

IAU Symposium

375

5–9 December 2022

Kathmandu, Nepal

Proceedings of the International Astronomical Union

The Multimessenger Chakra of Blazar Jets

Edited by

Ioannis Liodakis
Margo F. Aller
Henric Krawczynski
Anne Lähteenmäki
Timothy J. Pearson

ISSN 1743-9213

International Astronomical Union



CAMBRIDGE
UNIVERSITY PRESS



THE MULTIMESSENGER CHAKRA OF BLAZAR JETS
IAU SYMPOSIUM 375

COVER ILLUSTRATION:

Artistic impression of Hindu lord Vishnu holding an accretion disk with a jet. In Hindu sculptures in Nepal and India, the accretion disk pictorially resembles lord Vishnu's Sudarshan Chakra, conceived as a deity of destruction.

IAU SYMPOSIUM PROCEEDINGS SERIES

Chief Editor

JOSÉ MIGUEL RODRIGUEZ ESPINOSA, General Secretariat

Instituto de Astrofísica de Andalucía

Glorieta de la Astronomía s/n

18008 Granada

Spain

IAU-general.secretary@iap.fr

Editor

DIANA WORRALL, Assistant General Secretary

HH Wills Physics Laboratory

University of Bristol

Tyndall Avenue

Bristol

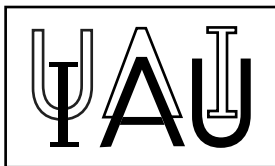
BS8 1TL

UK

IAU-assistant.general.secretary@iap.fr

INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE

International Astronomical Union



THE MULTIMESSENGER CHAKRA OF BLAZAR JETS

PROCEEDINGS OF THE 375th SYMPOSIUM OF
THE INTERNATIONAL ASTRONOMICAL UNION
KATHMANDU, NEPAL
5–9 DECEMBER, 2022

Edited by

IOANNIS LIODAKIS

Finnish Centre for Astronomy with ESO, Finland

MARGO F. ALLER

University of Michigan, USA

HENRIC KRAWCZYNSKI

Washington University St. Louis, USA

ANNE LÄHTEENMÄKI

Aalto University, Finland

and

TIMOTHY J. PEARSON

California Institute for Technology, USA



**CAMBRIDGE
UNIVERSITY PRESS**

CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
1 Liberty Plaza, Floor 20, New York, NY 10006, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© International Astronomical Union 2023

This book is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without
the written permission of the International Astronomical Union.

First published 2023

Printed in Great Britain by Henry Ling Limited, The Dorset Press, Dorchester, DT1 1HQ

Typeset in System L^AT_EX 2 ϵ

*A catalogue record for this book is available from the British Library Library of Congress
Cataloguing in Publication data*

This journal issue has been printed on FSCTM-certified paper and cover board. FSC is an
independent, non-governmental, not-for-profit organization established to promote the
responsible management of the world's forests. Please see www.fsc.org for information.

ISBN 9781009353014 hardback
ISSN 1743-9213

Table of Contents

Preface	vii
Editors	viii
List of Participants	ix
Extragalactic Jets from Radio to Gamma-rays	1
<i>E. Meyer, A. Shaik, K. Reddy and M. Georganopoulos</i>	
Multiwavelength monitoring of the nucleus in PBC J2333.9–2343: A giant radio galaxy with a Blazar-like core	9
<i>L. Hernández-García, F. Panessa, G. Bruni, L. Bassani, P. Arévalo, V. M. Patiño-Alvarez, A. Tramacere, P. Lira, P. Sánchez-Sáez, F. E. Bauer, V. Chavushyan, R. Carraro, F. Förster, A. M. Muñoz Arancibia and P. Ubertini</i>	
A <i>WISE</i> perspective of the blazar hunt in the γ -ray sky	14
<i>Francesco Massaro and Raffaele D’Abrusco</i>	
Gamma-ray flux distribution analysis on 145 gamma-ray bright blazars	18
<i>Kenji Yoshida, Foteini Oikonomou, Maria Petropoulou and Kohta Murase</i>	
Milliarcsecond Core Size Dependence of the Radio Variability of Blazars	22
<i>Po-Chih Hsu, Jun Yi Koay, Satoki Matsushita, Chorng-Yuan Hwang, Talvikki Hovatta, Sebastian Kiehlmann, Walter Max-Moerbeck, Tim Pearson, Anthony Readhead, Rodrigo Reeves and Harish Vedantham</i>	
Understanding the interplay between jets and ISM for winged radio galaxies	27
<i>Gourab Giri and Bhargav Vaidya</i>	
Exploring connections between the VLBI and optical morphology of AGNs and their host galaxies	31
<i>David Fernández Gil, Jeffrey A. Hodgson and Benjamin L’Huillier</i>	
RAD@home discovery of a one-sided radio jet hitting the companion galaxy	35
<i>Ananda Hota, Pratik Dabhade and Sravani Vaddi</i>	
RAD@home RGB-maker web-tool for citizen science research in multi-wavelength study of AGNs with radio jets	40
<i>Avinash Kumar, Ck. Avinash, Arundhati Purohit and Ananda Hota</i>	
RAD@home Inter-University Collaboratory for citizen science in galaxy evolution with multi wavelength RGB images	42
<i>Megha Rajoria, Arundhati Purohit and Ananda Hota</i>	
3D PIC Simulations for Relativistic Jets with a Toroidal Magnetic Field	44
<i>Kenichi Nishikawa, Athina Meli, Christoph Köhn, Ioana Duțan, Yosuke Mizuno, Oleh Kobzar, Nicholas MacDonald, José L. Gómez and Kouichi Hirotani</i>	

Effect of Inverse Compton Cooling on Relativistic Particles Accelerated at Shear Boundary Layers in Relativistic Jets	49
<i>Tej Chand and Markus Böttcher</i>	
Particle acceleration via magnetic reconnection in large-scale MHD jet simulations	54
<i>Matteo Nurisso, Annalisa Celotti, Andrea Mignone and Gianluigi Bodo</i>	
Radio Polarization: A Powerful Resource for Understanding the Blazar Divide	56
<i>Janhavi Baghel, P. Kharb, Silpa S., Luis C. Ho and C. M. Harrison</i>	
The Microvariability and Wavelength Dependence of Polarization Vector of BL Lacertae in the Outburst 2020 to 2021	61
<i>Ryo Imazawa, Mahito Sasada, Natsuko Hazama, Yasushi Fukazawa, Tatsuya Nakaoka, Hiroshi Akitaya, Koji S. Kawabata, Thomas Bohn and Anjasha Gangopadhyay</i>	
Intraday variations of polarization vector in blazars: a key to the optical jet structure?	66
<i>Elena Shablovinskaya, Eugene Malygin and Dmitry Oparin</i>	
Identifying γ -ray emitting blazars in the PASIPHAE era: polarimetry as a unique probe	71
<i>Nikolaos Mandarakas</i>	
Scientific Potential of MeV Polarimetry for Relativistic Jets	76
<i>Haocheng Zhang</i>	
J2102+6015: a potential distant multimessenger?	86
<i>Leonid I. Gurvits, Sándor Frey, Máté Krezinger, Oleg Titov, Tao An, Yingkang Zhang, Alexander G. Polnarev, Krisztina É. Gabányi, Krisztina Perger and Alexey Melnikov</i>	
VLBI Scrutiny of a New Neutrino-Blazar Multiwavelength-Flare Coincidence	91
<i>F. Eppel, M. Kadler, E. Ros, F. Rösch, J. Heßdörfer, P. Benke, P. G. Edwards, C. M. Fromm, M. Giroletti, A. Gokus, J. L. Gómez, S. Hämmerich, D. Kirchner, Y. Y. Kovalev, T. P. Krichbaum, M. L. Lister, C. Nanci, R. Ojha, G. F. Paraschos, A. Plavin, A. C. S. Readhead, J. Stevens and P. Weber</i>	
Redshift determination of blazars for the Cherenkov Telescope Array	96
<i>E. Kasai, P. Goldoni, S. Pita, C. Boisson, M. Backes, G. Cotter, F. D'Ammando and B. van Soelen</i>	
Author Index	101

Preface

This special volume includes contributions from the IAU 375 symposium “The multimessenger chakra of blazar jets” that took place in Kathmandu Nepal during 5–9 December 2022 and included 91 participants from 25 countries across the world. The symposium lasted for 5 days covering all aspects of blazar science. The key science themes included multiwavelength/multimessenger theory and observations, particle acceleration mechanisms, jet structure, formation, composition and acceleration, multiwavelength polarization, as well as future experiments. The chapters of this volume have been organized to reflect the topics covered in each of the days.

Blazars are among the most intriguing and consistently bright objects in the observable Universe. They are the most extreme active galactic nuclei with powerful relativistic jets extending out to kpc from the central engine. Understanding how blazars form and shine has been a cumbersome endeavor since their discovery in the 1960s. Several fundamental questions regarding their intrinsic properties and the properties of the supermassive black holes in their centers are open to this day. 2020s mark the beginning of a new era, an era of large scale surveys, multimessenger astrophysics, high-energy polarization, and extreme angular resolution, setting the ideal stage to study astrophysical jets. The symposium had three goals. First, to bring together experts from all different aspects of the blazar community and facilitate the building of new collaborative efforts just in time to take advantage of the wealth of new incoming data that will help finally provide answers to long standing questions. Second, as the first IAU symposium in Nepal, to establish collaborative bridges between scientists from Nepal and scientists from around the World. Third, to support ongoing local efforts to promote astrophysics, and astrophysical research in Nepal.

To achieve a more interactive meeting and bridge the senior-junior scientist gap we organized mini workshops during lunch breaks on different topics related to the scientific theme of the day. We also organized “junior-senior lunches” by randomly assigning senior and junior scientists to different lunch groups giving the opportunity to break the ice between participants and allow junior scientist to gain the most out of the meeting.

Finally, throughout the symposium, we organized a vivid and diverse outreach program led by the Nepal Astronomical Society (NASO). The program included visits to schools by the symposium’s participants, on-site training seminars on teaching astronomy for high-school teachers, and public talks. We also coordinated with RAD@home India and organized training sessions for citizen science related to radio galaxies and blazars.

Ioannis Liodakis
On behalf of the organizers

Editors

Ioannis Liodakis, Finnish Centre for Astronomy with ESO, Finland
Margo F. Aller, University of Michigan, USA
Henric Krawczynski, Washington University St. Louis, USA
Anne Lähteenmäki, Aalto University, Finland
Timothy J. Pearson, California Institute for Technology, USA

SOC Co-chairs

Roger Blandford, Stanford University, USA
Vasiliki Pavlidou, University of Crete, Greece

SOC members

Keiichi Asada, ASIAA, Taiwan
Geoffrey Bicknell, Australian National University, Australia
Carolina Casadio, Institute of Astrophysics, Greece
Annalisa Celotti, SISSA, Italy
Noemie Globus, University of California Santa Cruz, USA
Jose Luis Gomez, Instituto de Astrofisica de Andalucia , Spain
Talvikki Hovatta, University of Turku, Finland
Svetlana Jorstad, Boston University, USA
Yuri Kovalev, Max Planck Institute for Radioastronomy, Germany &
Lebedev Physical Institute, Russia
Sang-Sung Lee, KASI, South Korea
Masanori Nakamura, ASIAA, Taiwan
Rodrigo Nemmen, University of Sao Paolo, Brazil
Maria Petropoulou, University of Athens, Greece
Claudia Raiteri, Osservatorio Astrofisico di Torino, Italy
Anamparambu Ramaprakash, IUCAA, India
Stas Shabala, University of Tasmania, Australia
Makoto Uemura, University of Hiroshima, Japan

LOC Co-chairs

Suresh Bhattacharai, Nepal Astronomical Society, Nepal
Manisha Dwa, Nepal Astronomical Society, Nepal

LOC members

Dmitry Blinov, Institute of Astrophysics, Greece
Dinesh Kandel, Stanford University, USA
Ioannis Liodakis, Finnish Centre for Astronomy with ESO, Finland

List of Participants

Agniva Roychowdhury, University of Maryland, Baltimore County
Aleksandr Popkov, Moscow Institute of Physics and Technology
Alessandro Paggi, University of Turin
Alexander Plavin, Lebedev Physical Institute
Alice Pasetto, ITyA-UNAM
Amal Abdulrahman, Department of Physics, Farook College, Calicut University
Amar Raj Ghimire, Tribhuvan University
Aminabi Thekkoth, University of Calicut
Amir Levinson, Tel Aviv University
Anabella Araudo, LUPM (CNRS) and ELI Beamlines (Czech Academy of Sciences)
Anamparambu Ramaprakash, IUCAA
Ananda Hota, UM-DAE CEBS & RAD@home, India
Anastasiia Omeliukh, Ruhr University Bochum
Andrzej Zdziarski, N. Copernicus Astronomical Center
Annalisa Celotti, SISSA, Italy
Anthony Readhead, California Institut of Technology
Athira M Bharathan, CHRIST Deemed to be University
Avinash Kumar, RAD@home India
Baheeya Cholakkal, University of Calicut
Callum McCall, Liverpool John Moores University
Carolina Casadio, Institute of Astrophysics - FORTH
David Fernandez, Sejong University
Dmitry Blinov, IA, FORTH
Eileen Meyer, University of Maryland Baltimore County
Elena Nokhrina, Moscow Institute of Physics and Technology
Elena Shablovinskaya, Special astrophysical observatory RAS
Eli Kasai, University of Namibia
Elina Lindfors, Finnish Centre for Astronomy with ESO, University of Turku
Erin O'Sullivan, Uppsala University
Evaristus Iyida, Department of Physics and Astronomy, University of Nigeria, Nsukka
Florian Eppel, JMU Wuerzburg
Florian Roesch, JMU Wuerzburg
Francesco Massaro, University of Turin
Gabriele Giovannini, IRA/INAF and Bologna University
Georgios Filippou Paraschos, Max Planck Institute for Radio Astronomy
Gourab Giri, Indian Institute of Technology Indore
Haocheng Zhang, NPP Fellow/NASA GSFC
Ioannis Liodakis, Finnish Centre for Astronomy with ESO, University of Turku
Ishika Palit, Tel Aviv university, Israel
Ivan Agudo, IAA-CSIC
Jae-Young Kim, Kyungpook National University (KNU)
Janhavi Baghel, National Centre for Radio Astrophysics, Pune, India
Jeffrey Hodgson, Sejong University
Joana Kramer, Max Planck Institute for Radio Astronomy
Jun Yi (Kevin) Koay, Academia Sinica Institute of Astronomy and Astrophysics
Kenichi Nishikawa, Alabama A&M University
Kenji Yoshida, Shibaura Institute of Technology
Konstantinos Tassis, IA-FORTH and University of Crete
Koushik Chatterjee, Harvard University
Krzysztof Nalewajko, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences

Lawrence Peirson, Stanford University
Lea Heckmann, Max Planck Institute for Physics
Lea Marcotulli, Yale University
Leonid Gurvits, Joint Institute for VLBI ERIC and Delft University of Technology
Lorena Hernandez-Garcia, MAS/UV (Chile)
Luca Ighina, Uni. Insubria + INAF-Brera
Maria Charisi, Vanderbilt University
Markus Boettcher, North-West University
Megha Rajoria, RAD@home India
Monika Moscibrodzka, Radboud University
Naoki Isobe, ISAS/JAXA
Nicholas MacDonald, Max Planck Institute for Radio Astronomy
Olivier Hervet, UC Santa Cruz
Po-Chih Hsu, Graduate Institute of Astronomy, National Central University, Taiwan
Preeti Kharb, National Centre for Radio Astrophysics - Tata Institute of Fundamental Research
Rajesh Kumar Bachchan, Tribhuvan University
Ravi Pratap Dubey, Max Planck Institute for Astronomy
Ryo Imazawa, Hiroshima University
Sagar Chapagain, Tribhuvan University
Sasha tcheshkovskoy, Northwestern University
Shivangi Pandey, Aryabhata Research Institute of Observational Sciences, Nainital
Soeb Razzaque, University of Johannesburg
Sriyashri Acharya, Indian Institute of Technology Indore
Sushma Bashyal, Tribhuvan University
Susmita Das, Presidency University, Kolkata, India
Susumu Inoue, Bunkyo U. / RIKEN
Swaraj Pradhan, Nepal Astronomical Society, Astronomers Without Borders
Tapio Pursimo, Nordic Optical Telescope / Aarhus Universitet
Tej Bahadur Chand, Centre for Space Research, North-West University Potchefstroom,
South Africa
Thalia Traianou, IAA-CSIC
Tullia Sbarrato, INAF - Osservatorio Astronomico di Brera
Tuomas Savolainen, Aalto University
Uwe Bach, Max-Planck-Institut fuer Radioastronomie
Vasiliki Pavlidou, IA-FORTH and University of Crete
Vasily Beskin, Lebedev Physical Institute & Moscow Institute of Physics and Technology
Yamuna Rana, Tribhuvan University
Yogesh Singh Maharjan, Tribhuvan University
Yosuke Mizuno, Tsung-Dao Lee Institute, Shanghai Jiao Tong University
Yuh Tsunetoe, Kyoto University
Yuri Kovalev, MPIfR
Zahoor Ahmad Malik, University of Kashmir



Group photograph of the Symposium's participants at the venue.



Group photograph of the Symposium's participants during the excursion at the UNESCO's world heritage site of Bhaktapur.