

1. Meeting Identification Number: Focus Meeting 1
2. Meeting Title: Physics of relativistic jets on all scales
3. Coordinating Division: D
4. Dedication of meeting (if any):
5. Location (city, country): Busan, Republic of Korea
6. Dates of meeting: 4 and 9 August 2022
7. Number of participants: 72 (who submitted abstracts)
8. Total Amount of IAU Grant funds received (in euros):
9. Number of IAU Grant recipients: 15
10. List of represented countries: 23 (first authors)
11. Anticipated number of separate papers in the proceedings:
12. Report submitted by: B. W. Sohn, G. Giovannini, M. Orienti
13. Date and place: 17/10/2022
14. Signature of SOC Chairperson: B.W. Sohn, G. Giovannini, M. Orienti

## FM1: Final scientific programme

Day 1, August 4

<b>9:45 – 10:30</b>	<b>Morning e-Poster Session</b>	
<b>10:30 – 12:05</b>	<b>Morning Oral Session</b>	<b>Chair: Bong Won Sohn</b>
10:30 – 10:50	Kazuhiro Hada [Invited][Remote]	Event Horizon Telescope Observations of M87
10:50 – 11:10	Elisabete de Gouvêa dal Pino [Invited][Remote]	Magnetic Reconnection and Particle Acceleration in Relativistic Jets
11:10-11:25	Jae-Young Kim	Space-VLBI view of the heart of M87 by Radioastron at 22 GHz
11:25 – 11:40	Guang-Yao Zhao	Unravelling the Innermost Jet Structure of OJ287 with GMVA+ALMA observations
11:40 – 11:55	Ije Cho	The Intrinsic Structure of Sagittarius A* at 1.3cm and 7mm
<b>11:55 – 13:30</b>	<b>Lunch</b>	
<b>13:30 – 14:40</b>	<b>Afternoon Oral Session 1</b>	<b>Chair: Gabriele Giovannini</b>
13:30 – 13:50	Jongho Park [Invited]	Collimation and Acceleration of AGN Jets
13:50 – 14:05	Giancarlo Mattia	Jets from Accretion disk dynamos: a consistent model for dynamo and resistivity
14:05 – 14:25	Andrew Chael [Invited]	Supermassive black holes and relativistic jets: Insights from simulations and Event Horizon Telescope observations

14:25 – 14:40 José Luis Gómez The filamentary structure of 3C279 probed by Radioastron

**14:40 – 15:15 Break**

**15:15 – 16:50 Afternoon Oral Session 2 Chair: José Luis Gómez**

15:15 – 15:30 Philip Edwards The parsec-scale properties of TeV blazars

15:30 – 15:45 Markus Boettcher A shock-in-jet synchrotron mirror model

15:45 – 16:05 Z. Lucas Uhm [Invited] Physics of Relativistic Jets in Gamma-ray Bursts in the Era of Multi-messenger Astrophysics

16:05 – 16:20 James Leung Unveiling gamma-ray burst jet properties with radio observations

16:20 – 16:35 Florian Eppel First Results of the TELAMON AGN Monitoring Program in the Light of the Doppler Crisis and Neutrino emission

16:35 – 16:50 Gaëtan Fichet de Clairfontaine Characteristic multi-wavelength emission signatures from strong shock-shock interactions in perturbed relativistic jets

**16:50 – 17:30 Afternoon e-Poster Session**

**Day 2, August 9**

**09:45 – 10:30 Morning e-Poster Session**

**10:30 – 12:05 Morning Oral Session Chair: Markus Boettcher**

10:30 – 10:50 Susumu Inoue [Invited][Remote] Gamma-ray bursts and their outflows: physics and implication

		of very high energy emission
10:50 – 11:05	Bestin James	Modeling the GRB jet properties with 3D general relativistic simulations of magnetically arrested accretion flows
11:05 – 11:20	David Russell	Universal magnetic field properties in relativistic jets from accreting objects
11:20 – 11:35	Mark Birkinshaw	PKS 2152-699: jet coherence after strong jet-cloud interactions
11:35 – 11:50	Kohei Ichikawa [Remote]	Rapidly growing supermassive black holes in extremely radio-loud galaxies
11:50 – 12:05	Shifu Zhu [Remote]	The origin of X-ray emission from most radio-loud quasars
<b>12:05 – 13:30</b>	<b>Lunch</b>	
<b>13:30 – 14:55</b>	<b>Afternoon Oral Session 1</b>	<b>Chair: Diana Worrall</b>
13:30 – 13:50	Dipanjan Mukherjee [Invited][Remote]	Simulating young evolving relativistic jets from supermassive black holes
13:50 – 14:05	Filippo Maccagni	Jets and ISM interplay from the nucleus to the outskirts: the two cases of Centaurus A and Fornax A
14:05 – 14:20	Motoki Kino [Remote]	Witnessing the moments of jet-cloud collision in the young radio galaxy 3C84
14:20 – 14:40	Francoise Combes [Invited][Remote]	Jet-ISM interaction: observations
<b>14:40 – 15:15</b>	<b>Break</b>	

<b>15:15 – 16:50</b>	<b>Afternoon Oral Session 2</b>	<b>Chair: Jae-Young Kim</b>
15:15 – 15:35	Andrew Fabian [Invited][Remote]	Jet-ICM interaction
15:35 – 15:55	Filippo D’Ammando [Invited][Remote]	Unveiling the physics of relativistic jets with LSST and CTA
15:55 – 16:15	Maria Rioja [Invited][Remote]	New opportunities with Next-Generation Instruments: SKA and Millimetron
16:15 – 16:30	Ulisses Barres de Almeida	Potential for Very High Energy gamma-ray transient monitoring with SWGO
<b>16:30 – 16:50</b>	<b>Gabriele Giovannini</b>	<b>Concluding Remarks</b>
<b>16:50 – 17:30</b>	<b>Afternoon e-Poster Session</b>	

## **FM1: List of Invited Speakers**

Andrew Chael  
 Andrew Fabian  
 Dipanjan Mukherjee  
 Elisabete de Gouveia dal Pino  
 Filippo D’Ammando  
 Francoise Combes  
 Gabriele Giovannini  
 Jongho Park  
 Kazuhiro Hada  
 Maria Rioja  
 Stefan Wagner  
 Susumu Inoue  
 Z.Lucas Uhm

Gender distribution of speakers invited talks: 10 males, 6 females;

Gender distribution of speakers invited talks who accepted the invitation: 10 males (1 could not arrive on time due to COVID-19 restrictions) and 3 females;

Gender distribution of speakers contributed talks: 17 males (2 females could not come).

## **FM1: List of Session Chairs**

Bong Won Sohn  
Gabriele Giovannini  
José Luis Gómez  
Markus Boettcher  
Diana Worrall  
Jae-Young Kim

## **FM1 - Summary of the Scientific Highlights**

The meeting had a large presence of in-person attendees. It was a good occasion to (re)start a useful discussion among people involved in the study of relativistic jets. Main Scientific Highlights are:

- High quality images of SMBHs in M87 – SgrA\* - and other objects obtained with EHT.
- Instrumental progress provided important results and high quality images using EAVN, MEERKAT, RadioAstron, VLBI+ALMA among other facilities.
- M87 confirmed to be a key object. We can study the ring size, surface brightness, and connection with Doppler boosting and spin clockwise. Polarization results show that magnetic fields are dynamically important in the SMBH region. The large jet opening angle measured with RadioAstron shows the jet interaction with the surrounding medium. Important to observe the jet-disk connection.
- EHT images of SgrA\* structure at 1.3 and 0.7 cm cannot unambiguously unveil the presence of a jet.
- Other objects were discussed in detail: OJ287, one of the best candidates for hosting a SMBH binary system; NGC 315 and other FRI jet profiles allow the study of jet collimation and acceleration. Deep radio, optical, and X-ray data for PKS 2152-699 and 3C84 clearly show strong jet-cloud interactions. RadioAstron images of 3C 279 show a peculiar filamentary structure. Doppler boosting problems are present in this 3C 279 structure. TeV sources (HBL BL Lacs) usually do not show superluminal motion suggesting low component speeds, with a Doppler crisis that is still to be understood.

- 3D GRMHD simulations show the evolution of accretion disk around a Kerr black hole. The jets produced in these models are structured.

- Jets are launched from compact objects spanning more than nine orders of magnitude in mass. The magnetic field is generally tangled, with polarization levels  $< \sim 10\%$ , at small distances from the compact object where particles are being accelerated. At larger distances, the magnetic field can be highly ordered ( $>10\%$ ). Polarization structures are associated with shock compression at the outer edges of jets.

- Gamma-ray bursts (GRBs) are the most luminous sources of electromagnetic radiation in the Universe. Although widely believed to involve collimated outflows with ultra-relativistic bulk velocities, many of their basic aspects remain poorly understood. Gamma rays at *very* high energy ( $>100$  GeV) were detected for the first time from different types of GRBs, offering important new insight. The jet origin in GRBs was discussed, and two radiation mechanisms for the production of gamma rays were presented. Bulk acceleration in GRB relativistic jets is likely due to Poynting flux Energy.

## **FM1: Executive Summary**

The Focus Meeting (FM) 1 Physics of Relativistic Jets on All Scales could put together many communities working on different aspects of relativistic jets. FM 1 gathered a huge interest in the astrophysical communities around the globe which warmly responded to the call for contributions: 13 invited talks, 17 contributed talks, 21 e-Talks, and 23 e-Posters, for a total of 74 contributions.

We noticed that the environment of the pandemic acted more negatively on women in terms of participation in academic conferences.

Experts in observational, theoretical and computational astrophysics could provide the latest research findings on the physics of relativistic jets from stellar to galactic scales. The presence of both active galactic nuclei (AGN) and gamma-ray bursts (GRB) communities fostered a constructive discussion and new ideas.

The advent of multi-messenger astrophysics allowed the investigation of many aspects of the physics of jets that could not be tackled by observations in the electromagnetic spectrum alone. In this context, a few contributions dealt with neutrino emission from AGNs and gravitational waves from GRBs.

The latest results on M87 and SgrA\* obtained with the Event Horizon Telescope were discussed in several talks, showing the fundamental role played by state-of-the-art facilities in improving our knowledge of supermassive black holes and their capability to launch relativistic jets. The advent of the forthcoming facilities, from radio band to very high energies, will allow a step forward in our understanding of the physics of

relativistic jets. During the meeting there were several contributions dealing with the impact new facilities, like the Cherenkov Telescope Array, the Square Kilometer Array and the Vera C. Rubin Observatory, will have on the study of relativistic jets and related transient phenomena.

Moving to larger scales, the interplay between observations and simulations proved to play a crucial role in our understanding of the jet structure and evolution as jets propagates in the environment, first within the host galaxy and then in the intracluster medium. Several contributions dealt with the interaction between jets and the surrounding ambient medium, showing the importance of high-resolution and polarization observations as well as state-of-the-art numerical simulations.

In summary, contributions to Focus Meeting 1 reflected all these topics and fostered fruitful discussions and brandnew collaborations, which are key for understanding the physics and role of relativistic jets on all scales: from stellar-scale GRB-related jets to Megaparsec-scale AGN jets.