in the evolution of the accretion-ejection system, which we will present in detail. Further, we will also discuss possible applications of our models to understand spectral state transition phenomena in BH-XRBs.

## AGN jet heating with cosmic rays in magnetized, turbulent galaxy clusters

*Kristian Ehlert* **CT30**

Leibniz-Institut für Astrophysik (AIP), Germany

Feedback processes by active galactic nuclei in the centres of galaxy clusters appear to prevent large-scale cooling flows and impede star formation. However, the detailed heating mechanisms remain uncertain. Promising heating scenarios invoke the dissipation of Alfvén waves that are generated by streaming cosmic rays (CRs) or the dissipation of cluster turbulence. In order to study the idea of CR heating, we use three-dimensional magneto- hydrodynamical simulations with the Arepo code that follow the evolution of jet-inflated bubbles filled with CRs in a turbulent, magnetized cluster atmosphere. We find that a single injection event recovers the correct CR distribution and heating rate for a successful heating model in Perseus over a duty cycle of 30 Myrs. In order to study the idea of turbulent heating, we analyzed the impact of active galactic nuclei (AGN)-induced turbulence on X-ray line broadening and compared our results to recent Hitomi data. We find that AGN jets drive turbulence, which however remains localized in the wake of the buoyantly rising bubbles after the jets have terminated. Cluster turbulence as inferred from broadened X-ray lines and Faraday rotation measures must hence be driven by other processes such as precipitation due to thermal instability or cosmological infall. In the final part, we present new simulations that study the interplay of radiative cooling and heating induced by AGN jets that self-regulate the cooling cluster cores and may provide the long-thought solution to the cooling flow problem in galaxy clusters.

## Systematic differences in radiative cooling between blazar classes revealed by gamma-ray observations in the time domain

***Manel Errando*** **CT52**

Washington University in St Louis, United States

The blazar sequence explains the spectral properties of different blazar classes based on variations in the accretion rate onto the central supermassive black hole. We use Fermi-LAT data of a flux-limited sample of 28 blazars to establish a blazar sequence based solely on the flux variability properties of their GeV light curves in timescales of days to years. Our characterization of light curves is based on an ARFIMA time series model that, unlike the Fourier transformation, does not rely on the underlying physical process being stationary. We find that variability patterns are correlated with blazar spectral properties, and that BL Lac-type blazars and flat spectrum radio quasars show distinguishable flaring features. Our results align with predictions from leptonic emission scenarios, with the differences in flux variability properties being explained by varying rates of radiative cooling. BL Lac-type blazars display higher levels of gamma-ray flux variability as their luminosity increases and their broadband spectral energy distribution shifts to redder frequencies. Quasar light curves show the largest deviations from stationary behavior, suggesting long-memory processes that give rise to multi-year scale variability. Our time series analysis also reveals low-significance indications of periodic behavior in some BL Lac-type blazars.

## Flux variability from ejecta in structured relativistic jets with large-scale magnetic fields

***Gaëtan Fichet de Clairfontaine*** **CT46**

LUTH-Observatoire de Paris, France

Particle acceleration in stationary and moving internal shocks in AGN relativistic jets is one of the most plausible ways to explain the variability observed from the radio up to the gamma-ray band. Using the SRMHD code MPI-AMRVAC, coupled with a treatment of radiative transfer, we study the emergence of radio flares in a moving shock, standing shock interaction. To understand the impact of the magnetic configuration on a structured jet and to visualize the emission regions, we generate light curves for four cases : turbulent, toroidal, poloidal and helical. We reproduce a standing shock structure inside a two-component jet surround by an unmagnetized ambient medium. An over-density is injected at the base of the jet and generates a moving shock wave. The injection of relativistic particles, their radio synchrotron emission and the radiative transfer are calculated in post-treatment for given observation angles. We demonstrate that the presence of a toroidal or a poloidal magnetic field component affect differently cohesion of the standing shock, its intensity and morphology. This leads to an observed profile of flares characterized by interactions of moving and standing shocks of varying strengths. A qualitative comparison with VLBI and single-dish radio data from the quasar 3C 273 will be discussed.

## Simulations of Magnetic AGN Feedback in Galaxy Clusters

***Forrest Glines*** **CT19**

Michigan State University, US

Feedback from active galactic nuclei (AGN) is the most promising mechanism to counterbalance rapid overcooling and star formation in cool-core galaxy clusters, resolving the cooling flow problem. However, we still do not know the precise details of how the AGN couples to its host galaxy cluster to produce a self-regulating system. The magnetic energy from the AGN and the existing magnetic field within the cluster are likely to affect how the feedback thermalizes into thermal energy that can support the cluster. Due to the difficulty in observing magnetic fields in diffuse distant objects, simulations play a key role in understanding the interaction between AGN and magnetized galaxy clusters. To probe the effects of AGN feedback on magnetized galaxy clusters, we have developed idealized galaxy cluster simulations within AthenaPK, a new performance portable adaptive-mesh refinement code for CPUs and GPUs. In our simulations, we probe the impact of magnetically-dominated AGN jet feedback models with specific attention to self-regulation of the AGN and how the feedback thermalizes in the intracluster medium.

## Timing analysis of blazar sources: all the colors of noise

***Arti Goyal*** **CT44**

Jagiellonian University, Poland

The power-law form of flux variability power spectral densities (PSDs) with slopes ranging from 1–3 indicates that the variability is a colored noise type stochastic process. We present the results of our PSD analysis using both Fourier and time-domain approaches on multiwavelength datasets and covering timescales ranging from a few decades to minutes. Our findings are: (1) nature of the variability process at synchrotron frequencies is different from those at Inverse Compton frequencies (slopes 2 and 1); this could imply, that gamma-ray variability, unlike the synchrotron one (radio to optical), is generated by the superposition of two stochastic processes with different relaxation timescales, (2) the main driver behind the optical variability is the same on decades, years, months, days, and hours timescales (slope=2), which argues against the scenario where different drivers behind the long-term and intranight flux changes are considered. Our results do not easily fit into a simple model, in which a single compact emission zone dominates the radiative output of blazar across all the timescales probed. Instead, we argue that the frequency-dependent shape of the variability power spectra points out a more complex picture, with highly inhomogeneous outflow producing non-thermal emission over an extended, stratified volume.

## Jet-accretion system in the nearby mJy Radio Galaxies

***Paola Grandi*** **CT61**

INAF-OAS, ITALY

It is generally thought that FRII radio galaxies (RGs) host thin optically thick disks, while FRIs are powered by ADAFs. The sources with an efficient engine are optically classified as HERGs and those with an inefficient motor as LERGs. Recently, the study of RGs down to mJy fluxes has cast serious doubts on the LERG-FRI and HERG-FRII correspondence, revealing that many LERGs show FRII radio morphologies. The radio-optical catalogs compiled by Capetti et al. (2017ab) and Baldi et al. (2018) have allowed us to explore this issue in the local ($z < 0.15$) mJy Universe. We show that the majority of nearby mJy objects are in a late stage of their life. FRII-LERGs appear more similar to the old FRI-LERGs than to the young FRII-HERGs. FRII-LERGs might be aged HERGs that, exhausted the cold fuel, have changed their accretion regime or a separate LERG class particularly efficient in launching jets. Exploiting the relations which convert L[OIII] and L(1.4 GHz) into accretion power and jet kinetic power, respectively, we observed that LERGs with similar masses and accretion rates expel jets of different power. Different black hole properties (spin and magnetic field) could determine the observed spread in jet luminosity. In this view, FRII-LERGs should have the fastest spinning black holes and/or the most intense magnetic fluxes.

## TeV flares of radiogalaxies, the case of the great flare of NGC 1275 on January 1st 2017

***Olivier Hervet*** **CT53**

UC Santa Cruz, USA

Intermediate blazars (IBLs and LBLs) are known to present complex multivavelength SEDs and variabilities, often requiring an interpretation beyond standard one-zone emission models. OJ 287 is the archetype of such a complex blazar. On top of hosting a binary supermassive black hole system, it presents multiple other unusual features like an X-ray extended jet, possible jet precession, complex observed radio jet kinematics, and orphan flares. We focus our attention of such an orphan flare that happened only in soft X-ray in Feb 2017. With data in radio-VLBI, optical, UV, X-ray, gamma-ray, and very high energy with VERITAS; we study the multiwavelength behavior of the source before, during, and after the flare. Based on the discovery of a radio jet ejecta emerging from the core at the same period, we present a scenario of a compact zone moves through the powerful emission of the core that can accurately depict the multiwavelength SED at different periods. This scenario is discussed in the broader context of the intermediate blazar's characterization.

## AGN Jets as Probes of Intracluster Media Dynamics and Physics

***Tom Jones*** **CT62**

University of Minnesota, USA

Radio galaxies are found throughout galaxy clusters. RG jets can penetrate vast distances depositing energy, momentum, magnetic fields and relativistic particles. The evolution of the jets, along with their impact on the ICMs depend strongly on ICM dynamical and physical properties. Thus, RG outflows can provide uniquely powerful tools to uncover and decode ICM dynamics and physics. We report on a high resolution, 3D-MHD simulation study of interactions between RG jets and dynamically active ICMs spanning a range of ICM structures generated during cluster formation. The simulations include energy-dependent transport of relativistic electron populations and their nonthermal emissions to establish observational diagnostic tools that can help to identify and decode pre-existing ICM structures as well as the consequences of the RG encounters with these structures as they co-evolve. This work has been supported by the US National Science Foundation through grant AST1714205 and by the University of Minnesota Supercomputing Institute.

## Confronting observations of VHE gamma-ray blazar flares with reconnection models

***Jenni Jormanainen*** **CT25**

Finnish Centre for Astronomy with ESO, Finland

Several models have been suggested to explain the fast gamma-ray variability observed in blazars, but its origin is still debated. One scenario is magnetic reconnection, a process that can efficiently convert magnetic energy to energy of relativistic particles accelerated in the reconnection layer. In our study, we compare results from state-of-the-art particle-in- cell simulations with observations of blazars at Very High Energy (VHE, $E > 100$ GeV). Our goal is to test our model predictions on fast gamma-ray variability with data and to constrain the parameter space of the model, such as the magnetic field strength of the unreconnected plasma and the reconnection layer orientation in the blazar jet. For this first comparison, we used the remarkably well-sampled VHE gamma-ray light curve of Mrk 421 observed with the MAGIC and VERITAS telescopes in 2013. The simulated VHE light curves were generated using the observable parameters of Mrk 421, such as the jet power, bulk Lorentz factor, and the jet viewing angle, and sampled as real data. Our results pave the way for future model-to-data comparison with next-generation Cherenkov telescopes, which will help further constrain the different variability models.

## AGN jet simulations for double-double radio galaxies

***Rony Keppens*** **CT17**

CmPA, KU Leuven, Belgium

The class of Double-Double Radio Galaxies (DDRGs) relates to episodic jet outbursts. How various regions and components add to the total intensity in radio images is less well known. We synthesize synchrotron images for DDRGs based on special relativistic hydrodynamic simulations [1,2], making advanced approximations for the magnetic fields [3]. We study the synchrotron images for: • Three different radial jet profiles; • Ordered, entangled or mixed magnetic fields; • Spectral ageing from synchrotron cooling; • The contribution from different jet components; • The viewing angle and Doppler (de-)boosting; • The various epochs of the evolution of the DDRG. To link our results to observational data, we adopt to J1835+6204 as a reference source. [1] Relativistic AGN jets I. The delicate interplay between jet structure, cocoon morphology and jet head propagation, S. Walg, A. Achterberg, S. Markoff, R. Keppens, & Z. Meliani, 2013, MNRAS 433, 1453-1478. Full paper, doi: 10.1093/mnras/stt823 [2] Relativistic AGN jets II. Jet properties and mixing effects for episodic jet activity, S. Walg, A. Achterberg, S. Markoff, R. Keppens, & O. Porth, 2014, MNRAS 439, 3969-3985. Full paper, doi: 10.1093/mnras/stu253 [3] Relativistic AGN jets III. Synthesis of synchrotron emission from Double-double Radio Galaxies, S. Walg, A. Achterberg, S. Markoff, R. Keppens & O. Porth, 2020, MNRAS 497, 3638-3657 Full paper, doi:10.1093/mnras/staa2195

## Modeling the Polarized Synchrotron Radiation from Magnetohydrodynamic Jets

***Stefania Kerasioti*** **CT35**

University of Athens (NKUA), Greece

The observational evidence for the magnetic field in AGN jets comes mainly by studying the resolved polarization VLBI maps. We model the polarized synchrotron radiation by adopting a disk-driven jet configuration, based on a steady-state radial self-similar solution of the magnetohydrodynamic equations. The resolved spatial distribution of radiation is achieved by applying a light tracing code on the jet structure, assuming a time independent population of non-thermal particles throughout the whole jet. All Stokes parameters are calculated considering both absorption and propagation effects. We study the intensity and polarization patterns by exploring source and observational parameters such as the composition and the angle of observation. We discuss the dependence of the polarization maps on the geometry of the magnetic field.

## The zoo of brightness temperature distribution in parsec-scale AGN jets

***Evgeniya Kravchenko*** **CT21**

MIPT, Russia

The most promising model of AGNs suggests that their radio emission is explained by synchrotron radiation from relativistic electrons, which is highly magnified due to relativistic motion close to the line of sight. This yields extreme brightness temperatures at the jet base, which then decrease rapidly downstream the jet. Analysis of individual objects shows significant enhancement of the brightness temperature at the position of jet knots or bends. There is also an indication that jets, showing transition from a parabolic to a conical shape, the best-established case of which is the radio galaxy M87, are accompanied by the break in brightness temperature profile. To make a statistically study of the brightness temperature distributions along the AGN jets, we analyzed the sample of the brightest AGN jets in the northern sky, that comprises 459 sources observed within the Monitoring Of Jets in Active galactic nuclei with VLBA Experiments (MOJAVE) program at 15 GHz. Using almost 40,000 individual jet component measurements, we analyse variations in their brightness temperature and size to constrain the jet geometry, gradients of a magnetic field strength and particle density along the jet, as well as to locate and study discontinuities in the jet. We find that these distributions exhibit the variety of different behaviors and we show that brightness temperature is an excellent tool to locate, trace and study different inhomogeneities in AGN jets: non-radial motion, helical and bent jets, shocks, recollimation profiles etc.

## Probing the Environments of Giant Radio Galaxies

***Ting-Wen Lan*** **CT64**

UCSC, USA

Giant radio galaxies (GRGs) are a rare population of radio galaxies, having enormous radio structures with jets/lobes spanning beyond 1 Mpc scales. While they have been detected for three decades, the origin of such radio structures is still poorly understood. One hypothesis is that GRGs tend to live in low density environments and, therefore, the radio jets/lobes from supermassive black holes can propagate into such a large scale without encountering the intergalactic medium. In this talk, I will show the latest results which challenge this hypothesis. I will show that by cross-correlating about $\sim 100$ GRGs identified from the LORAR Two- Metre Sky Survey and photometric galaxies detected by the DESI Legacy Imaging Surveys, one can investigate the GRG environments traced by surrounding galaxies. Our results show that the properties of galaxies around GRGs are similar with that around the control samples, demonstrating that external galaxy environments are not the primary driver for the giant radio structures.

## Particle Acceleration by Instabilities and Reconnection with Turbulence in Jets and Implications for Their Polarized Emissions

***Li Hui*** **CT23**

Los Alamos National Laboratory, US

We discuss how kink instabilities are likely to occur in the current-carrying magnetized plasma jets, and how such instabilities can lead to reconnection, turbulence and particle acceleration. We study how these processes will produce highly accelerated particle populations and how they could produce the multi-wavelength emissions, including their polarized signatures. For certain jet conditions, we also explore how both electrons and protons can be accelerated and lead to possible neutrino emissions. Results from special relativistic MHD studies (including polarized emission transport) and kinetic plasma simulations using PIC simulations will be presented. Implications for both short-term and long-term emissions from jets will be discussed.

## Understanding high-energy emission processes in blazar jets through X-ray Polarization

***Ioannis Liodakis*** **CT04**

Finnish center for Astronomy with ESO, Finland

X-ray polarization can be an important new probe of the magnetic field geometry, acceleration physics, and high-energy emission processes of blazar jets, but near-future missions will have limited sensitivity. We used existing lower energy polarization observations and jet simulations in the context of a multi-zone leptonic model to predict the X-ray polarization degree of different sources. This helped us identify the most attractive candidates for NASA's upcoming mission: the Imaging X-ray Polarimetry Explorer (IXPE) scheduled to launch in Q4 2021, and will allow us to soon test high-energy emission processes. I will discuss our current efforts to construct even powerful tests of emission models in blazar jets that can provide answers to long standing questions regarding jet formation, composition, and multimessenger emission.

## Full Stokes Polarized Radiative Transfer In 3D Relativistic Jet Simulations: Application of the TRISTAN, PLUTO, and RADMC-3D Codes

***Nicholas MacDonald*** **CT45**

Max Planck Institute for Radio Astronomy, Germany

What are relativistic jets made of? The answer is central to our understanding of how supermassive black holes influence their surrounding galactic environments. In this talk I will present my research on the composition of relativistic jets (and in particular blazars) within the context of global mm-wave very long baseline interferometric (VLBI) observations. In particular, VLBI arrays (such as phased ALMA and The Event Horizon Telescope) are capable of imaging the polarized synchrotron emission emanating from the innermost regions of relativistic blazar jets with unprecedented angular resolution and sensitivity. The linearly and circularly polarized synchrotron emission from blazars carry imprints of both the strength and orientation of the collimating magnetic fields as well as the plasma content of each jet. In parallel to these advances in VLBI imaging, modern computational resources now support the production and execution of increasingly sophisticated 3D numerical jet simulations, from semi-analytic shock-in-jet and turbulence models, to relativistic magneto-hydrodynamic (RMHD) and particle-in-cell (PIC) jet plasma simulations. My research focuses on bridging the gap between these 3D relativistic jet simulations and mm-wave global VLBI observations of blazar jets through the application of ray-tracing and polarized radiative transfer. In this talk, I will present a suite of relativistic jet simulations that attempt to place firmer constraints on the as yet unknown plasma content of black hole jets.

## Particle acceleration in radio galaxies with flickering jets: GeV electrons to ultra-high energy cosmic rays

***James Matthews*** **CT20**

IoA, University of Cambridge, UK

Variability is a general property of accretion discs and their associated jets, and many radio galaxies show evidence for restarting or flickering jet activity. We show that this variability has some important implications for the acceleration of both ultrahigh energy cosmic rays (UHECRs) and synchrotron electrons in jets. We introduce a simple model for particle acceleration and jet dynamics which allows us to simulate radio galaxies with flickering jet powers. We show that the UHECR and nonthermal radiative luminosities track the jet power but with a response set by the escape and cooling times, respectively. We find that jet variability produces structure in the synchrotron and UHECR spectra that deviates from that produced for a constant jet power. In addition, we introduce the idea of proxy electrons that are cooling at the same rate that UHECRs of rigidity 10 EV are escaping from the source. We also discuss our hydrodynamic simulations showing that shocks in the backflows in radio galaxies are good accelerators of UHECRs, then present similar simulations in which the jet flickers and discuss the impact on the jet morphology and shock structures. Finally, we highlight our related work in which the radio galaxies Centaurus A and Fornax A were identified as promising UHECR sources, arguing that they can act as slowly leaking UHECR reservoirs and can explain the observed UHECR anisotropies.

## Astrophysical jets from strongly magnetized systems- A non isotropic accretion disk dynamo

*Giancarlo Mattia* **CT59**

Max Planck Institute for Astronomy, Heidelberg

Astrophysical jets are launched from strongly magnetized systems that host an accretion disk surrounding a central object. The origin of the jet-launching magnetic field is one of the open questions for modeling the accretion–ejection process. Here we address the question of how accretion-disk magnetization and the field structure required for jet launching are generated. Applying the PLUTO code, we present the first resistive magnetohydronamic simulations of jet launching including a non-scalar accretion-disk mean-field dynamo in the context of largescale disk-jet simulations. We have investigated a disk dynamo that follows analytical solutions of the mean-field dynamo theory, essentially based only on a single parameter, the Coriolis number. We thereby confirm the anisotropy of the dynamo tensor acting in accretion disks, allowing both the resistivity and mean-field dynamo to be related to the disk turbulence. Our new model recovers previous simulations by applying a purely radial initial field while allowing for a more stable evolution for seed fields with a vertical component. We also present correlations between the strength of the disk dynamo coefficients and the dynamical parameters of the jet that is launched (as, e.g., the jet speed, which we have found to be larger for larger values of the Coriolis number), and discuss their implications for observed jet quantities.

## The Relativistic Jet Dichotomy and the End of the Blazar Sequence

*Eileen Meyer* **CT31**

University of Maryland Baltimore County, USA

Our understanding of the unification of jetted AGN has evolved greatly as jet samples have increased in size (e.g. 132 sources for the blazar sequence of Fossati et al., (1998), 257 for the blazar envelope of Meyer et al., (2011). Here, based on the largest-ever sample of over 2000 well-sampled jet spectral energy distributions, we examine the synchrotron peak frequency – peak luminosity plane, and find little evidence for the anti-correlation known as the blazar sequence. Instead, we find strong evidence for a dichotomy in jets, between those associated with efficient or 'quasar-mode' accretion (strong/type II jets) and those associated with inefficient accretion (weak/type I jets). Type II jets include those hosted by high-excitation radio galaxies, flat-spectrum radio quasars (FSRQ), and most low-frequency- peaked BL Lac objects. Type I jets include those hosted by low-excitation radio galaxies and blazars with synchrotron peak frequency above $10^{15}$ Hz (nearly all BL Lac objects). We have derived estimates of the total jet power for over 1000 of our sources from low-frequency radio observations, and find that the jet dichotomy does not correspond to a division in jet power. Rather, type-II jets are produced at all observed jet powers, down to the lowest levels in our sample, while type-I jets range from low to moderately high jet powers, with a clear upper bound at $\sim 10^{43}$ erg/s. The range of jet power in each class matches exactly what is expected for efficient (i.e., a few to 100% Eddington) or inefficient (<0.5% Eddington) accretion onto black holes ranging in mass from $10^7$ to $10^{10}$ solar masses.

## Fermi tutti? Unveiling particle acceleration and high-energy emission processes in hotspots

***Giulia Migliori*** **CT12**

INAF-IRA, Italy

In radio galaxies, hotspots represent the working surface of the jets, where particles are accelerated and produce radio to X-ray emission. The standard picture of a single acceleration site, and synchrotron-IC emission, is challenged by: (i) the detection of diffuse optical/X-ray synchrotron emission; (ii) spatial offsets between the peaks of the radio and X-ray emission; (iii) the radio spectral shape at low-frequencies in tension with predictions from diffusive shock acceleration. We present our study on a small sample of hot spots, based on new JVLA, VLT and Chandra observations. We probe the small-scale structure of the hot spots, unveiling the presence of compact (<hundreds pc) features, resolve the ordered vs random component of the magnetic field and investigate the high-energy emission on month-to-year timescales. We discuss the implications of our findings within the framework of mechanisms accelerating particles (eg. I- vs II-order Fermi) and producing the broadband radio-to-X-ray hot spot emission.

## Comparison of the ion-to-electron temperature ratio prescription: two-temperature GRMHD simulations

***Yosuke Mizuno*** **CT54**

TDLI / Shanghai Jiao Tong University, China

The Event Horizon Telescope (EHT) collaboration recently captured the first images of the central supermassive black hole in M87. These images were interpreted as gravitationally-lensed synchrotron emission from hot plasma orbiting around the black hole. In the accretion flows around low-luminosity AGN such as M87, electrons and ions are not in thermal equilibrium. Therefore, the electron temperature, which is important for the thermal synchrotron radiation at EHT frequencies of 230GHz, is not independently determined. In the past, simplified parameterised ion-to-electron temperature ratio prescriptions have been applied to model the emission from single-fluid GRMHD simulations in post-processing. In this work, we investigate the commonly used parameterised ion-to-electron temperature ratio prescription, the so- called R-$\beta$ model, considering images at 230GHz by comparing with electron-heating prescriptions obtained from GRMHD simulations with different recipes for the electron thermodynamics. We found that the R-$\beta$ prescription is well-matched by both turbulent- and magnetic reconnection-heating prescriptions, although images from these electron-heating prescriptions have a more extended and diffuse jet emission region.

## Quasi-periodic oscillations in GRMHD simulations of tilted accretion disks

***Gibwa Musoke*** **CT58**

University of Amsterdam, Netherlands

Black hole X-ray binaries (BHXRBs) and luminous active galactic nuclei (AGN) display a wide range of variability phenomena, from large-scale spectral state changes to broadband variability and quasi periodic oscillations (QPOs), however the physical mechanisms driving the variability are not well understood. Using a high resolution three-dimensional general relativistic magnetohydrodynamic (GRMHD) simulation of a highly tilted accretion disk, we explore the mechanisms behind the observed variability and look for evidence of QPOs in the data. The simulation, presented first in (Liska et al. 2019) displays the Bardeen-Petterson effect, with the inner regions of the accretion disk aligning with the black hole spin axis while the outer region of the disk remains misaligned and tears away from the inner disk. We identify a QPO feature associated with accreting material in close proximity to the location of disk tearing. The frequency of this QPO is consistent with that of high-frequency QPOs in BHXRBs, and is comparable to the local radial epicyclic frequency. This result supports the view that disk tearing due to the Bardeen-Petterson effect may be a mechanism for generating high- frequency QPOs.

## F-GAMMA / QUIVER : Full-Stokes, multi-frequency radio monitoring of Fermi blazars

***Ioannis Myserlis*** **CT43**

Instituto de Radioastronomía Milimétrica, Spain

The Fermi-GST AGN Multi-frequency Monitoring Alliance (F-GAMMA) comprises the most comprehensive monitoring program of gamma-ray emitting AGNs in the radio bands in terms of: sample size (total of 150 blazars), frequency coverage (2.6 - 345 GHz in 13 frequency steps), cadence (monthly), and duration (2007 - 2015). Here, we will present the complete dataset, focusing on the radio variability and spectral evolution, as well as selected highlights of our results, including the correlation of our multi- frequency radio light curves with Fermi data to estimate the location of gamma-ray emission in jets. Within the F-GAMMA framework, we developed a novel data analysis methodology for high-precision linear and circular polarimetry. The application of this methodology has been extended to our follow-up monitoring program, QUIVER, which focuses on a sub-sample of highly polarized sources, monitored with bi-weekly cadence. To augment our full-Stokes datasets, we developed a polarized radiative transfer model that generates synthetic light curves and spectra, accommodating a number of propagation processes in astrophysical plasmas. The direct comparison of observed and synthetic data, done simultaneously in total flux, linear and circular polarization is used to put strict constraints on the physical conditions in AGN jets.

## Association of IceCube neutrinos with radio sources observed at Owens Valley and Metsähovi Radio Observatories

***Elina Lindfors*** **CT40**

FINCA, University of Turku, Finland

Identifying the most likely sources for high-energy neutrino emission has been one of the main topics in high-energy astrophysics ever since the first observation of high-energy neutrinos by the IceCube Neutrino Observatory. Active galactic nuclei with relativistic jets, blazars, have been considered to be one of the main candidates due to their ability to accelerate particles to high energies. In our recent study, we investigated the connection between radio emission and IceCube neutrino events using data from the Owens Valley Radio Observatory and Metsähovi Radio Observatory blazar monitoring programs. We identified sources in our radio monitoring samples, which are positionally consistent with IceCube high-energy neutrino events. We estimated their mean flux density and variability amplitudes around the neutrino arrival time, and compare these with values from random samples to establish the significance of our results. In this talk, I will describe the main findings of this study. In particular, we find that even if all neutrino events are not accompanied by strong radio flares, when we see large amplitude radio flares in a blazar at the same time as a neutrino event, it is unlikely to happen by random coincidence.

## AGN jet boundary shape break – what can we learn?

***Elena Nokhrina*** **CT57**

MIPT, Russia

Discovery of a dozen of nearby active galactic nuclei with the jet boundary shape transition from parabolic to conical suggests that the effect may be common. Some universal physical mechanism underlying the phenomenon might be at work. We propose that such a break is due to a transition of an outflow from the magnetically dominated to the particle dominated (equipartition) regime. In this case, the jet collimation and acceleration are closely connected. The recent discovery of a break position an order of magnitude smaller than the Bondi radius supports this assumption. We test two different semi-analytical models that allow reproducing the observed phenomenon, with the results being quite close to each other. We explore the possibility of bounding the light cylinder radius (and black hole spin) and a total magnetic flux in a jet using the observations of a break position (for a dozen of sources) and kinematics (for M87).

## Young Quasar Jets Revealed by Dynamic Radio Surveys

***Kristina Nyland*** **CT33**

NRC fellow, resident at NRL, USA

An exciting new frontier in understanding the connection between AGN and their host galaxies is feedback driven by compact radio jets at z = 1-3. Compact jets are common cosmic noon, possibly due to lower intrinsic jet powers, interaction with a dense ISM, or shorter jet lifetimes. Although jet-ISM interactions on kpc-scales out to high redshifts have been found, the prevalence of this population – and its potential impact on galaxy evolution – remains largely unknown. Multi-epoch radio surveys offer a promising path forward by enabling the systematic identification of faint (mJy-level), compact jets on the basis of radio variability. Recently, a sample of quasars that have transitioned from radio-quiet to radio-loud in the past 1-2 decades was identified by comparing data from the on-going Very Large Array Sky Survey (VLASS) with historical data from FIRST. The radio properties of these sources, including their peaked spectral shapes, are consistent with young and growing jets. Here, I present the results of new radio and X-ray follow-up observations. I also discuss implications for our understanding of radio jet lifecycles and their impact on galaxy evolution.

## Magnetohydrodynamic simulations of the interaction between the jet and the intra-cluster magnetic filed

***Takumi Ohmura*** **CT28**

The University of Tokyo, Japan

The intra-cluster magnetic field plays a significant role in the jet dynamics and the transport and re-acceleration process of cosmic-ray electrons. MeerKAT observations of a radio galaxy MRC 0600-399 revealed that the jet bend at where the cluster plasma property has changed and the collimated jet further extends over 100 kpc from the bend point. In addition to this, the spectral index flattens downstream of the bend point, indicating the re-acceleration of electrons. These features are not found in the typical bent jet. To understand the main mechanism of the origin of the unusual bent jet, we have performed magnetohydrodynamic simulations of the interaction between the jet and the intra-cluster field using CANS+ code. We revealed that the motion of the jet across the ordered magnetic fields is suppressed due to the magnetic field tension, and the jet changes direction along with the ordered field. The overall morphology of the bent jet bears remarkable similarities with the simulations, which greatly strengthens our understanding of the interaction between relativistic electrons and an intra- cluster field.

## Can we finally map the magnetic field in extragalactic jets?

*Alice Pasetto* **CT22**

IRyA-UNAM, Mexico

One of the most powerful tools to study the magnetic field is through the analysis of linearly polarized synchrotron emission at radio wavelengths. The most recent powerful radio instrumentation allows to perform high sensitivity studies in a wide range of frequency. In this talk I will demonstrate how broadband polarimetric observations are important 1) to understand the complexity and the density of the environment enclosing the relativistic jet and 2) to study the configuration and strength of the magnetic field in the jet. In this talk I will present the highest sensitivity images up to date of both the continuum and the polarized emission, of the entire kpc relativistic jet of M87. Full polarized data covering the 4 to 15 GHz frequency range, taken with the Jansky Very Large Array (JVLA), reveal interesting features all along the jet which I will discuss. The most impressive result is, for the first time, a map of the magnetic field (with spatial resolution of 10 pc) with unprecedented detail. Indications of regions of particles acceleration, front shocks and instabilities are revealed. These results open a new field to be explored with upcoming radio facilities, such as ngVLA and SKA, and allow direct comparison with predictions from theoretical models .

## The role of stars on FRI jet deceleration.

*Manel Perucho* **CT26**

Universitat de València, Valencian Country, Spain

Recent observational results seem to indicate that the deceleration of FRI jets must be caused by the development of small-scale instabilities that force mixing at the jet boundary. According to these results, the mixing layer expands and propagates down to the jet axis along several kiloparsecs, until it covers the whole jet cross-section. Several candidate mechanisms have been proposed as the initial trigger for the generation of such mixing layer. However, the instabilities proposed so far do not fully manage to explain the observations of FRI jets and/or require a triggering mechanism. Therefore, there is not still a satisfactory explanation for the original cause of jet deceleration. In this talk, I present a recent work in which I show that the interaction between stars and jet boundaries could give the adequate explanation by means of creating a jet-interstellar medium mixing layer that expands across the jet. In addition, I will present steady-state RMHD simulations that include a mass-load term to study the process of jet deceleration within the inner 500 parsecs of evolution and the effects that this may have on jet dynamics and energy dissipation.

## AGN jet feedback in galaxy clusters: the case for cosmic-ray heating

***Christoph Pfrommer*** **CT27**

Leibniz Institut für Astrophysik Potsdam, Germany

Jet feedback by active galactic nuclei (AGNs) appears to be critical in balancing radiative cooling of the low-entropy gas at the centres of galaxy clusters and in mitigating the star formation of elliptical galaxies. However, the heating mechanism has not been unambiguously identified to date. This talk takes a fresh look at this problem and combines four different lines of evidence to argue for a novel comprehensive model for the physical heating mechanism: as cosmic rays (CRs) escape from the jet lobes and are conducted into the intracluster medium, they stimulate the magnetic fields to oscillate at the Alfvén frequency. Those waves scatter CRs and in turn hold them together to form a streaming fluid. Damping of Alfvén waves heats the cooling plasma and potentially balances cooling. 1. Low-frequency radio observations by LOFAR revealed the absence of fossil cosmic ray (CR) electrons in the radio halo surrounding the M87 jet, which implies mixing of CRs with the dense cluster plasma and cooling via coulomb interactions, thus explaining the absence of this elusive component. 2. This interpretation of the LOFAR data implies the escape of CR protons from the M87 lobe jet and the production of gamma-rays via hadronic CR interactions with the ambient gas - as observed in form of a steady gamma-ray emission in the low state of M87. 3. Steady state solutions of a large sample of 40 cool core clusters demonstrate the success of these models in clusters with low cooling rates but not in clusters hosting radio mini halos. However, those systems show large star formation rates and may not be stably heated after all. 4. High-resolution MHD simulations of low-density jets in turbulent cluster atmospheres show sufficient isotropization of streaming CRs and imply heating rates in accordance with the steady state models over observable AGN duty cycles. I will finish this talk with open problems and future opportunities to consolidate or rule out this picture.

## High-energy neutrinos from central parsecs of AGNs

***Alexander Plavin*** **CT50**

Lebedev Physical Institute, Russia

Astrophysical neutrinos of TeV and PeV energies have been observed by multiple telescopes in the last decade. However, their origins still remained unknown. We utilize a statistical approach to locate cosmic neutrinos' sources. We determine that blazars positionally associated with IceCube neutrino detections have stronger parsec-scale radio emission compared to the rest of the sample. The probability of a chance coincidence is only $4 \times 10^{-5}$ (4.1$\sigma$). We select five strong radio blazars as probable sources of neutrinos above 200 TeV: 3C 279, NRAO 530, TXS 1308+326, PKS 1741-038, and PKS 2145+067. There are at least 70 more bright blazars that emit neutrinos of lower energies starting from TeVs. Moreover, with the continuous RATAN-600 monitoring we find that radio flares in relativistic jets coincide with neutrino arrival dates. The most pronounced example of such behavior is PKS 1502+106 that experienced a major flare in 2019. We show that blazars may explain the entire astrophysical neutrino flux derived from IceCube muon-track analyses. Neutrinos can be born in photohadronic interactions within parsec-scale relativistic jets, implying the presence of accelerated ultrarelativistic protons there.

## Magnetic fields of parsec-scale AGN jets from multi-epoch VLBA linear polarization imaging

***Alexander Pushkarev*** **CT02**

Crimean Astrophysical Observatory, Russia

We present recent polarization results from the MOJAVE VLBA program (Monitoring of Jets in AGN with VLBA Experiments). The program database includes over 6000 milliarcsecond (mas)-resolution 15 GHz polarimetric images for more than 400 sources and time coverage starting since 1996. We used the fully calibrated VLBA polarimetric data in the uv-domain at all available epochs and constructed stacked images for 440 sources having at least five observing epochs. Stacking improves the image sensitivity and effectively fills out the jet cross-section both in total intensity and linear polarization. It delineates the long-term persistent magnetic field configuration and its regularity by restoring spatial distributions of the electric vector position angle (EVPA) and fractional polarization, respectively. We find that the degree of polarization significantly increases down and across the jet towards its edges, typically manifesting U or W-shaped transverse profiles. The EVPA distributions show a clear spine-sheath polarization structure in many sources. The MOJAVE program is supported under NASA-Fermi grant 80NSSC19K1579.

## Millimetre and X-ray correlated variability of the jet in Centaurus A

***Venkatessh Ramakrishnan*** **CT51**

University of Concepcion, Chile

The talk summarises the ongoing study of the correlated variability at millimetre and X-rays in Centaurus A. We constrain the emission processes of this variability using time-dependent leptonic models, which provides a causal connection by successfully reproducing the flare at both wavelengths. The result has a profound impact when placed in context against other Seyferts, especially those of class 2 that are akin to Centaurus A. These constraints also improve our understanding of the maximum jet efficiency during flares while also giving hints to the lack of polarisation in these low-luminosity AGNs.

## Magnetic reconnection and plasmoid formation in black hole accretion flows

***Bart Ripperda*** **CT09**

Flatiron Institute, US

Plasmoids, or hot spots, forming due to magnetic reconnection in current sheets, are conjectured to power frequent X-ray and near-infrared flares from Sgr A*, the black hole in the center of our Galaxy. It is unclear how, where, and when current sheets form in black-hole accretion flows. We show extreme resolution 3D general-relativistic resistive magnetohydrodynamics and 2D general-relativistic particle-in-cell simulations to model reconnection and plasmoid formation in black hole magnetospheres. Plasmoids can form in thin current sheets In the inner 15 Schwarzschild radii from the event horizon, after which they can merge, grow to macroscopic hot spots of the order of a few Schwarzschild radii and escape the gravitational pull of the black hole. Large plasmoids are energized to relativistic temperatures via magnetic reconnection near the event horizon and they significantly heat the jet, contributing to its limb-brightening. We find that only hot plasmoids forming in magnetically dominated plasmas can potentially explain the energetics of Sgr A* flares. The flare period is determined by the reconnection rate, which we find to be consistent with studies of reconnection in isolated Harris-type current sheets.

## Unanticipated Jets: the view from MeerKAT

***Lawrence Rudnick*** **CT32**

University of Minnesota, United States

We have discovered jets in the MeerKAT Galaxy Cluster Legacy Survey whose behavior is far outside the norm of the known populations of jets and outside what can be explained by our current models. Here we report on the initial investigations of four of these, including: 1. A jet with steep spectrum transverse “ribs” reaching up to 70kpc across, associated with quasi- periodic jet brightening; 2. Jets which form the central line in a bilateral trident-shaped structure which tracks the jet brightness; 3. Jets which bend into a projected 930 kpc long tailed structure while remaining strongly collimated; and 4. A flat spectrum jet that is draped by a steep spectrum intracluster magnetic filament where it sharply bends at the location of a compact patch of X-rays. We will briefly discuss the physical questions raised by these unanticipated behaviors, and ideas about how to make progress in addressing them.

## Signatures of jets and accretion for the EHT

***Dominik Schleicher*** **CT34**

Universidad de Concepcion, Chile

The Event Horizon Telescope (EHT) has published the first image of a supermassive black hole in 2019 and the first polarization data recently in 2021. Quite generally, it provides a novel and unique opportunity to study jets and accretion from nearby supermassive black holes in unprecedented detail. To derive theoretical predictions for what can be expected with upcoming future observations, we have applied advection dominated accretion flow (ADAF) and jet models to a first sample of nearby Low-Luminosity Active Galactic Nuclei (LLAGN), comparing the predicted spectral energy distributions (SED) with existing multi-frequency data from the radio up to the X-ray regime, with the goal to infer the signatures from the accretion disk and the jet. We used the model-predicted radial emission profiles at different frequency bands to predict whether the inflow can be resolved by the EHT or subsequently the ng-EHT. The sources included in this study are Cen A, M84, NGC 4594, NGC 3998, and NGC 4278, as well as M87 for comparison purposes, finding very promising results for the EHT as well as the next generation of the telescope. The results were published as Bandyopadhyay et al. (2019).

## Critical aspects of identifying and analysing optical EVPA rotations

***Kiehlmann Sebastian*** **CT05**

FORTH Institute of Astrophysics, Greece

Rotations of the optical polarization angle and the potential connection to gamma-ray flaring activity remain of high interest in studying the magnetic field and emission processes of blazars. Studying rotations sparks several critical questions: How do we define and identify rotations? What effects have time sampling and the 180 degrees ambiguity on the identification of rotations. How do these choices and observational constraints affect results and conclusions? We address these questions using four years of RoboPol monitoring data. We show how different rotation definitions affect individual rotations but not general statistical results. We address the potential connection between rotations and gamma-ray activity and show that contemporaneous events are common, but do not provide sufficient evidence for a physical connection. We show the critical effects of time sampling and argue that carefully applying the exact same observational constraints of real data to simulated data is necessary for reliable comparisons of models and data.

## On the microphysics of resistivity in relativistic flows

***Sebastiaan Selvi*** **CT36**

Anton Pannekoek Institute for Astronomy, The Netherlands

Currently, the most promising mechanism to explain rapid flares and plasma heating in astrophysical sources is magnetic reconnection. The non-linear dynamics and effective dissipation of magnetic reconnection is still uncertain as its study requires an understanding of the formation of the current sheet (e.g. through turbulent processes) as well as a description of the microphysical parameters in the current sheet itself. With the recent incorporation of non-ideal resistive effects in global GRMHD simulations (e.g. the Black Hole Accretion Code) it is now in principle possible to accurately capture the reconnection process. A physically motivated model for the resistivity parameter to be used in such simulations is however lacking to date. By comparing Particle-In-Cell and resistive relativisitc MHD reconnection simulations we try to formulate a resistivity model as closure in fluid-scale magnetohydrodynamic simulations. In both PIC and resistive relativistic MHD methodologies we study a reconnecting double Harris sheet setup with high Lundquist number and high plasma magnetizations.

## GLEAMing the Powerful Jets at the Highest Redshifts

***Nick Seymour*** **CT06**

ICRAR/Curtin University, Australia

High-redshift radio galaxies are vital laboratories for studying the impact of jets on their environment in the early Universe. We have developed a new selection technique for finding these rare, powerful systems, making use of spectral curvature in the Murchison Widefield Array 70-230 MHz GLEAM survey. Distant radio galaxies are expected to be young, compact radio sources due to significant inverse-Compton losses at high redshift. In this talk, I will give an overview of our pilot study in the 60 deg$^2$ GAMA-09 field. From just four targets, we discovered the second-most distant radio galaxy currently known $(z = 5.55)$, with the possibility that an additional source is at $z > 5$. The compact nature of these two sources is constrained by our ALMA imaging and interplanetary scintillation observations at low frequencies. Additionally, Low-Frequency Array 34-66 MHz data have been obtained to constrain and model the spectral turnover for both the z > 5 candidate and our $z = 5.55$ discovery. We also have upcoming VLBI observations of these sources. From the broad-band $(0.07 - 100$ GHz) radio SEDs we can constrain the jet powers and ages of these sources. In turn, with the constraints on the accretion rates from their non-detection in the infra-red, this allows us to constrain the parameter space of the accretion rate and black hole mass.

## Disk-Jet Connection in Black Hole Sources

***Mayur Shende*** **CT60**

IISER, Pune, India

Several active galactic nuclei and microquasars exhibit interesting observational behavior in which significant dips in the X-ray light curve are followed by ejections of plasmoids at radio frequency that move at relativistic speeds. We envisage the plasmoids as pre-existing current carrying magnetic flux ropes that were initially anchored in the accretion disk- corona. The plasmoids are ejected outwards via a mechanism called the toroidal instability (TI). The TI, which was originally explored in the context of laboratory tokamak plasmas, has been very successful in explaining coronal mass ejections from the Sun. Our detailed model predictions compare favorably with a representative set of multi-epoch observations of radio emitting knots from the radio galaxy 3C120. On the other hand, the temporal behaviour of X-rays is thought to arise from the rapid collapse of the hot, inner parts of their accretion disks. The collapse can occur over the radial infall time-scale of the inner accretion disk. However, estimates of this time-scale are hindered by a lack of knowledge of the operative viscosity in the collisionless plasma comprising the inner disk. We use published simulation results for cosmic ray diffusion through turbulent magnetic fields to arrive at a viscosity prescription appropriate to hot accretion disks. We construct simplified disk models using this viscosity prescription and estimate disk collapse time scales for 3C 120, 3C 111, and GRS 1915+105. The Shakura–Sunyaev 945; parameter resulting from our model ranges from 0.02 to 0.08. Our inner disk collapse time- scale estimates agree well with those of the observed X-ray dips. We find that the collapse time-scale is most sensitive to the outer radius of the hot accretion disk. Combining, our work outlines a plausible scenario for episodes of (inner) disc collapse accompanied by blob ejection.

## Gamma-ray flares from relativistic magnetic reconnection in the jet of the quasar 3C 279

***Amit Shukla*** **CT24**

Indian Institute of Technology Indore, India

Accreting black holes are suspected of converting rotational energy into Poynting flux escaping along their rotation axes. In blazars, the non-thermal emission at the highest frequencies allows witnessing the physical processes in the jets' innermost parts in the time domain. A characteristic peak-in-peak variability pattern is a rare transient blazar phenomenon. This variability pattern on time scales of minutes at gamma-ray energies is observed from the active galactic nuclei 3C 279 with the space-borne telescope Fermi-LAT. This study revealed that the black hole's rotational energy powers plasma jets through the magnetic flux. The absence of gamma-ray pair attenuation shows that particle acceleration occurs at a distance of ten thousand gravitational radii fromthe black hole where the fluid dynamical kink instability drives plasma turbulence.

## Radiative turbulence in magnetically-dominated jets

***Emanuele Sobacchi*** **CT67**

Columbia University, USA

Relativistic jets launched by supermassive black holes are powerful emitters of non-thermal radiation. Extraction of the rotational energy of the black hole through electromagnetic stresses produces magnetically-dominated jets, where the magnetic energy density exceeds the rest mass energy density of the plasma. Turbulence is a natural candidate to dissipate the magnetic energy, and accelerate non-thermal particles that emit synchrotron and inverse Compton radiation. The advent of large-scale Particle-In-Cell simulations makes it possible to study radiative turbulence in magnetically-dominated plasmas from first principles. I will show that non-thermal particles accelerated by turbulence are anisotropic, and move nearly along the direction of the local magnetic field. I will discuss how the anisotropy of the emitting particles shapes non-thermal radiation from blazars. Since synchrotron emission is suppressed when particles move along the magnetic field, inverse Compton radiation from strongly anisotropic particles may produce orphan gamma-ray flares, which lack a luminous counterpart at low energies. On the other hand, particles with a low level of anisotropy may produce comparable synchrotron and inverse Compton luminosities. Finally, I will argue that the effect of the anisotropy can be important also for the modelling of prompt emission from Gamma-Ray Bursts.

## Inter Galactic Magnetic field constraints through the gamma ray observations of the Extreme High-frequency-peaked BL Lac candidate HESS 1943+213

***Silvestri Stefano*** **CT41**

University of Pisa, Italy

Extreme High-frequency-peaked BL Lac (EHBL) objects, a subclass of blazars characterised by a synchrotron peak frequency exceeding $10^{17}$ Hz, and, in some cases, an inverse Compton peak energy exceeding 1 TeV, are ideal sources to study the InterGalactic Magnetic Field (IGMF) due to the hardness of their spectrum. HESS J1943+213 is a Very High Energy (VHE, >100 GeV) $\gamma$-ray source shining through the Galactic Plane discovered by HESS. Recently, also VERITAS published a VHE spectrum spanning from 200 GeV up to about 2 TeV consistent with that of HESS within the errors (photon index=2.8). The archetypical EHBL source is 1ES 0229+200 which has a redshift z=0.14 and a similar VHE slope (photon index=2.9). Since the observed flux of HESS J1943+213 at 1 TeV is more than a factor of two larger, and its redshift is bigger (z<0.23), a much larger reprocessed power is expected, which allowed us to study the magnetic field strength with great accuracy. We used the simulation code CRpropa 3 to simulate the cascade emission assuming different IGMF configurations and a detailed analysis of the 10 years of Fermi-LAT data to extend the observed VHE spectrum down to 5 GeV. Comparing the cascade spectrum with the combined spectra from Fermi-LAT and Cherenkov telescopes we derived a lower limit on the IGMF strength of the order of 6e-14 G which is at least a factor of 4 larger than previously published results obtained with the source 1ES0229+200. Effects of the duty cycle are also taken into consideration.

## Blandford-Znajek jets in galaxy formation simulations

***Rosemary Talbot*** **CT56**

IoA, University of Cambridge, United Kingdom

Jets launched by active galactic nuclei (AGN) are believed to play a significant role in shaping the properties of galaxies and provide an energetically viable mechanism to quench star formation in massive galaxies. Here, I will present a novel AGN feedback model, which has been incorporated into the moving mesh code, AREPO. The model evolves the black hole mass and spin as the accretion flow proceeds through a thin accretion disc which we self-consistently couple to a Blandford-Znajek jet. I will present the results of simulations in which we apply this model to the central region of a typical radio-loud Seyfert galaxy embedded in a hot circumgalactic medium. I will show how effective self-regulation by accretion flows leads to evolution in the jet power and discuss how this affects the interaction of the jet with the surrounding medium. I will also show that the direction of jets launched directly into the circumnuclear disc change considerably due to effective Bardeen-Petterson torquing and that these jets obliterate the innermost regions of the disc and drive large-scale, multi-phase, turbulent, bipolar outflows. Finally, I will discuss preliminary findings of simulations that apply our Blandford-Znajek jet model to galaxy merger scenarios.

## GRB jet energetics and structure

***Yuji Urata*** **CT66**

IANCU, Taiwan

Gamma-Ray Bursts (GRBs) are highly energetic explosions involving compact objects; they are caused by mergers or by the core collapse of massive stars. For both the two populations of the GRBs, short and long GRBs, understanding of the jet and its structure is essential. To understand GRB jet energetics and jet structures, we have been working on the (1) energetics including nonaccelerated electron fraction through mm/submm polarimetry, and (2) jet structure by identifying radiation from shocked jet cocoon afterglow and seeking off-axis orphan GRB afterglows. In the case of GRB171205A, we made the first detection of radio polarization of a GRB afterglow in the millimeter range. The linear polarization degree in the millimeter band at the subpercent level is lower than those observed in late-time optical afterglows. The Faraday depolarization by nonaccelerated, cool electrons in the shocked region is one of the possible mechanisms for the low value. This scenario requires a total energy that is larger by a factor of $\sim$10 than ordinary estimates without considering nonaccelerated electrons. We also demonstrated that he two components of the jets observed in the GRB 160623A afterglow is caused by the jet and the shocked jet cocoon afterglows. We will present our recent results based on ALMA, SMA, Pan-STARRS1 and Subaru observations.

## Modelling the synchrotron emission and self-absorption from AGN jets simulations using the particle hybrid module for the PLUTO Code

***Izak van der Westhuizen*** **CT16**

University of the Free State, South Africa

Relativistic Magneto-hydrodynamic (RMHD) simulations provide a powerful tool for studying the dynamics and morphology of Active Galactic Nuclei (AGN) jets. In this contribution we present the results of modelling the non-thermal synchrotron emission of RMHD jet simulations using the particle hybrid module of the PLUTO code. The jet simulation consist of a 3D Cartesian grid with a stratified background medium. Jet fluid is injected into the computational grid using the lower z boundary conditions and the domain is evolved with time. We considered a jet model that is kinetically dominated ($L_{\rm kin} = 10^{46}$ erg.s$^{-1}$) with a toroidal magnetic field. A sample of Lagrangian particles are continuously injected with the the jet fluid. Each Lagrangian particle represent a distribution of non-thermal electrons, with a power-law energy distribution that is updated with time. Processes such as adiabatic expansion, radiative cooling and second order Fermi acceleration are taken into account when updating the particle distribution. By using the spectral information of the particles their synchrotron emissivity is calculated. In addition to the emissivity we present new modifications the PLUTO module to incorporate the synchrotron self absorption. Relativistic boosting of the emission is taken into account in the calculation of the coefficients. These coefficients are integrated along a line of sight using ray tracing to reproduce intensity maps of the simulations at different radio frequencies.

## The effect of low-power, compact AGN jets on their host galaxies as seen by VLT/MUSE

***Giacomo Venturi*** **CT15**

Pontificia Universidad Católica de Chile, Chile

Traditionally, the AGN feedback effect on galaxies is thought to operate through either kinetically powerful ($> 10^{44-45}$ erg/s), extended (10s kpc) jets in radio-loud AGN or massive gas outflows. Recent works suggest that also low-power ($< 10^{44}$ erg/s), compact (<1 kpc) jets may affect their host galaxies, and the most recent cosmological simulations indicate that these may be the dominant source of feedback on sub-kpc scales, but little is known about their effect on the galaxy host. In this context, we investigated the interplay between low-power radio jets and their host galaxies exploiting VLT/MUSE optical integral field observations as part of our MAGNUM survey of nearby AGN. In the only four galaxies of our sample hosting a low- power ($< 10^{44}$ erg/s), compact ($< 1kpc$) radio jet we detected strongly enhanced ($> 800$ km/s) and extended ($> 1kpc$) ionised gas velocity spreads perpendicular to the direction of the jet and AGN ionisation cones. Based on our analysis, the most likely origin for this peculiar perpendicular high-velocity dispersion gas is the strong interaction of the low-power jets with the gas in the host galaxy disc, perturbing and shocking the disc material, in accordance with predictions from hydrodynamic simulations of jet-disc interaction. In line with recent cosmological simulations, our results demonstrate that low-power, compact jets are indeed capable of strongly affecting their host galaxies.

## The impact of jets on galaxy clusters: a simulation perspective

***Rainer Weinberger*** **CT18**

CfA, Harvard  Smithsonian, USA

Supermassive black holes are an important ingredient in modern cosmological simulations of galaxy cluster formation. Their feedback effects have proven to be essential for reproducing key properties, yet, some, like the central cooling times, X-ray luminosities and gas content remain hard to reproduce. In this talk, I will present our multi-year effort to improve the modeling of AGN jet mode feedback in large scale simulations, using lessons learned form dedicated studies of AGN jet propagation. Using isolated simulations of galaxy clusters, we study the detailed response of the intra-cluster gas to determine a feedback efficiency. Furthermore, I will present a comparison between this improved jet-model and existing models used in the literature, such as the kinetic AGN feedback model used in the IllustrisTNG simulations, as well as other models, finding some important differences how they act on the intra-cluster gas. Finally, I will show first results from simulations including this new jet model in cosmological zoom simulations, pushing the resolution and time integration limitations to a new level, and present how this compares to the by now well established (and computationally far less expensive) model used in IllustrisTNG. Using these results, I will discuss which level of sophistication is needed to model this kind of AGN feedback in future, large scale simulations of structure formation, and what the resulting uncertainties are.

## Gamma-ray emission from pair cascades at the border of broad line regions

***Christoph Wendel*** **CT08**

MU Würzburg, Germany

Ultra-relativistic electrons and gamma rays accelerated in black-hole jets interact with soft photons from the accretion flow and from photoionised clouds initiating pair cascades. The spectral energy distribution of the escaping flux of the gamma rays is rather insensitive to the hard injection of electrons, but shows imprints of the low-energy photon spectra, from which inferences of the location of the gamma-ray emission region can be made. Solving kinetic equations for electrons and photons with escape terms, we numerically obtain steady-state spectra for the linear inverse-Compton pair cascades. We study the blazars Markarian 501 and 3C 279 which showed peculiar features in their gamma-ray spectra. The hints for a 3 TeV feature in the spectrum of Markarian 501, detected with the MAGIC telescopes during a large X-ray flux activity in July 2014, can be explained with pair cascades initiated by the interaction of an electron beam carrying 0.1 % of the Blandford-Znajek luminosity from a transient magnetospheric vacuum gap with hydrogen and helium emission line photons reprocessing 1 % of the accretion luminosity. The observed spectrum of 3C 279 which can neither be explained by a power-law nor by a log-parabola spectrum, can be successfully fitted with the pair-cascade model.

## The imprint of protons on the emission of extended blazar jets

***Michael Zacharias*** **CT49**

LUTH, Observatoire de Paris, France

Blazars – active galaxies with the jet pointing at Earth – emit across all electromagnetic wavelengths. The so-called one-zone model has described well both quiescent and flaring states, however it cannot explain the radio emission. In order to self-consistently describe the entire electromagnetic spectrum, extended jet models are necessary. Notably, kinetic descriptions of extended jets can provide the temporal and spatial evolution of the particle species and the full electromagnetic output. Here, we present the initial results of a recently developed hadronic extended-jet code. As protons take much longer than electrons to lose their energy, they can transport energy over much larger distances than electrons and are therefore essential for the energy transport in the jet. Furthermore, protons can inject additional leptons through pion and Bethe-Heitler pair production, which can explain a dominant leptonic radiation signal while still producing neutrinos. We will present a detailed parameter study and provide insights into the different blazar sub-classes.

## Investigating the X-ray enhancements of highly radio-loud quasars at $z > 4$

***Shifu Zhu*** **CT68**

Penn State Department of A&A, United States

We have investigated the jet-linked X-ray emission from highly radio-loud quasars (HRLQs; $\log R > 2.5$) at high redshift. We studied the X-ray properties of 15 HRLQs at z>4, using new Chandra observations for six objects and archival XMM–Newton and Swift observations for the other nine. We focused on testing the apparent enhancement of jet-linked X-ray emission from HRLQs at $z > 4$. Utilizing an enlarged (24 objects) optically flux-limited sample with complete X-ray coverage, we confirmed that HRLQs at $z > 4$ have enhanced X-ray emission relative to that of HRLQs at $z \simeq 1\breve{}2$ with matched UV/optical and radio luminosity, at a 4.0–4.6 sigma level; the X-ray enhancements are confirmed considering both two-point spectral indices and inspection of broad-band spectral energy distributions. The typical factor of enhancement is revised to 1.9, which is smaller than but consistent with previous results. A dominant IC/CMB model is inconsistent with our data. A fractional inverse-Compton/cosmic microwave background (IC/CMB) model can explain our results at high redshift, which puts tighter constraints on the fraction of IC/CMB X-rays at lower redshifts, assuming the physical properties of quasar jets do not have a strong redshift dependence.

## Energy transfer from jets to the ICM from the analysis of density fluctuations on various spatial scales

***Irina Zhuravleva*** **CT63**

University of Chicago, United States

The evolution of massive galaxies residing in the central regions of galaxy clusters is shaped by the energy injection from jets associated with the central supermassive black holes. Interacting with hot gaseous atmospheres, these jets inflate bubbles of relativistic plasma, which, after an expansion, rise buoyantly in cluster atmospheres. A major challenge is understanding the physical processes responsible for energy transfer from the jets to the ICM. In the talk, I will present a statistical analysis of X-ray surface brightness fluctuations in regions dominated by AGN feedback to reveal the nature of fluctuations and, therefore, the dominant energy-transferring mechanism(s). Our analysis shows that gas fluctuations are mostly isobaric or a mix of isobaric and isothermal. The contribution of adiabatic fluctuations associated with weak shocks does not exceed 10 percent. Our results from the brightest nearby galaxy clusters support a gentle scenario of AGN feedback, in which the AGN-injected energy first goes into bubbles of relativistic plasma rather than shocks. At the end of the talk, I will briefly discuss the application of this technique to numerical simulations of AGN feedback to bridge observations and simulations and test various physics included in the simulations.

## Probing the physical conditions and processes in jet through multi-band and multi frequency polarization monitoring

*Emmanouil Angelakis*

**P01**

University of Athens, Greece

We present two prototype cases to demonstrate the potential of multi-band and multi-frequency polarization monitoring to reveal the physical conditions and processes in extra-galactic jets at scales inaccessible even to the highest resolution observations. A. In the case of OJ287 we analyse radio and optical polarization data trains on the basis of different opacities and show that the jet is characterised by a helical topology of the B-field modulate by a simultaneous large-scale bending. We also compute mechanical properties of the flow as well as physical conditions. B. In the case of gamma-ray loud narrow line Seyfert 1 galaxies, we used optical polarization monitoring to examine the potential occurrence of long polarization plane rotations. Indeed, in two cases (J1505+0326 and J0324+3410), we detect the first candidate rotations like those found in powerful, large SMBH mass blazars that appear associated with gamma ray activity. We use exhaustive simulations to show that it is highly unlikely that those are the mere result of noise and are rather driven by internal jet processes. Thus, providing yet another indication that these systems possess jets qualitatively similar to those of the powerful Quasars and Bl Lacs indicating the universality of the underlying processes.

## Can’t see the Galaxies for the Stars: Improving Cross-Identification for Radio Surveys using Ridgelines

***Bonny Barkus***

P02

Open University, United Kingdom

Cross-identification of radio sources with optical and infrared catalogues is essential for determining host properties and distances, leading to intrinsic properties such as luminosity and size; but it is also far from straight forward. For simple, compact or isolated sources this can be done in an automated fashion. However, for extended sources or those which contain multiple components this becomes more complicated and has more often been achieved through human classification. As surveys become larger and sources more numerous this method becomes less efficient. The LOFAR Two metre Sky Survey (LoTSS) is the largest radio survey to date in terms of numbers of sources and data volume and is sensitive to both compact and extended emission, making it ideal for the study of radio sources. Using the LoTSS data release 1, the innovative idea of ridgelines, tracing the path of a jet, to link radio sources to their host galaxies has been applied. This poster introduces ridgelines in the context of extended radio sources, and how they have been successfully integrated into established methods for cross-identification. The effectiveness of the method is demonstrated with the results of sample sets from LoTSS and MeerKAT. The poster will highlight the potential of ridgelines to sub-classify populations with different underlying physics, through the combination of surface brightness profiles and cross- identification.

## Anisotropic (Braginskii) viscosity as a heating mechanism in momentum driven AGN jets

***Thomas Berlok***

P03

Leibniz Institute for Astrophysics (AIP), Germany

Braginskii viscosity, i.e. anisotropic diffusion of momentum with respect to the direction of the magnetic field, has been theorized to be of importance in the weakly collisional plasma that comprises the intracluster medium (ICM). In this talk, I will explain how the Braginskii viscosity terms have been implemented in the moving mesh code AREPO. I will present a number of examples that serve to test the implementation and illustrate the modified dynamics that can be found when including Braginskii viscosity in simulations. I will then show our first results from simulations of momentum driven AGN jets that include Braginskii viscosity. Previous such studies have focused on the ability of Braginskii viscosity to suppress fluid instabilities and the consequent influence on bubble survival time and morphology. They found that including Braginskii viscosity does not significantly change the bubble survival time (Dong 2009, Kingsland 2019). Braginskii viscosity has also been theorized to provide a heating rate via dissipation of turbulent motions (Kunz 2011). In the talk, I will focus on this latter potential influence of Braginskii viscosity by calculating the heating rate associated with viscous dissipation of motions generated by the bubble as it buoyantly rises in the ICM.

## Modeling blazars non-thermal emission: from radio to $\gamma$-rays

***Styliani Boula*** P04

NKUA, Greece

Blazars have their jet pointing towards us and are known for their emission that covers practically all electromagnetic spectrum frequencies. These sources, in some cases, exhibit a correlation between $\gamma$-ray and radio emission, especially during flaring episodes. Adopting the hypothesis that high-energy photon emission by relativistic electrons occurs close to the central black hole, we study the evolution of this population of particles as they move along the jet and lose energy by radiation and adiabatic expansion. In this scenario, $\gamma$-rays are produced early on, when the electrons are still very energetic, while radio emission at a later time when the emission region becomes optically thin to synchrotron self-absorption due to expansion. We develop an expanding one-zone code to calculate the emitted spectrum by simultaneously solving the kinetic equations of particles and photons. We will discuss the parameters entering our calculations, like the magnetic field strength, the density of relativistic electrons, etc., in connection to the observational data by applying our results to the case of Mrk421.

## Variability and Spectral Characteristics of Three Flaring Gamma-ray Quasars Observed by VERITAS and Fermi-LAT

***Aryeh Brill*** P05

Columbia University, USA

Flat spectrum radio quasars (FSRQs) are the most luminous blazars at GeV energies, but only rarely emit detectable fluxes of TeV gamma rays, typically during bright GeV flares. We explore the gamma-ray variability and spectral characteristics of three FSRQs that have been observed at GeV and TeV energies by Fermi-LAT and VERITAS, making use of almost 100 hours of VERITAS observations spread over 10 years: 3C 279, PKS 1222+216, and Ton 599. We explain the GeV flux distributions of the sources in terms of a model derived from a stochastic differential equation and estimate the timescales of magnetic flux accumulation and stochastic instabilities in their accretion disks. We identify distinct flares using a procedure based on Bayesian blocks and analyze their daily and sub-daily variability and gamma-ray energy spectra. Using observations from VERITAS as well as Fermi, Swift, and the Steward Observatory, we model the broadband spectral energy distributions of PKS 1222+216 and Ton 599 during TeV-detected flares in 2014 and 2017, strongly constraining the jet Doppler factors and gamma-ray emission region locations during these events. Finally, we place analytic constraints on the potential production of PeV- scale neutrinos during TeV flares.

## The blazar OJ 287 jet from parsec to kiloparsec scales

***Marina Butuzova***

**P06**

Crimean Astrophysical Observatory, Russia

We analyzed the observed curved shape of the kiloparsec-scale jet of the blazar OJ 287 in the framework of the precession of the central engine. To calculate the jet helix period, it is necessary the kiloparsec-scale jet velocity and angle with the line of sight. We obtained these parameters based on two competing assumptions about the X-ray emission mechanism. Namely, there were both the inverse Compton scattering of the microwave background for the relativistic kiloparsec-scale jet and the inverse Compton scattering of the central source radiation for the sub-relativistic jet. The latter coincides with all available observed data, including the upper limit on the gamma-ray jet flux fixed by Fermi-LAT data. We found that only the period of the kiloparsec-scale jet helix, estimated in the framework of the inverse Compton scattering of the central source radiation, agrees with the precession period of the central engine, determined from the modulation of the peak values of 12-year optical flares and implied a single supermassive black hole in the center of the active nucleus. (The research was supported by the RSF grant 19-72-00105).

## The jet collimation profile at high resolution in BL Lacertae

***Carolina Casadio***

**P07**

Institute of Astrophysics - FORTH, Greece

Controversial studies on the jet collimation profile of BL Lacertae (BL Lac), the eponymous blazar of BL Lac objects class, complicate the scenario in this already puzzling class of objects. Understanding the jet geometry, in connection with the jet kinematics and the physical conditions in the surrounding medium, is fundamental to better constrain the formation, acceleration and collimation mechanisms in extragalactic jets. With the aim of investigating the jet geometry in the innermost regions of the jet of BL Lac, we explore the radio jet in this source, using high-resolution 86 GHz GMVA and 43 GHz VLBA data (VLBA-BU-BLAZAR). We obtained high dynamic range images at the two frequencies, stacking almost ten years of data in both cases, and we infer the jet collimation profile by means of two comparable methods. We analyze the kinematics at 86 GHz, and we discuss it in the context of the jet expansion. We found that local oscillations, often neglected in jet collimation profiles, may have a physical meaning when explored with high-resolution data. A higher expanding rate region is observed between $\sim 5$ and 10 pc (de-projected) from the black hole. Such a region is associated with the decrease in brightness usually observed in high-frequency VLBI images of BL Lac. The jet retrieves the original jet expansion around 17 pc, where the presence of a recollimation shock is supported by both the jet profile and the 15 GHz kinematics (MOJAVE survey). The change in the jet expansion profile occurring at $\sim 5$ pc could be associated with a change in the external pressure profile in correspondence of the Bondi radius ($\sim 3.3 \times 10^5 R_s$). The jet, in its whole, expands with a conical geometry.

## Stability analysis of relativistic magnetized astrophysical jets

***Sinnis Charalampos*** **P08**

National Kapodistrian University Athens, Greece

Astrophysical jets are observed as stable structures, extending in lengths several times their radii. The role of various instabilities and how they affect the observed jet properties has not been fully understood. Using the ideal relativistic MHD equations to describe jet dynamics we aim to study the stability properties through linear analysis. Our jets' physical quantities are defined by the acceleration and collimation processes near the central object that generates the outflow. So, the distribution of each quantity carries the signature of the processes taking place at the early stages of jet propagation. In order to find the growth rates for the instabilities we solve numerically the perturbed system. We find connections between growth rates and various characteristic parameters such as magnetization, as well as the underlying dominating physical mechanism that trigger the instabilities, whether it is a matter- or magnetic field-dominated process.

## Analytical Solution of Magnetically Dominated Jets: Jet Launching, Acceleration, and Collimation

***Liang Chen*** **P09**

Shanghai Astronomical Observatory, CAS, China

Jets are ubiquitously in association with different celestial objects. However, most of previous theoretical studies of them rely on numerical calculations, not being able to provide a more convenient way for understanding rather abundant observational results. Now we have obtained a general analytical solution for describing a magnetically dominated jet, through separating the jet core equation (which maintains the radial dynamic equilibrium) into rotating and non-rotating terms, finding that each of the two-term equations can be solved analytically, and the two solutions match each other very well. The analytical model based on this solution can measure jet properties (3D morphology of magnetic fields, velocity, density, current and charge profiles) and explain the main results of jet observations and numerical simulations, such as jet shape configuration, acceleration profile (from non-relativistic to relativistic), and polarization pattern etc. Furthermore, the solution is applicable to, e.g., limb- brightening (a hollow jet), periodical variability (a helical jet), and complex proper motion pattern (a stratified jet) etc. I this talk, I will present the details of the theory, examples of comparing with observations, and a variety of predictions (Ref. Chen & Zhang, 2021, ApJ, 906, 105).

## 3C 84: A Possibly Precessing Jet in 43 GHz Observations

***Rune Michael Dominik***

P10

TU Dortmund University, Germany

The central galaxy in the Perseus galaxy cluster, 3C 84 or NGC 1275 is one of the nearest and best observed Active Galactic Nuclei and offered insight to a variety of phenomenons over the past decades. Although close and well observed, some key properties of 3C 84 remain unknown. One of this properties is the inclination angle between the jet and the line of sight onto the source, where a wide range of values can be found in publications. Previous studies have indicated a precessing behaviour of 3C 84's jet that could explain these discrepancies. We analyse this behaviour on parsec scales using VLBA-BU-BLAZAR Program 43 GHz data and find a significant change in the position angle, necessary for a precession. Using a non-relativistic model, we find that the data is consistent with a precessing jet. Further, we investigate an additional nutation.

## Variability - Insights from Long-Term Monitoring

***Daniela Dorner***

P11

Universität Würzburg, Germany

To understand extremely variable sources like blazars, unbiased long-term observations are crucial. Often, multi-wavelength observations are triggered by flares detected in one band. This biases the overall data sample towards higher fluxes. Also data samples used for modelling are mostly limited to short time ranges describing only part of the variability. To constrain models, the high-energy peak in the spectral energy distribution of blazars is important. In the GeV regime, Fermi-LAT is continuously scanning the sky. At TeV energies, FACT and HAWC dedicate their observation time to unbiased monitoring. In more than eight years, FACT has collected an unprecedented data sample (> 14700 hours of physics data) with a total of 1900 hours to 3200 hours for each of the monitored sources. Per night, a source is observed up to 7 hours depending on its visibility. Variability found on time scales from minutes to years provides new inputs for the modelling. A systematic analysis of the long-term variability puts new constraints on the underlying physics processes. For example Mrk 501 shows variability on short time scales during bright outbursts in 2012 or 2014, while starting from 2017 it is in a continuous low state. Explaining these extreme long-term flux variations and variability characteristics poses new challenges for the modelling.

## Synthetic observation of S-shaped jet from dual AGN candidate 2MASX J12032061+1319316

***Ravi Pratap Dubey***

P12

Indian Institute of Technology Indore, India

Extended radio galaxies are characterized by the presence of well-collimated plasma flows from the center of a compact core. Sometimes, these jets show significant distortion in their structure, forming an S-shaped radio morphology. This appearance is predicted to be the outcome of a precessing jet. The existence of dual or binary AGN at the center of these galaxies or a tilted accretion disk are the two plausible mechanisms invoked to explain this precession. The goal of this work is to study the formation and evolution of S-morphology due to the rotating jet. In this regard, we have performed 3D MHD simulations of a precessing jet propagating in an ambient galaxy and have obtained synthetic emission signatures in the presence of radiative losses and diffusive shock acceleration. Here, I will discuss the parametric restrictions under which the S-morphology formed along with the characteristics obtained from its dynamics. Further, the implication of equipartition in the age estimation of the galaxy will be discussed. A comparison between our synthesized maps with VLA observations of dual AGN candidates 2MASX J12032061+1319316 will be presented, along with a prediction for the polarization map in the radio band.

## Time-dependent Modeling of Flares from Blazar Jets

***Justin Finke***

P13

Naval Research Laboratory, USA

I present time dependent modeling of short timescale blazar flares observed in the optical through gamma rays. These are explored in the context of a one-zone relativistically moving expanding blob. The modeling includes two features not often taken into account in blazar flare modeling: light travel time effects and the changing external radiation field, as observed in the frame of the blob. Emission and electron energy loss rates are computed with the full Compton cross-section, taking into account the changing geometry of the external fields. The energy loss rates are used in solving a continuity equation for the electron distribution, which is used to compute the synchrotron and Compton scattering emission.

## The evolution of relativistic jets through the magnetized medium produced by the fusion of two neutron stars

***Leonardo Enrique Garcia*** **P14**

IA-UNAM, Mexico

The merger of a binary neutron star system can result in the emission of gravitational waves, a highly dense and magnetized environment, and the launch of a collimated relativistic jet which eventually produces a short gamma-ray burst (SGRB). Although the evolution of a jet-SGRB has been studied through different media the evolution through a magnetized medium remains to be fully understood. Therefore, in order to understand the importance of the medium's magnetic field, we studied the evolution of a series of SGRB-jets through media with different **B** using two-dimensional magneto-hydrodynamic relativistic numerical simulations. Specifically, we follow the evolution of jets-SGRB with $L_j$ and $\theta_j$variables through a medium with different distributions of **B** and magnitudes of **B**.

## The curious case of X-shaped radio galaxies: Back-flow

***Gourab Giri*** **P15**

IIT Indore, India

X-shaped radio galaxies are a subclass of extended radio galaxies which can be identified from the presence of two double lobed structures aligned at an angle to each other (active lobe and wing). The formation mechanism of these radio galaxies is still not well understood and several models have been invoked to explain this peculiar structure. In this work, we aimed to study the formation of X-shaped radio galaxies due to the back-flow model. In this regard, we have performed axisymmetric (2D) and three-dimensional (3D) simulations of relativistic magneto-hydrodynamic jet propagation from tri-axial galaxies and have obtained synthetic emission signatures in the presence of radiative losses and diffusive shock acceleration. Here, I will present the crucial role played by the magnetic field strength of the jet and pressure gradient of ambient in shaping the relative extent of the wing and the lobe structure. The characteristic emission signatures from the back-flow model in terms of its synchrotron spectra will be discussed along with the implication of equipartition in age estimation of the galaxy. Further, the effect of viewing angle on the difference of spectral index of the active lobes and the wings will be showcased to comprehend and constrain the formation mechanisms of X-shaped radio galaxies.

## Is PKS 0625-354 another variable TeV active galactic nucleus?

***Dorit Glawion***

**P16**

ECAP, FAU Erlangen-Nürnberg, Germany

The majority of the active galactic nuclei detected at very-high-energies above 100 GeV belong to the class of blazars with a small angle between the jet-axis and the line-of-sight. Only about 10 percent of the gamma-ray AGN are objects with a larger viewing angle resulting in a smaller Doppler boosting of the emission. Originally, it was believed that gamma-ray emission can only be observed from blazars and those are variable in its brightness. Instead, the last years have shown that non-blazar active galaxies also show a fascinating variability behaviour which provide important new insights into the physical processes responsible for the gamma-ray production and especially for flaring events. Here, we report on the observation of gamma-ray variability of the active galaxy PKS 0625-354 detected with the H.E.S.S. telescopes in November 2018. The classification of PKS 0625-354 is a still matter of debate. The H.E.S.S. measurements were performed as part of a flux monitoring program and showed in the first night of the observation a detection of the object within one observation run of 30 minutes. A denser observation campaign followed for the next nine nights resulting in a decrease of the gamma-ray flux. Those observations were accompanied with Swift and ATOM measurements in the X-ray and UV/optical band allowing for the reconstruction of the first simultaneous broad-band spectral energy distribution. We will discuss the implications of the gamma-ray variability of the object as well as the spectral energy distribution.

## Constraints on the nature of the blazar S5 0716+714 optical radiating region obtained from the long-term variability

***Mark Gorbachev***

**P17**

Kazan (Volga region) Federal University, Russia

Multiband optical photometry data of blazar S5 0716+714 obtained from 2002 to 2019 at CrAO reveal stable color index change with variability. We analyzed this trend under variability caused by the Doppler factor change in the presence of a curved photon energy spectrum. We considered that curved photon spectrum is due to neither a break in the energy spectrum of emitting electrons, which is caused by radiative losses, nor the synchrotron self-absorption acting in a compact jet part of the jet. We have obtained that the observed color index change with variability can be explained by geometric effects under the assumption that the radiating region is the synchrotron self-absorbed core and the bright optically thin jet. In this framework, for the radiation region size of one gravitational radius of a black hole with a mass in a range of $10^8 - 10^9$ solar masses, the magnetic field strength is consistent with other independent estimates. (The research was partly supported by the RSF grant 19-72-00105).

## Signatures of the energy-dependent diffusion in X-ray spectra of BL Lac Mkn 421

***Pranjupriya Goswami***

P18

Tezpur University, India

We present simplistic assumptions of shock acceleration theory to model and interpret the observed X-ray spectral curvature of BL Lac source Mkn 421 under the simplistic assumptions of shock acceleration theory. The curved spectrum can be alternatively described as an outcome of the energy-dependent electron diffusion in the acceleration region (EDD model; Goswami et al. (2018),480,2046; (2020),499,2094). The model parameter determines the intrinsic curvature in terms of energy-dependent electron escape timescale. For the observational study, we utilize simultaneous Swift-XRT and NuSTAR data of Mkn 421 during 2012-2013 including flaring/quiescent flux states. While the model is capable of explaining various flux state spectra satisfactorily, the best-fit parameters show a strong linear correlation. The observed linear correlation enables us to determine an expression for the product of source magnetic field (B) and jet Doppler factor($\delta$) in terms of synchrotron and Compton peak energies. The model further suggests a correlation between the intrinsic curvature and the synchrotron peak energy, and the correlation is consistent with our analysis. We show that the knowledge of energy-dependent diffusion has the potential to probe the magnetohydrodynamic turbulence in the jet. In the case of Mkn 421, our analysis indicates a possible shift in the turbulence from Kolmogorov/Kraichnan type to the Bohm limit during high flux states.

## Deciphering the 2017 soft X-ray flare of OJ 287, a radio-to-TeV study

***Olivier Hervet***

P19

UC Santa Cruz, USA

Intermediate blazars (IBLs and LBLs) are known to present complex multivavelength SEDs and variabilities, often requiring an interpretation beyond standard one-zone emission models. OJ 287 is the archetype of such a complex blazar. On top of hosting a binary supermassive black hole system, it presents multiple other unusual features like an X-ray extended jet, possible jet precession, complex observed radio jet kinematics, and orphan flares. We focus our attention of such an orphan flare that happened only in soft X-ray in Feb 2017. With data in radio-VLBI, optical, UV, X-ray, gamma-ray, and very high energy with VERITAS; we study the multiwavelength behavior of the source before, during, and after the flare. Based on the discovery of a radio jet ejecta emerging from the core at the same period, we present a scenario of a compact zone moves through the powerful emission of the core that can accurately depict the multiwavelength SED at different periods. This scenario is discussed in the broader context of the intermediate blazar's characterization.

## Selection and characterization of Red Geysers: What is the source of gas ionization?

***Gabriele Ilha***

P20

Universidade Federal de Santa Maria, Brazil

Red Geysers are quiescent galaxies that show outflows, but the mechanism that produces these outflows is still unclear. For the prototype of this class of galaxies (Akira galaxy), the bipolar outflow is probably originated in a low-luminosity AGN. We have used data cubes from MaNGA project from SDSS-IV to select and analyze a sample of Red Geysers. The following selection criteria were used to select the Red Geyser sample: rest frame color NUV-r>5, star formation rate with log(SFR[M/yr]<-2), bi-symmetric pattern in H$\alpha$-EW maps aligned with the gas kinematic axis and misaligned with the stellar kinematic axis, velocity fields of H$\alpha$ are at least 1.5 times as high as the values of the stellar velocity fields, difference in the orientation of the kinematic axis of stellar and gas velocity fields between $10° < \Delta PA < 170°$. The selected sample is composed of 92 galaxies and only 11% of them have gas ionization caused by an AGN. We selected 9 Red Geysers to observe with the GMOS instrument from Gemini telescope. Preliminary results for the galaxy MaNGA 1-385124 using data from MaNGA indicate that the source of gas ionization can not be an AGN, however using GMOS data we have an AGN.

## Neutrino Emission from Supermassive Binary Black Hole Mergers

***Ilja Jaroschewski***

P21

Ruhr-University Bochum, TP IV, Germany

The first high-probability association of an extragalactic neutrino to the blazar TXS 0506+056 in 2017 identified such active galaxies as potential high-energy neutrino emitters. Two distinct episodes of neutrino emission were detected within 3 years, indicating a possible periodicity. Such periodic behavior is explainable by a supermassive binary black hole system close to its merger as a result of jet precession. We present a model for predicting the arrival times of neutrino flares and gravitational waves for such systems and apply it on TXS 0506+056 assuming that it is an ongoing binary merger. We conclude that the next neutrino emission could already have occurred, possibly still hidden in IceCube's not-yet-analyzed data, and deliver binary properties for a successful detection of its gravitational waves by LISA. As supermassive black hole mergers could occur more frequently due to merging of their host galaxies, we further investigate a possible connection between their radiated gravitational wave energy and the diffuse astrophysical neutrino flux that is measured by IceCube. We estimate the contributions of these mergers and binary stellar mass black hole mergers in starburst galaxies on top to the diffuse neutrino flux.

## A candidate dual AGN in a double-peaked emission-line galaxy with precessing radio jets

***Rubinur Khatun***

**P22**

NCRA-TIFR, India

I will present the high-resolution radio continuum observations with the Karl G. Jansky very large array at 6, 8.5, 11.5 and 15 GHz of the double-peaked emission-line galaxy 2MASXJ12032061+1319316. The radio emission has a prominent S-shaped morphology with highly symmetric radio jets that extend over a distance of 1.5 arcsec (1.74 kpc) on either side of the core of size $\sim 0.1$ arcsec (116 pc). The nuclear bulge velocity dispersion gives an upper limit of $(1.56 \pm 0.26) \times 10^8 M_{Sun}$ for the total mass of nuclear black hole(s). We fitted a simple model of precessing jets in 2MASXJ1203 and found that the precession time-scale is around $10^5$ yr: this matches the source lifetime estimate via spectral ageing. The calculated expected supermassive black hole (SMBH) separation corresponding to this time-scale is 0.02 pc. We used the double-peaked emission lines in 2MASXJ1203 to determine an orbital speed for a dual AGN system and the associated jet precession time-scale, which turns out to be more than the Hubble time, making it unfeasible. We concluded that the S-shaped radio jets are due to jet precession caused either by a binary/dual SMBH system, a single SMBH with a tilted accretion disc or a dual AGN system where a close pass of the secondary SMBH in the past has given rise to jet precession.

## Ray-Tracing in Relativistic Jet Simulations: A Polarimetric Study

***Joana Kramer***

**P23**

Max Planck Institute for Radio Astronomy, Germany

Jets emanate from centers of AGNs are among the most energetic objects in the universe. Through the use of 3D relativistic magnetohydrodynamic jet simulations (via PLUTO) we study how the morphology of the jet's synchrotron emission depends upon either the magnetic nature of the jet's plasma or on the conversion of PLUTO's thermal variables to non-thermal expressions that parametrize the electron power-law distribution. In particular, we look at the structure of a purely poloidal as well as toroidal, and a helical magnetic field. To account for the power-law distribution we approached it to be proportional to (i) the fluid's thermal density, (ii) the fluid's internal energy density, and (iii) the fluid's magnetic energy density. Further, the different results are analyzed in synthetic emission maps. The images (via the ray-tracing code RADMC-3D) highlight the total intensity, linearly polarized intensity, and circularly polarized intensity we get from each jet simulation. As a last step, we recently included particles within the jet simulations to account for the electron energy distribution itself after performing an interpolation. With the particle module included lately in PLUTO we managed to extend the physics to synchrotron losses and shock acceleration.

## On the magnetization of relativistic jets with radial velocity shear


***Dominika Król***

P24

Jagiellonian University, Poland



Here we consider the simplest analytical models for astrophysical jets, consisting of a cylindrical relativistic outflow with normal velocity shear and a purely toroidal magnetic field, confined by the external pressure. We demonstrate, that if in the magnetohydrostatic equilibrium, such jets cannot be dominated by the Poynting flux, but instead must be dominated by the particle energy flux. We discuss the main implication of our finding for the general models of the large-scale jets in active galactic nuclei.


## Investigating intra-day variability in the relativistic jets of AGN due to blob propagation using RMHD simulations


***Daniel Kulik***

P25

University of the Free State, South Africa



Active Galactic Nuclei (AGN) are compact regions in the centre of galaxies exhibiting higher than normal luminosity. Blazars, the most luminous type of AGN, have relativistic jets that are directed very nearly along the line-of-sight and exhibit variability in their light curves. Observations of intra-day variability for AGN suggest the presence of blobs in their jets. Blob formation has been attributed to shocks, perturbations, and plasmoids generated by magnetic confinement. We investigate the morphology and dynamics of blobs generated with different characteristics (velocity, density, and magnetic fields) and how this can result in variable light curves. Relativistic magnetohydrodynamic (RMHD) jets were simulated using PLUTO, an astrophysical fluid simulation software, and allowed to develop in time forming multiple recollimation shocks. Quasi-spherical blobs were then injected into the jet by varying parameters at the jet base and allowed to propagate and interact with the jet and its shocks. A post-processing code was used to find the integrated specific intensity of synchrotron emission in the radio regime, accounting for relativistic effects. From this, light curves have shown how the specific intensity changed over time and indicated significant variability during blob propagation with peaks that formed during blob-recollimation shock interactions.

## Interplay of particle acceleration processes in AGN Jets

***Sayan Kundu*** P26

Indian Institute of Technology Indore, India

AGN Jets are observed to possess various sites for particle acceleration, which gives rise to the observed non-thermal spectra. Diffusive shock acceleration (DSA) and stochastic turbulent acceleration (SA) are claimed to be the candidates for producing very high energetic particles in weakly magnetized regions. While DSA is a systematic acceleration process, SA is a random energization process, which is usually modelled as a biased random walk in energy space with a Fokker-Planck equation. Due to the ubiquitous nature of plasma fluctuations, SA gives rise to diffuse emission, whereas DSA leads to localized emission. In astrophysical systems, different acceleration processes work in an integrated manner along with various energy losses. I will present our novel method of implementing SA in the hybrid Eulerian-Lagrangian framework that accounts for DSA in the presence of radiative processes like synchrotron and IC emission. The focus would be to showcase the interplay between the particle acceleration process due to shocks and turbulence. Further, I will also discuss the application of these acceleration mechanisms in governing the characteristic of the non- thermal emission from the radio lobes of AGN jets.

## Excluding Possible Sites of Gamma-Ray Emission in 3C84/NGC1275

***Lena Linhoff*** P27

TU Dortmund, Germany

The radio galaxy 3C 84 is a well studied source of radio emission and was detected as misaligned blazar NGC 1275 also in the very high-energy regime by gamma-ray detectors like MAGIC and FermiLAT. Unless the innermost structure of 3C 84 can be resolved with radio observations at 43 GHz, the mechanisms producing gamma-ray emission are still not fully understood. A necessary step to understand the production of high-energy photons, is to localize the emission region of gamma-rays in the central region of the source. For this aim, we investigate the optical depth within the broad-line region (BLR) to constrain the origin of the gamma-ray emission. With this approach, we exclude regions within the BLR as location of the very-high energy emission. In this talk we place our results in the context of theoretical models and other multi-wavelength analysis results.

## Simulations of Precessing Jets and Their Role in AGN Feedback

*Ying-He Celeste Lu*

P28

University of Cambridge, United Kingdom

The role of AGN jet feedback in galaxy evolution has been a challenge to model in simulations. In this work we present a new subgrid code to model accretion and jet feedback from AGN in idealized galaxy cluster simulations. With the model we investigate how the feedback energy from the AGN is deposited into the ICM, studying the interplay between precessing jets and the turbulent intra-cluster medium, as well as the effect this interaction has on radiative cooling.

## Radio Galaxies: does accretion always rhyme with jets power?

*Duccio Macconi*

P29

INAF/OAS Bologna - University of Bologna, Italy

If there is a link between accretion onto SMBH and jets power in radio galaxies (RG), as generally thought, why are powerful jets observed also in inefficiently accreting RG? About a quarter of the 3CR sources at z<0.3 with radio-optical cross-classification are indeed classified as FRII-LERG. They show low-excitation emission lines (i.e. modest nuclear accretion rates) but strong extended radio power and FRII-like morphology. To shed light on their nature, we combined X-ray spectral analysis (Chandra+XMM-Newton) of all the cross-classified RG within 3CR at z<0.3 with optical-radio data from literature. When compared to FRI-LERG (i.e. low-power RG with inefficient accretion flow) and FRII-HERG (i.e. high-power RG with high-excitation emission lines due to an efficient accretion disk), FRII-LERG have intermediate properties in terms of accretion $(L_{\mathrm{X}}/L_{\mathrm{Edd}})$ and obscuration. Two possibilities are viable: (i) intermediate accretion flows are still able to launch powerful jets; (ii) FRII-LERG are aged FRII-HERG. To disentangle between these two scenarios, our study was extended to the CoNFIG sample (Gendre et al. 2013) at $z < 0.3$ with low flux density limit: 0.5 mJy @ 1.4 GHz. Our preliminary results indicate that FRII-LERG are more similar to FRI-LERG than FRII-HERG in the mJy regime, making the evolutive scenario more appealing.

## The twin-jet system in 3C 452


***Eftychia Madika***

P30

Max-Planck-Institut f$\ddot{u}$r Radioastronomie, Germany



The radio galaxy 3C452 displays a unique combination of symmetric double-jet morphology, large black hole mass, and vicinity (z=0.081). It is a rare example of a powerful Fanaroff-Riley II source that can be imaged at high resolution through high-sensitivity VLBI observations. Here we present the first-ever VLBI images of this source on sub-parsec scales, which revealed a highly symmetric twin-jet system. We performed a pixel-by-pixel analysis of the innermost $10^3 - 10^4$ Schwarzschild radii, aiming at identifying the centre of symmetry and pinpointing the core location. Through a jet to counter-jet analysis, we obtained the speed profile and set an upper limit of approximately 80 deg on the jet viewing angle. The jet orientation close to the plane of the sky makes 3C452 a prime target to test the existence of a thick obscuring torus surrounding the supermassive black hole, as predicted by the standard model of active galactic nuclei. To this end, we performed an X-ray analysis using XMM-Newton data. The X-ray spectrum appears to be dominated by Compton reflection off cold matter, indicating a highly absorbed source with an intrinsic hydrogen column density of $6 \times 10^{23} cm^{-2}$.


## Local alignments of parsec-scale AGN radiojets


***Nikos Mandarakas***

P31

University of Crete, Physics Department, Greece



Coherence in characteristics of neighboring sources in 2D and 3D space may suggest the existence of cosmic structures, which are useful for cosmological studies. Numerous works have been conducted to detect such features in global scales as well as in confined areas of the sky. However, results are often contradictory and their interpretation remains controversial. We investigate the potential alignment of parsec-scale radio jets in localized regions of the coordinates-redshift space, using data from the Astrogeo VLBI FITS image database to deduce jet directions of radio sources. We perform the search for statistical alignments between nearby sources and explore the impact of instrumental biases. We unveil four regions for which the alignment between jet directions deviates from randomness at a significance level of more than 5 sigma and are unlikely due to instrumental systematics. Intriguingly, their locations compare with other known large-scale cosmic structures and/or regions of alignments. If the alignments found are the result of physical processes, the discovered regions may designate some of the largest structures known to date.

## A constrained transport method for the solution of Resistive Relativistic plasmas in the PLUTO code


***Giancarlo Mattia***

**P32**

Max Planck Institute for Astronomy, Germany


Astrophysical jets are launched from strongly magnetized systems that host an accretion disk surrounding a central object. The origin of the jet-launching magnetic field is one of the open questions for modeling the accretion–ejection process. Here we address the question of how accretion-disk magnetization and the field structure required for jet launching are generated. Applying the PLUTO code, we present the first resistive magnetohydronamic simulations of jet launching including a non-scalar accretion-disk mean-field dynamo in the context of largescale disk-jet simulations. We have investigated a disk dynamo that follows analytical solutions of the mean-field dynamo theory, essentially based only on a single parameter, the Coriolis number. We thereby confirm the anisotropy of the dynamo tensor acting in accretion disks, allowing both the resistivity and mean-field dynamo to be related to the disk turbulence. Our new model recovers previous simulations by applying a purely radial initial field while allowing for a more stable evolution for seed fields with a vertical component. We also present correlations between the strength of the disk dynamo coefficients and the dynamical parameters of the jet that is launched (as, e.g., the jet speed, which we have found to be larger for larger values of the Coriolis number), and discuss their implications for observed jet quantities.

## The detectability of fast gamma-ray blazar flares from magnetic reconnection with the Fermi Large Area Telescope


***Manuel Meyer***

**P33**

Erlangen Center for Astoparticle Physics, Germany


The physical mechanism for the production of fast gamma-ray variability in blazars remains debated. Plasmoids – magnetized quasi-circular structures of plasma formed self-consistently in reconnecting current sheets – are ideal candidates for the production of broadband variable non-thermal emission. Using state-of-the-art kinetic simulations of magnetic reconnection and radiative transfer calculations, we generate artificial gamma-ray light curves that would be observed with the Fermi Large Area Telescope (LAT). Our goal is to investigate if characteristic features of the theoretical light curves, such as the ultra-rapid gamma-ray flares predicted by the reconnection model, are detectable with the typical Fermi-LAT observations. A comparison with observed luminous and fast gamma-ray flares from flat spectrum radio quasars (FSRQs) reveals that magnetic reconnection events lead to comparable flux levels and variability patterns, especially when the reconnection layer is slightly misaligned with the line of sight. Emission from fast plasmoids moving close to the line of sight could explain fast variability on the time scales of minutes for which evidence has been found in observations of FSRQs. Our results motivate improvements in the existing reconnection model for blazars as well as dedicated searches for fast variability in LAT data as evidence for magnetic reconnection events.

## Modeling of TeV emission from gamma-ray bursts

***Davide Miceli***

P34

University of Udine & INFN Trieste, Italy

The presence of a very high energy (VHE, E > 100 GeV) emission component in gamma-ray bursts has always been one of the most debated open questions both from the observational and the theoretical side. The recent discoveries claimed by the MAGIC and H.E.S.S. telescopes have firmly proved the existence of such component up to TeV energies. These results have been fundamental to directly investigate for the first time ever the responsible mechanisms and the physical properties of such energetic component as well as its connection with the emission at lower energy bands. The multi-wavelength afterglow emission from the long gamma- ray burst GRB 190114C was successfully explained with a numerical modeling reproducing both the synchrotron and synchrotron-self Compton radiation emitted from electrons within the external forward shock scenario. In this contribution the main ingredients which were used to develop such model and the conclusions derived from GRB 190114C modeling will be presented. Moreover, the current growing number of GRB detections in the VHE band will be exploited to perform initial population and systematic studies of GRBs detected in the VHE band testing the synchrotron and SSC external forward shock scenario.

## Low Frequency Observations of Peculiar Radio Galaxies

***Arpita Misra***

P35

Jagiellonian University, Poland

Radio galaxies strikingly produce collimated jets from kiloparsec to megaparsec scale. These jets are powered by relativistic particles and magnetic field emanating from the core of active galactic nuclei. With new highly resolved deep sky surveys more radio galaxies are discovered with interesting morphologies such as S-, X- and Z-shaped sources. Radio galaxies with such twisted jets underlie a complex and dynamic mechanism taking place at their cores. With many theories explaining the cause behind these peculiar structures, there is less evidence in support of either of them. We intend to probe the distorted jet/lobe morphology in order to understand the physical conditions at the centres of such host galaxies and therefore we present here new 610 MHz data of a sample of S-shaped sources from dedicated low frequency GMRT observations.

## agnpy: an open-source, do it yourself, approach to (jetted) AGN modelling

***Cosimo Nigro*** **P36**

IFAE, Spain

The reproducibility crisis affecting astroparticle physics is often addressed from the data analaysis perspective, rarely from the interpretation and modelling side. Envisioning a reproducible interpretation of jetted active galaxies, I have created agnpy, an open-source python package modelling their broad-band emission. agnpy gathers and implements the most common leptonic radiative processes considered in jetted AGN modelling. Besides the computation of non-thermal spectra, agnpy includes additional classes describing the AGN components emitting thermal and line radiation. It also allows computing the absorption of the highest-energy photons on galactic and extragalactic soft photon fields and offers the possibility of a self-consistent constraint of the model parameters. agnpy is easily interfaceable with the python data-analysis tools increasingly dominant in astroparticle physics and has recently been included among the packages affiliated with the astropy project. In the talk, I will illustrate the code capabilities and examples of its applitcation to different science cases. Repsoitory: https://github.com/cosimoNigro/agnpy Documentation: https://agnpy.readthedocs.io/en/latest/

## Precessing Radio Galaxy Jets: Simulations and Observable Signatures

***Chris Nolting*** **P37**

College of Charleston, United States

Some radio galaxies show signs of changes in jet orientation or direction in the form of off- (current)axis lobes or S, X, or Z-shape radio morphology. One explanation for this is the precession of the AGN jet axis, possibly caused by a binary supermassive black hole companion. We present simulations of precessing jets as well as synthetic radio maps calculated from a cosmic ray electron distribution that was evolved with a Fokker-Planck solver and radiative losses. We show that depending on the viewing angle and the phases of the jet's precession and evolution, the radio source can take on a wide range of morphologies. This will naturally lead to cases of 'mistaken identify' and misunderstanding the underlying jet or environmental dynamics. We discuss some observable signatures of jet precession.

## The physical processes driving jets during the formation of massive stars

*G. Andre Oliva*

P38

University of Tuebingen, Germany

Massive stars live short but intense lives. While less numerous than low-mass stars, they enormously impact their surroundings by several mechanical and radiative feedback mechanisms. They form in opaque and distant regions, making one of these feedback mechanisms a highlight of the observability of the earliest phases of high-mass star formation: their large-scale jets and outflows, which have been detected in extra-galactic VLT/MUSE observations (see McLeod et al. 2018, Nature). We investigate the formation of high-mass stars starting from the collapse of a rotating magnetized cloud, and the subsequent formation of a system composed by a centrifugally-supported accretion disk and magnetically-driven outflows embedded in the infalling proto-stellar envelope. For this purpose, we ran numerical simulations with non-ideal MHD, self-gravity and radiation transport on grids with high resolution as it has never been achieved before in the context of massive star formation. We find that non-ideal MHD effects are required to form a centrifugally-supported accretion disk, and identify the several physical processes involved in the launching and development of the outflows. We find a fast, collimated, magneto-centrifugally launched jet, and a wide-angle tower flow driven by magnetic pressure. A wall develops between the boundary between infall and the jet. This wall contributes to both the infall and the outflows, with intermittent ejections of material driven by centrifugal force and magnetic reconnection. Taking into account both the mass launched from the surface of the disk and the entrained material from the envelope, we find an ejection-to-accretion efficiency of 10%. We also study the long-term evolution of the outflows and the disk. We find that magnetic braking eventually becomes strong enough to cause the wall to lose centrifugal support and collapse, limiting or even stopping the magneto-centrifugally launched jet, but not the magnetic-pressure-driven tower flow. Magnetic braking also causes the inner region of the disk to lose centrifugal support, although most of the disk is still near Keplerian. Finally, we performed several parameter studies, including the initial magnetic field strength and the mass of the cloud.

## 3D PIC simulations of current-driven instabilities in cylindrical magnetized jets.

*José Ortuño-Macías*

P39

Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences.

High-energy astrophysical phenomena commonly present regions with magnetic energy density that locally dominate the rest-mass density of matter. Such relativistic magnetizations can be converted to relativistic particle acceleration which is observed in the form of luminous non-thermal emission with photon energies extending into the gamma-ray band. Relativistically magnetized regions are expected in relativistic jets which may involve ordered magnetic fields with poloidal and toroidal components prone to kink and pinch instabilities. Recently, first 3D kinetic simulations of cylindrical magnetized columns reported particle acceleration from two different magnetic field configurations, toroidal field supported by magnetic poloidal field or by gas pressure. In this work we introduce a radial profile of toroidal magnetic field that can be supported by a combination of poloidal magnetic field and gas pressure and investigate the particle acceleration mechanisms.

# Disentangling the optical spectral variability of gamma-ray bright blazars through statistical studies

***Jorge Otero-Santos***

Instituto de Astrofisica de Canarias, Spain

**P40**

Blazars are a subclass of active galactic nuclei (AGNs) with a relativistically boosted jet pointing towards the Earth. They are one of the most violent and variable objects in the Universe, showing extreme variability across the entire electromagnetic spectrum. The jet generally dominates the emission of these sources. However, other components such as the stellar emission from the host galaxy or the accretion disk may contribute significantly to this emission. Disentangling the different contributions to the optical emission of these sources is challenging due to the high dominance of the jet, but is needed to study the variability detected in these objects. In this work we will present the results of the spectropolarimetric variability analysis performed in a sample of blazars monitored by the Steward Observatory. We make use of the non-negative matrix factorization (NMF), a statistical tool of dimensionality reduction. We develop a strategy to obtain a minimum number of components with a meaningful physical association with different parts of the AGN. With this decomposition we aim to study the global variability and the contribution of each component to the flux evolution. The separation of these components can shed light to the physical processes taking place in the jet. The interpretation of the results is complemented with the polarimetric data of each source, investigating the behaviour of the derived components with the polarization degree and angle.

## Waiting Times Between activity peaks of FSRQs

***Luigi Pacciani***

**P41**

INAF-IAPS, Italy

The study of the statistical distribution of waiting times between activity peaks (waiting times are the time intervals between consecutive activity peaks (see, e.g., Wheatland 2002) can give information on the distribution of flaring times, and constrain the physical mechanism responsible for Gamma-ray emission. Candidate activity peaks are revealed using a photometric unbinned peak detection method (Pacciani 2018); fake flares are removed from the sample by comparing the photometric results with the standard likelihood analysis performed within the identified peak activity period. We found that the waiting times distribution can be described with a set of overlapping bursts of flares, with an average burst duration $\sim 0.6$ year, and with an average burst rate of $\sim 1.3/y$. For short waiting times (below 1 d host frame) we reveal a second population: the blue component with a few tens of short waiting times. In our analysis, CTA 102 showed the large majority of short waiting times. Interestingly, the period of conspicuous detection of the blue component of waiting times for this source coincides with the crossing time of the superluminal K1 feature with the C1 stationary feature in radio reported in Jorstad 2017 and in Casadio 2019. The obtained distribution of waiting times between Gamma-ray flares can be interpreted as originating from relativistic plasma moving along the jet for a deprojected length of $\sim 30-60$ pc (assuming a bulk Gamma=10), that sporadically produce Gamma-ray flares. Duration and Burst rate is roughly in agreement with distribution of fading time and ejection rate of traveling structures observed with VLBA at 43 GHz.

## Where is 3C84's black hole located?

***Georgios Filippos Paraschos***

**P42**

Max Planck Institute for Radioastronomy, Germany

In recent years, theoretical models trying to explain jet launching mechanisms in AGN have substantially progressed. Their predictions for jet-shape (width), spectral index, and polarization at the jet base are of particular interest. Magnetic fields anchored in the rotating black hole (Blandford-Znajek) and/or in the accretion disk (Blandford-Payne) are the two most widely accepted scenarios for relativistic jet launching. In these models the magnetic field and jet geometry differ substantially. The radio galaxy 3C84 displays a unique blend of brightness, large black hole mass and proximity. Its jet exhibits intermittent activity and subluminal motion, offering a distinctive opportunity to study the inner jet and core region. The GMVA's unprecedented resolution at 3mm, down to a few hundred Rs, enables us to precisely pinpoint this jet's collimation profile and investigate the kinematics in the close vicinity of the VLBI core. The true location of the black fole influences the possible launching scenarios heavily, elevating or rejecting competing models, and thus substantially furthering our knowledge of jet launching. In this talk, I will present the different jet launching scenarios for 3C84 and make a case as to where its black hole is truly located by employing 2 independent methods: examining of the spectral index of the core and measuring the jet to counter-jet ratio.

## High-resolution VLA Imaging of Heavily Obscured and Luminous Quasars with Young Radio Jets at $z\ 2$

***Pallavi Patil***

P43

National Radio Astronomy Observatory, United States

I present sub-arcsecond-resolution Karl G. Jansky Very Large Array (VLA) imaging at 10 GHz of 155 ultra-luminous (log (Lbol/Lsun)   11.7-14.2) and heavily obscured quasars with redshifts $z \sim 0.4 - 3$. The sample was selected to have extremely red MIR-optical color ratios based on data from WISE along with detection of bright, unresolved radio emission from the NVSS/FIRST Survey. Our sample galaxies are believed to be in a unique evolutionary stage just after the (re)ignition of the radio AGN, while the host galaxy is still experiencing substantial starburst activity. VLA observations have revealed that the majority of sample sources are compact on angular scales < 0.2" ( 1.7 kpc at $z \sim 2$). I also present broadband radio spectra of the entire sample constructed from our 10 GHz VLA observations and archival radio data. About half of our sample exhibits peaked or curved spectral shapes consistent with those typically seen in young radio AGN (e.g., Gigahertz Peaked Spectrum and Compact Steep Spectrum sources). The application of a simple adiabatic lobe expansion model is consistent with the radio jets that are relatively young (< 0.01-10 Myr) and propagating into a dense ambient medium. The presence of a dense ISM is further supported by the direct detection of large molecular gas reservoirs in a pilot ALMA follow-up study. Overall, our sample is consistent with a population of recently triggered, young radio jets caught in a unique evolutionary stage in which they reside in a dense ISM. Finally, I discuss the implications of our study for understanding the impact of young jets on the ISM and star formation rates in powerful young AGN. I also discuss the importance and role of upcoming facilities such as ngVLA/ngLOBO and SKA in constraining the life cycles of young radio AGN at high redshift.

## The optical polarization of PKS 2155-304 during an optical flare in 2010

***Nikki Peceur***

P44

University of Cape Town, South Africa

An analysis of the optical polarimetric and multi-color photometric (BVRJ) behaviour of the blazar PKS 2155-304 during an outburst in 2010 is presented. The flare develops over roughly 117 days and is associated with a flux doubling time of 11 days, which increases from blue to red wavelengths. The polarization angle is initially aligned with the jet axis but rotates by roughly 90 degrees as the flare grows. Two distinct states are evident at low and high fluxes. Below 18 mJy, the polarization angle takes on a wide range of values, without any clear relation to the flux. In contrast, there is a positive correlation between the polarization angle and flux above 18 mJy, with a correlation coefficient r = 0.84. The polarization degree does not display a clear correlation with the flux. We find that the photopolarimetric behaviour for the high flux state can be attributed to a variable component with a steady power-law spectral energy distribution and high optical polarization degree (13.3 per cent). These properties are interpreted within the shock-in-jet model, which shows that the observed variability can be explained by a shock that is seen nearly edge-on. Some parameters derived for the relativistic jet within the shock-in-jet model are the magnetic field strength, Doppler factor and viewing angle of the jet.

## A high-resolution study of NGC 315

P45

***Luca Ricci***

Max Planck Institute for Radio Astronomy, Germany

Nearby radio galaxies are ideal targets for investigating the physical phenomena regulating the formation and evolution of relativistic jets. These fundamental processes are expected to occur very close to the central supermassive black hole, on scales that can be only resolved through very-long-baseline interferometry (VLBI) observations. In this framework, we present our study of the nearby (z = 0.0165), giant radio galaxy NGC 315 by means of multi-frequency and multi-epoch VLBI observations. We constrained the acceleration and the collimation of the jet to be co-spatial and to take place on sub-parsec scales, within $\sim 10^{3\smile}10^{4}$ Schwarzschild radii (Rs) from the central engine. Beyond this region, we determine an intrinsic jet velocity of 0.9 c, comparable to the speed recovered on kpc scales by previous studies, and an intrinsic jet opening angle of $\sim 5^{\circ}$ . These results, combined with the modelling and the spectral analysis of the jet on sub- parsec/parsec scales, provide a complete overview of the physical properties of the jet base in NGC 315.

## Radio Jet Interactions in the Interstellar Medium of an Extreme Radio-loud Quasar in the first Gyr of the Universe

P46

***Sofia Rojas Ruiz***

Max Planck Institute for Radio Astronomy, Germany

High-redshift quasars can shed light on black hole formation and jet activity in the very early universe. Observational constraints on radio jet and interstellar medium feedback processes are still very limited at redshift $z > 2$. We investigate the quasar P362-15 near the end of Reionization at redshift z=5.831 (age of the universe 948 Myr). This quasar is one of the most powerful radio emitters with the first direct evidence of a kpc-scale radio jet ($\sim 1.6$ kpc) at these high redshifts. We analyze the spectral energy distribution of this quasar from millimeter and radio observations. The FIR millimeter continuum emission for radio-quiet quasars at these redshifts has usually been interpreted as cold dust and is modeled as a modified black body. However, our analysis for this radio-loud quasar shows that we cannot model the FIR data as cold dust alone. The FIR continuum observation is six times brighter than expected from dust emission, but three times dimmer than the extrapolated synchrotron radiation. I will present evidence that the radio emission from this object is affecting the observed FIR and [CII] properties in this radio-loud quasar. We are observing for the first time radio jet feedback in the host galaxy of a quasar in the first Gyr of the universe.

## Locating the gamma-ray emission zone in jetted narrow-line Seyfert-1 galaxies with Cherenkov Telescope Array simulations

***Patrizia Romano***

INAF-OAB, Italy

**P47**

Determining the location of the gamma-ray emitting region in jetted sources is one of the currently open issues that can be efficiently addressed by future observations with the Cherenkov Telescope Array (CTA). For transients/flaring events (time-scales of 1 day or shorter) CTA will be at least two orders of magnitude more sensitive with respect to Fermi-LAT in the overlapping energy range above 25 GeV, thus providing an unprecedented opportunity to investigate flaring gamma-ray emitting narrow-line Seyfert 1 galaxies (g-NLS1). We simulated the spectra of the most promising sources, SBS 0846+513, PMN J0948+0022, and PKS 1502+036, by adopting a detailed treatment of gamma-gamma absorption in the radiation fields of the BLR as a function of the location of the gamma-ray emission region with parameters inferred from observational constraints. We find that, due to the energy range extent and its sensitivity, CTA is particularly well suited to locate the gamma-ray emitting region in gamma-NLS1. In particular CTA will be able not only to distinguish whether the gamma-ray emitting region is located inside or outside the BLR, but also where inside the BLR it may be.

## A VLA and VLBI proper-motion study of extragalactic jets: connecting the parsec and kiloparsec scales

***Agniva Roychowdhury***

University of Maryland Baltimore County, United States

**P48**

Proper motions of extragalactic jets, primarily conducted with very long baseline interferometry (VLBI), have revealed that these jets have bulk relativistic velocities which can exceed 99.999% the speed of light (Lorentz factors up to 80). The parsec-scale proper motions traced by VLBI observations, however, often show a flow that is still accelerating on these scales. The measurement of the full velocity profile of jets from pc to kpc scales has only been done for a handful of jets, owing to the difficulty of obtaining decades-long time baselines for comparison on the larger (kpc) scales. The Very Large Array (VLA) has now been in operation for over 40 years, and the NRAO hosts a very rich archive of observations of extragalactic jets. I will present a new effort to mine the VLA archives to measure the proper motions of jet plasma on kilo-parsec scales, where I have analyzed archival VLA observations of radio galaxy 3C78 for proper motions where we detect for the first time proper motions for multiple knots with speeds of 0.1-0.4c. Although subluminal, we find that the maximum kpc velocity (most suggestive of underlying bulk speed) is 3 times higher than the maximum VLBI speed, in keeping with observations of M87 and 3C 264 which have showed that the fastest bulk speeds in these FR I jets are reached on the > 100 parsec scale. I will conclude with a discussion of the prospects for radio and sub-mm wavelength proper-motion studies of jets and the large catalog we intend to build using new and archival data.

## Black hole spin, accretion and feedback in hydrodynamical simulations

***Luca Sala*** **P49**

University Observatory Munich (USM/LMU), Germany

Active galactic nuclei (AGNs) are massive black holes (BHs) caught in the act of accreting gas at the centre of their host galaxies. In this process, a great amount of energy is released into the surrounding medium, in a process loosely referred to as AGN feedback. I will present my work which focuses on the design and implementation of sub-grid models for accretion and feedback, to be applied in cosmological hydrodynamical simulations. Regarding the treatment of accretion, my work aims at adding an intermediate step in the mass transfer from the resolved scales of the simulation onto the BH, through the inclusion of a sub-grid accretion disc, then self-consistently evolve its properties as well as the BH spins. This allows to obtain a population of BHs with their associated spins and track their evolution across cosmic time. Moreover, to include the effect of feedback, energy or momentum (or both) can be coupled to the nearby gas. While isotropic injection of purely thermal energy has been a common way of including a feedback mechanism, I will present results of simulations that assume a momentum-driven non-isotropic feedback model, then introduce an energy injection approach aimed at reproducing the result of the interaction of jets from AGNs with the surrounding medium, as we observe in features like radio lobes.

## One decade of multiwavelength variability of the blazar PKS 2155-304

***David Sanchez*** **P50**

France

The variability of BL Lac objects is an important tool to probe the mechanism at play in the jet and the link between the jet and the accretion disk. We have studied the multiwavelength variability of PKS 2155-304 (z=0.116) with almost 10 years of optical, X-ray and gamma-rays data. The variability as a function of the energy presents a double bump behaviour. In optical and X-ray, the flux time-series follow a log-normal process. An intriguing hint for a periodicity of about approximately 700 days is found in the optical and in the high energy (100 MeV < E < 300 GeV) range. To explain these observational findings, a time-dependent, synchrotron self-Compton model is used which reproduces the energy-dependent variability and provide an explanation as to why the periodicity cannot be detected in X-ray and above 100 GeV.

## MeerKAT follow-up of enigmatic G4Jy sources

***Precious Sejake*** **P51**

Rhodes University, South Africa

An active galactic nucleus (AGN) is a compact luminous region at the centre of a galaxy. The energy source in an AGN is powered by accretion onto a supermassive black hole, producing radio jets and lobes. Observations of AGN are crucial in understanding galaxy formation and evolution. For example, radio jets impact galaxy evolution either by triggering or suppressing star formation. In this talk, I will present radio galaxies that have bizarre/complex radio morphologies in the GLEAM 4Jy Sample (White et al., 2020a, 2020b). These are the brightest radio sources in the southern sky, with flux densities above 4 Jy at 151 MHz. These sources were observed using Open Time on MeerKAT with the primary aim of identifying galaxies hosting the radio emission. MeerKAT 7-arcsec resolution images of this sample show distinctive cores, jets and lobes for some of these sources (Sejake et al., in prep). By studying radio galaxies based on their morphology, astronomers can understand the formation and evolution of galaxies and their sub-components as a function of radio luminosity, environment, stellar mass and star formation rate over cosmic time.

## Optical polarization vector IDV in BL Lac objects - a key to the jet structure

***Elena Shablovinskaya*** **P52**

Special Astrophysical Observatory, RAS, Russia

Recently, the interest in the study of the intraday variability (IDV) of BL Lac type objects is increasing due to the growing challenges providing by the variety of theoretical models. Our investigation of the blazars behaviour started with the optical observations of one of the most intensively studied blazar S5 0716+714. Here we present the results of 9-hour high- precision polarimetric monitoring of S5 0716+714 with a 70-sec resolution carried out using the 6-m telescope BTA of the Special Astrophysical Observatory, RAS. An analysis of the observations reveals variability in both the total and the polarized light on the same time scale of about 1.5 hours. The repeat observations two years after confirmed the stability of this period. Fitting the data with a geometrical model of plasma rotation in the helical magnetic field precessing in the jet with a $\sim 15$-day period revealed the linear size of the emitting region of about 10 a.u. at the <0.01 pc distance from the AGN central machine. Collecting similar polarimetric data for other highly variable objects as BL Lac, 3C 66A, etc. we show the dependency of polarization IDV on the activity phase and estimate the size of the optical jets.

## Inferring the jet parameters of Markarian 501

***Vitalii Sliusar*** P53

University of Geneva, Switzerland

Markarian 501 is a bright and close (z=0.034) HBL blazar emitting photons from radio to TeV energies. Using over five years of unbiased multi-wavelength observations from radio to TeV energies, the variability and inter-band correlations were investigated to characterize morphological and temporal properties of the corresponding emission regions. The delay between X-ray and TeV light curves was found to be compatible with a zero-day lag (<0.4 days). Such a delay indicates that the emission process is consistent with a leptonic scenario, where TeV photons are produced through the inverse Compton mechanism. The identification of individual flares in X-rays and TeV energies allowed the inter-flare delays to be studied. Such characteristic time intervals (around 20 days) between the flares hint that Lense-Thirring precession of the accretion disk may be driving the variability in X-rays and TeV energies. A simple fast-rise-slow-decay profile was used to reproduce the radio light curve from the GeV one. The rise time appears to be quite short and is comparable with the GeV light curve binning, while the decay time reaches about 120 days. The profile also shows a 217-days delay between the GeV and radio band and can be explained by the change of the environment properties downstream the jet, so that the medium becomes first transparent to gamma rays and later to the radio photons.

## Are jets of FR0 radio galaxies able to excavate cavities in the ICM? New insights from a Chandra observation of A795.

***Francesco Ubertosi*** P54

University of Bologna (DIFA/INAF), Italy

The recently discovered FR0 compact radio galaxies are five times more numerous than FRIs in the local Universe, but in contrast to well-studied extended AGNs their properties are largely unexplored. It has been suggested that their lack of extended radio emission derives either from an intrinsic jet weakness, or from an hostile environment limiting the growth of the radio galaxy. To investigate whether the intracluster medium could represent a source of frustration for FR0s living in galaxy clusters, we performed a detailed study of A795, a weakly cool core cluster hosting a central FR0. Using archival Chandra data we found a dynamically disturbed environment with evidence for ICM sloshing. We argue that the environment cannot explain the compactness of the FR0 radio galaxy, as similar conditions are also found around extended FRIs, thus the jet propagation is likely hampered by an intrinsic weakness. An unexpected discovery was the identification of a pair of X-ray cavities in the proximity of the FR0: these could have been created in a past outburst, and dragged away from the AGN by the large scale turbulence. This result could open a new window on the study of recurrency, jet power and evolution of this new class of compact AGNs, whose jets are not known to possess the mechanical power required to excavate cavities.

## Spectropolarimetry observations of flaring blazars as part of the Southern African Large Telescope AGN Transient programme

***Brian van Soelen***

P55

University of the Free State, South Africa

Active Galactic Nuclei, which are powered by the accretion of material onto a supermassive black hole, show non-thermal emission over a wide wavelength range and can power relativistic jets. For blazar sources, the line of sight is closely aligned with the direction of the jet propagation and the emission is greatly enhanced by Doppler boosting. Blazars can be sub-divided into BL Lac and Flat Spectrum Radio Quasars (FSRQs) where the FSRQs show a stronger thermal component in their optical spectrum. Blazars show variability over all time scales, and include periods of rapid flaring events. At lower energies, this is attributed to synchrotron emission originating from the jet, however, at optical wavelengths the emission is a superposition of the non-thermal jet contribution and the thermal contribution from the accretion disc, broad line region and galaxy. These components are difficult to disentangle but polarization provides a method to separate the unpolarized thermal from the polarized non-thermal contributions. To this end we have been undertaking spectropolarimetry observations of flaring blazars using the Southern African Large Telescope (SALT) since 2016. These observations have been undertaken during multi-wavelength flares to trace the evolution of the polarization, and are being coupled with multi-wavelength observations taken during these periods. Here we report on the overall SALT observing programme and results.

## How to Estimate the Ambient Medium Density Around Distant Radio Sources from Their Observed Radio Spectra

***Anna Wojtowicz***

P56

Jagiellonian University, Poland

Here we present our analysis of a dataset, consisting of the physical parameters derived from an extensive modeling of the largest currently available sample of FRII radio sources, for which good-quality multi-wavelength radio flux measurements could be collected. In the analyzed dataset, we notice a significant and non-obvious correlation between the spectral index of the non-thermal radio emission continuum, and density of the ambient medium. We propose that the discovered correlation could be used as a cosmological tool to estimate the density of ambient medium for large samples of distant FRII radio galaxies. Our method does not require any detailed modeling of individual sources, and relies on limited observational information, namely the slope of the radio continuum between the emitted frequencies 0.4GHz and 5GHz, possibly combined with the total linear size of the radio structure.

## A New Chapter in Hard X-rays of the M87 AGN

***Ka-Wah Wong***

P57

SUNY Brockport, USA

The nearby M87 hosts an exceptional relativistic jet. It has been regularly monitored in radio to TeV bands, but little has been done in hard X-rays above 10 keV. We have successfully detected hard X-rays up to 40 keV from its X-ray core with joint Chandra and NuSTAR observations, providing important insights to the X-ray origins. We argue that the hard X-ray emission mostly comes from the unresolved jet rather than the accretion flow. We found that the hard X-ray emission is significantly lower than that predicted by synchrotron self-Compton models introduced to explain the very-high-energy gamma-ray emission above a GeV. We report updates of our hard X-ray study and discuss recent models to understand these high energy emission processes.

## A relativistic shock scenario for extreme-TeV blazars.

***Andreas Zech***

P58

Observatoire de Paris, France

The multi-wavelength emission from extreme-TeV blazars is difficult to interpret with standard emission models. Large values of the minimum electron Lorentz factor and unusually low values of the magnetization seem required. We propose a scenario where protons and electrons are co-accelerated on internal or recollimation shocks inside the relativistic jet. In this situation, energy transfer from the protons to the electrons leads naturally to a high minimum Lorentz factor for the latter, while low magnetization is a necessary condition for particle acceleration. The shock co-acceleration scenario provides additional constraints on the set of parameters of a standard one-zone lepto- hadronic emission model, thus reducing its degeneracy. Values of the magnetic field strength of a few mG and minimum electron Lorentz factors of $10^3$ to $10^4$, required to provide a satisfactory description of the observed spectral energy distributions, result here from first principles. While acceleration on a single shock is sufficient to reproduce the emission of most of the handful of extreme-TeV sources we have examined, re-acceleration on a second shock appears needed for those objects with the hardest gamma-ray spectra, 1ES 0229+200 and 1ES 1101-232. With this new approach, satisfactory self-consistent representations were found for the most prominent representatives of this new blazar class.

## Generation of Internal Waves by Buoyant Bubbles in Galaxy Clusters and Heating of Intracluster Medium

***Congyao Zhang***

P59

The University of Chicago, United States

In the inner region of clusters, X-ray bubbles are inflated by powerful jets and rise buoyantly outwards. They are thought to play an important role in heating the intracluster medium (ICM). However, a big numerical challenge limits our understanding of the bubble dynamics – the bubbles are hard to maintain their integrity in the hydrodynamical simulations. For this reason, the internal gravity waves driven by the buoyant bubbles are always ignored in the previous studies. In this talk, I will show that these waves could be efficiently excited in the ICM and provide an attractive way to transfer the energy from the bubble to the cluster atmosphere. In our numerical simulations, we model the bubbles phenomenologically as rigid bodies buoyantly rising in the stratified cluster atmosphere. We find that the terminal velocities of the flattened bubbles are small enough so that the Froude number Fr<1. Clear signs of internal waves are seen in the simulations. These waves propagate horizontally and downwards from the rising bubble, spreading their energy over large volumes of the ICM. If our findings are scaled to the conditions of the Perseus cluster, the expected terminal velocity is 100-200 km/s near the cluster cores, which is in broad agreement with direct measurements by the Hitomi satellite.

## Linear polarization variability study of parsec-scale jets at 2 cm

***Daria Zobnina***

P60

Lebedev Physical Institute, Russia

Multi-epoch VLBI polarimetric data is a powerful tool to study both spatial and time variations of fractional polarization, electric vector position angle (EVPA) and, hence the magnetic field of the parsec-scale AGN jet. We made use of 15 GHz data provided by the MOJAVE VLBA survey (Monitoring of Jets in AGN with VLBA Experiments). Within this project, radio brightness and polarization of several hundreds of AGN jets have been monitored since 1996. We made a sample comprising more than 400 sources having at least 5 observing epochs. Multi-epoch polarization and total intensity epoch-averaged (the so-called stacked) maps for each object were constructed. In comparison to single-epoch images, the stacked maps are more sensitive and better reveal the jet cross-section. Having a number of epochs for each source, we derived a spatial distribution of EVPA variability that shows substantially larger values in the core region compared to those in the outer outflow. Moving down the jet along its ridge line in total intensity, we found that EVPA variability is typically inversely proportional to fractional polarization. This could be explained by a jet model with the magnetic field becoming more ordered further downstream from the core.

## An association of a Fermi-LAT flaring activity with a blazar candidate behind the Large Magellanic Cloud

***Natalia $\dot{Z}$ywucka***

**P61**

Centre of Space Research, North-West University, Potchefstroom, South Africa

An association of a Fermi-LAT flaring activity with a blazar candidate behind the Large Magellanic Cloud" We present the results of a preliminary investigation of a potential association of a blazar candidate behind the Large Magellanic Cloud (LMC) and a gamma-ray transient object. The hint of flaring activity appeared at the position (RA,dec)$\sim$(86.60 deg,-69.02 deg), while the J0545-6846 blazar candidate is located at (RA,dec)=(86.47 deg,-68.77 deg). J0545-6846 is characterised by a particularly large radio flux of 176.3 mJy at 843 MHz, a high value of the radio-loudness parameter R=6900, and an integrated gamma-ray flux >1 GeV of $\sim 9.6 \times 10^{-12} erg\, cm^{-2} s^{-1}$. We have analysed the Fermi-Large Area Telescope (LAT) data from the LMC region in order to verify the flaring activity detected in July/August 2008 and later in April 2015 in MeV and GeV energies, using the latest Fermi-LAT point source catalogue. The performed unbinned maximum likelihood analysis took into account the positions of all known point-like sources, diffuse emission as well as the advanced gas modelling from the investigated region. Our preliminary analyses indicate positional consistency between J0545-6846 and the flaring activity in both periods. This suggests that the observed transient activities are related to the same blazar.

## TXS 0128+554: A Young Gamma-Ray Emitting AGN With Episodic Jet Activity

***Matthew Lister***

**P62**

Purdue University, United States

We have carried out a Chandra X-ray and multifrequency radio Very Long Baseline Array study of TXS 0128+554, which is associated with the Fermi 947;-ray source 4FGL J0131.2+5547. The AGN is unresolved in a target 19.3 ks Chandra image, and its spectrum is well fit by a simple absorbed power-law model, with no distinguishable spectral features. Its relatively soft X-ray spectrum compared to other compact symmetric objects may be indicative of a thermal emission component, for which we were able to obtain an upper temperature limit of kT = 0.08 keV. The compact radio morphology and measured advance speed of 0.32 c ± 0.07 c indicate a kinematic age of only 82 yr ± 17 yr, placing TXS 0128+554 among the youngest members of the CSO class. The lack of compact, inverted spectrum hotspots and an emission gap between the bright inner jet and outer radio lobe structure indicate that the jets have undergone episodic activity, and were relaunched a decade ago. The predicted 947;-ray emission from the lobes, based on an inverse Compton-emitting cocoon model, is three orders of magnitude below the observed Fermi-LAT flux. A comparison to other Fermi-detected and non-Fermi-detected CSOs with redshift z < 0.1 indicates that the 947;-ray emission likely originates in the inner jet/core region, and that nearby, recently launched AGN jets are primary candidates for detection by the Fermi-LAT instrument.

## Gamma-ray emission from young radio galaxies and quasars

***Giacomo Principe***

**P63**

INFN / University of Trieste, Italy

According to radiative models, radio galaxies are predicted to produce gamma rays from the earliest stages of their evolution onwards. The study of the high-energy emission from young radio sources is crucial for providing information on the most energetic processes associated with these sources, the actual region responsible for this emission, as well as the structure of the newly born radio jets. Despite systematic searches for young radio sources at gamma-ray energies, only a handful of detections have been reported so far. Taking advantage of more than 11 years of Fermi-LAT data, we investigate the gamma-ray emission of 162 young radio sources (103 galaxies and 59 quasars), the largest sample of young radio sources used so far for a gamma-ray study. We analyse the Fermi-LAT data of each individual source separately to search for a significant detection. In addition, we perform the first stacking analysis of this class of sources in order to investigate the gamma-ray emission of the young radio sources that are undetected at high energies. We report the detection of significant gamma-ray emission from 11 young radio sources, including the discovery of significant gamma-ray emission from the compact radio galaxy PKS 1007+142. Although the stacking analysis of below-threshold young radio sources does not result in a significant detection, it provides stringent upper limits to constrain the gamma-ray emission from these objects. In this talk we present the results of our study and we discuss their implications for the predictions of gamma-ray emission from this class of sources.

# List of Participants

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|---|---|
| Sriyasriti Acharya | Indian Institue of Technology Indore, India |
| Ivan Agudo | IAA-CSIC, Spain |
| Emmanouil Angelakis | University of Athens, Greece |
| Tigran Arshakian | Byurakan Astrophysical Observatory, Armenia |
| Keiichi Asada | Academia Sinica, Taiwan |
| Uwe Bach | Max-Planck-Institut fuer Radioastronomie , Germany |
| Anne-Kathrin Baczko | Max-Planck-Institut fuer Radioastronomie, Germany |
| Ranieri Baldi | INAF- Institute of Radio Astronomy, Italy |
| Bidisha Bandyopadhyay | Universidad de Concepcion, Chile |
| Bonny Barkus | Open University,United Kingdom |
| Thomas Berlok | Leibniz Institute for Astrophysics (AIP), Germany |
| Bia Boccardi | Max Planck Institute for Radio Astronomy, Bonn, Germany |
| Nikhil S. Borse | Purdue University, USA |
| Styliani Boula | NKUA, Greece |
| Markus Böttcher | Centre for Space Research, South Africa |
| Catherine Boisson | LUTH, Observatoire de Paris, France |
| Niel Brandt | Penn State University, USA |
| Marisa Brienza | University of Bologna - IRA,INAF, Italy |
| Aryeh Brill | Columbia University, USA |
| Sara Buson | University of Wuerzburg, Germany |
| Marina Butuzova | Crimean Astrophysical Observatory, Russia |
| Carlos Carrasco-Gonzalez | IRyA-UNAM, Mexico |
| Carolina Casadio | Institute of Astrophysics - FORTH, Greece |
| Arthur Charlet | CRAL ENS de Lyon / LUPM, France |
| Koushik Chatterjee | Harvard University, USA |
| Liang Chen | Shanghai Astronomical Observatory, CAS, China |
| Judith Croston | Open University, United Kingdom |
| Ruth Daly | Pennsylvania State University, USA |
| Pushpita Das | University of Amsterdam The, Netherlands |
| Ranadeep Ghosh Dastidar | Purdue University, United States |
| Elisabete de Gouveia Dal Pino | IAG-USP, Universidade de São Paulo, Brazil |
| Abhishek Desai | University of Wisconsin Madison (WIPAC), USA |
| Jason Dexter | University of Colorado, USA |
| Indu Kalpa Dihingia | IIT Indore, India |
| Rune Michael Dominik | TU Dortmund University, Germany |
| Daniela Dorner | Universität Würzburg, Germany |
| Ravi Pratap Dubey | Indian Institute of Technology Indore, India |
| Kristian Ehlert | Leibniz-Institut für Astrophysik (AIP), Germany |
| Manel Errando | Washington University in St Louis, USA |
| Christian Fendt | Max Planck Institute for Astronomy, Germany |
| Gaëtan Fichet de Clairfontaine | LUTH - Observatoire de Paris, France |
| Justin Finke | Naval Research Laboratory, USA |

| | |
|---|---|
| Lucy Fortson | University of Minnesota, USA |
| Christian Fromm | University of Frankfurt, Germany |
| Leonardo Enrique | García IA-UNAM, Mexico |
| Dimitrios Giannios | Purdue, USA |
| Gabriele Giovannini | IRA/INAF & Bologna University, Italy |
| Aishwaryz Girdhar | ESO, Garching, Germany |
| Gourab Giri | IIT Indore, India |
| Dorit Glawion | ECAP, FAU Erlangen-Nürnberg, Germany |
| Forrest Glines | Michigan State University, US |
| Mark Gorbachev | Kazan Federal University, Russia |
| Pranjupriya Goswami | Tezpur University, India |
| Arti Goyal | Jagiellonian University, Poland |
| Philippe Grandeclement | OBSPM, France |
| Paola Grandi | INAF-OAS, Italy |
| Kazuhiro Hada | Mizusawa VLBI Observatory, NAOJ , Japan |
| Sebastian Heinz | University of Wisconsin Madison (WIPAC) |
| Olivier Hervet | UC Santa Cruz, USA |
| Talvikki Hovatta | University of Turku, Finland |
| Gabriele Ilha | Universidade Federal de Santa Maria, Brazil |
| Thomas Jannaud | Institut de Planétologie et d'Astrophysique de Grenoble |
| Ilja Jaroschewski | Ruhr-University Bochum, TP IV, Germany |
| Thomas Jones | University of Minnesota, USA |
| Jenni Jormanainen | Finnish Centre for Astronomy with ESO, Finland |
| Matthias Kadler | JMU Würzburg, Germany |
| Anna D. Kapinska | NRAO, USA |
| Rony Keppens | CmPA, KU Leuven, Belgium |
| Stefania Kerasioti | University of Athens (NKUA), Greece |
| Preeti Kharb | Tata Institute of Fundamental Research, India |
| Rubinur Khatun | NCRA-TIFR, India |
| Sebastian Kiehlmann | FORTH Institute of Astrophysics, Greece |
| Yuri Kovalev | Lebedev Physical Institute Russia |
| Joana Kramer | Max Planck Institute for Radio Astronomy, Germany |
| Evgeniya Kravchenko | MIPT, Russia |
| Dominika Król | Jagiellonian University, Poland |
| Daniel Kulik | University of the Free State, South Africa |
| Sayan Kundu | Indian Institute of Technology Indore, India |
| Robert Laing | SKA, United Kingdom |
| Ting-Wen Lan | UCSC, USA |
| Hui Li | Los Alamos National Laboratory, USA |
| Elina Lindfors | FINCA, University of Turku, Finland |
| Lena Linhoff | TU Dortmund, Germany |
| Ioannis Liodakis | Finnish center for Astronomy with ESO, Finland |
| Matthew Lister | Purdue University, United States |
| Ying-He Celeste Lu | University of Cambridge, United Kingdom |
| Duccio Macconi | INAF/OAS Bologna - University of Bologna, Italy |
| Nicholas MacDonald | Max Planck Institute for Radio Astronomy, Germany |
| Greg Madjeski | Stanford, USA |

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| Karl Mannheim | University of Wuerzburg |
| Eftychia Madika | Max-Planck-Institut für Radioastronomie, Germany |
| Nikos Mandarakas | University of Crete, Physics Department, Greece |
| James Matthews | IoA, University of Cambridge, UK |
| Giancarlo Mattia | Max Planck Institute for Astronomy, Germany |
| Kalyani Chaitnya Kumar Mehta | Tuebingen University, Germany |
| Eileen Meyer | University of Maryland Baltimore County, USA |
| Manuel Meyer | Erlangen Center for Astoparticle Physics, Germany |
| Davide Miceli | University of Udine & INFN Trieste, Italy |
| Giulia Migliori | INAF-IRA, Italy |
| Andrea Mignone | University of Torino |
| Arpita Misra | Jagiellonian University, Poland |
| Yosuke Mizuno | TDLI / Shanghai Jiao Tong University, China |
| Raffaella Morganti | Kapteyn Institute, Groningen, Netherlands |
| Dipanjan Mukherjee | IUCAA, India |
| Gibwa Musoke | University of Amsterdam, Netherlands |
| Ioannis Myserlis | Instituto de Radioastronomía Milimétrica, Spain |
| Cristina Nanci | INAF, Italy |
| Cosimo Nigro | IFAE, Spain |
| Elena Nokhrina | MIPT, Russia |
| Chris Nolting | College of Charleston, USA |
| Kristina Nyland | NRC fellow, resident at NRL, USA |
| Takumi Ohmura | The University of Tokyo, Japan |
| G. Andre Oliva | University of Tuebingen, Germany |
| José Ortuño-Macías | Nicolaus Copernicus Astronomical Center, Poland |
| Jorge Otero-Santos | Instituto de Astrofisica de Canarias, Spain |
| Luigi Pacciani | INAF-IAPS, Italy |
| Georgios Filippos Paraschos | Max Planck Institute for Radioastronomy, Germany |
| Alice Pasetto | IRyA-UNAM, Mexico |
| Sonal Ramesh Patel | Deutsches Elektronen-Synchrotron (DESY), Germany |
| Pallavi Patil | National Radio Astronomy Observatory, USA |
| Nikki Peceur | University of Cape Town, South Africa |
| Manel Perucho | Universitat de València, Spain |
| Maria Petropoulou | National & Kapodistrian University of Athens, Greece |
| Christoph Pfrommer | Leibniz Institut für Astrophysik Potsdam, Germany |
| Alexander Plavin | Lebedev Physical Institute, Russia |
| Markos Polkas | University of Athens, Greece |
| Oliver Porth | Anton Pannekoek Institute of Astronomy, Netherlands |
| Giacomo Principe | INFN / University of Trieste, Italy |
| Alexander Pushkarev | Crimean Astrophysical Observatory, Russia |
| Eleonora Puzzoni | Physics Department University of Turin, Italy |
| Venkatessh Ramakrishnan | University of Concepcion, Chile |
| Luca Ricci | Max Planck Institute for Radio Astronomy, Germany |
| Frank Rieger | Max Planck Institut fur Kernphysik, Germany |
| Bart Ripperda | Flatiron Institute, US |
| Sofia Rojas Ruiz | Max Planck Institute for Astronomy, Germany |
| Patrizia Romano | INAF-OAB, Italy |
| Agniva Roychowdhury | University of Maryland Baltimore County, USA |

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|---|---|
| Lawrence Rudnick | University of Minnesota, USA |
| Luca Sala | University Observatory Munich (USM/LMU), Germany |
| David Sanchez | France |
| Dominik Schleicher | Universidad de Concepcion, Chile |
| Bernd Schleicher | University of Wuerzburg, Germany |
| Precious Sejake | Rhodes University, South Africa |
| Sebastiaan Selvi | Anton Pannekoek Institute for Astronomy, Netherlands |
| Nick Seymour | ICRAR/Curtin University, Australia |
| Elena Shablovinskaya | Special Astrophysical Observatory, RAS, Russia |
| Mayur Shende | IISER Pune, India |
| Amit Shukla | Indian Institute of Technology - Indore, India |
| Stefano Silvestri | University of Pisa, Italy |
| Charalampos Sinnis | National Kapodistrian University Athens, Greece |
| Vitalii Sliusar | University of Geneva, Switzerland |
| Emanuele Sobacchi | Columbia University, USA |
| Francisco Suzuki-Vidal | Imperial College, United Kingdom |
| Rosemary Talbot | IoA, University of Cambridge, United Kingdom |
| Alexander Tchekovskoy | Northwestern University, USA |
| Eleonora Torresi | INAF-OAS Bologna, Italy |
| Francesco Ubertosi | University of Bologna (DIFA/INAF), Italy |
| Yuji Urata | IANCU, Taiwan |
| Bhargav Vaidya | IIT Indore, India |
| Izak van der Westhuizen | University of the Free State, South Africa |
| Brian van Soelen | University of the Free State, South Africa |
| Giacomo Venturi | Pontificia Universidad Católica de Chile, Chile |
| Stefano Vercellone | Italy |
| Sara Wagner | University of Wuerzburg, Germany |
| Rainer Weinberger | CfA, Harvard & Smithsonian, USA |
| Christoph Wendel | JMU Würzburg, Germany |
| Sarah White | SARAO/Rhodes University, South Africa |
| Anna Wojtowicz | Jagiellonian University, Poland |
| Ka-Wah Wong | SUNY Brockport, USA |
| Michael Zacharias | LUTH, Observatoire de Paris, France |
| Andreas Zech | LUTH, Observatoire de Paris, France |
| Congyao Zhang | The University of Chicago, USA |
| Shifu Zhu | Penn State Department of A&A, USA |
| Irina Zhuravleva | University of Chicago, USA |
| Daria Zobnina | Lebedev Physical Institute, Russia |
| Natalia Zywucka-Hejzner | Centre for Space Research, South Africa |