

IAU Symposium

342

14-18 May 2018

Noto, Italy

Proceedings of the International Astronomical Union

Perseus in Sicily: From Black Hole to Cluster Outskirts

Edited by

Keiichi Asada

Elisabete de Gouveia Dal Pino

Marcello Giroletti

Hiroshi Nagai

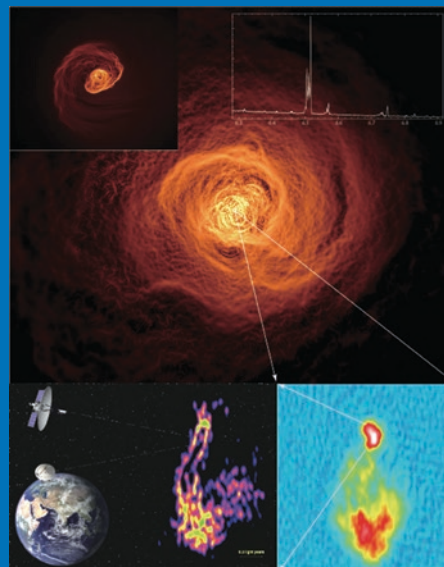
Rodrigo Nemmen

ISSN 1743-9213

International Astronomical Union



CAMBRIDGE
UNIVERSITY PRESS



PERSEUS IN SICILY:
FROM BLACK HOLE TO CLUSTER OUTSKIRTS

IAU SYMPOSIUM 342

COVER ILLUSTRATION:

(Top) X-ray image of the Per A. obtained by the Chandra X-ray Observatory (NASA/CXC/GSFC/S. A. Walker, et al.) together spectral data by the X-ray Astronomy Satellite “Hitomi” (Hitomi collaboration, JAXA, NASA, ESA, SRON, CSA). (Bottom Left) Innermost radio structure of 3C 84 taken by the RadioAstron (Giovannini et al. 2018) (Bottom Right) VSOP image of the Per A (Asada et al. 2006)

IAU SYMPOSIUM PROCEEDINGS SERIES

Chief Editor

PIERO BENVENUTI, IAU General Secretary

IAU-UAI Secretariat

98-bis Blvd Arago

F-75014 Paris

France

[*iau-general.secretary@iap.fr*](mailto:iau-general.secretary@iap.fr)

Editor

MARIA TERESA LAGO, IAU Assistant General Secretary

Universidade do Porto

Centro de Astrofísica

Rua das Estrelas

4150-762 Porto

Portugal

[*mtlago@astro.up.pt*](mailto:mtlago@astro.up.pt)

INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE

International Astronomical Union



**PERSEUS IN SICILY: FROM
BLACK HOLE TO CLUSTER
OUTSKIRTS**

**PROCEEDINGS OF THE 342nd SYMPOSIUM
OF THE INTERNATIONAL ASTRONOMICAL
UNION HELD IN NOTO, ITALY
14–18 MAY, 2018**

Edited by

KEIICHI ASADA

Academia Sinica, Taiwan

ELISABETE DE GOUVEIA DAL PINO

Universidade de Sao Paulo, Brazil

MARCELLO GIROLETTI

Istituto Nazionale di Astrofisica, Italy

HIROSHI NAGAI

National Astronomical Observatory of Japan

and

RODRIGO NEMMEN

Universidade de Sao Paulo, Brazil



**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 2020

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 2020

Printed in the UK by Bell & Bain, Glasgow, UK

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 9781108471534 hardback
ISSN 1743-9213

Table of Contents

Preface	x
Editors	xii
Participants	xiii
Black hole mass measurements in AGN: Polarization in broad emission lines <i>Luka Č. Popović, Victor L. Afanasiev and Djordje Savić</i>	1
Fully analytical solutions for Bondi accretion in galaxies with a central Black Hole <i>Luca Ciotti and Silvia Pellegrini</i>	5
Modelling the polarised emission from black holes on event horizon-scales <i>Ziri Younsi, Oliver Porth, Yosuke Mizuno, Christian M. Fromm and Hector Olivares</i>	9
Particle acceleration and the origin of the very high energy emission around black holes and relativistic jets <i>Elisabete M. de Gouveia Dal Pino, Grzegorz Kowal, Luis Kadowaki, Tania E. Medina-Torrejón, Yosuke Mizuno and Chandra Singh</i>	13
Numerical methods for General Relativistic particles <i>Fabio Bacchini, Bart Ripperda, Alexander Y. Chen and Lorenzo Sironi</i>	19
On the prospects of imaging Sagittarius A* from space <i>Freek Roelofs, Heino Falcke, Christiaan Brinkerink, Monika Moscibrodzka, Leonid I. Gurvits, Manuel Martin-Neira, Volodymyr Kudriashov, Marc Klein-Wolt, Remo Tilanus, Michael Kramer and Luciano Rezzolla</i>	24
The Hot Universe with XRISM and Athena <i>Matteo Guainazzi and Makoto S. Tashiro</i>	29
Low frequency observations of radio relics and halos <i>Ruta Kale</i>	37
Probing the non-thermal emission in the Perseus cluster with the JVLA <i>M. Gendron-Marsolais, J. Hlavacek-Larrondo, R. J. van Weeren, T. Clarke, A. C. Fabian, H. T. Intema, G. B. Taylor, K. M. Blundell and J. S. Sanders</i>	44
High-dynamic-range 21 cm JVLA observations of the Perseus Cluster <i>Charles L. H. Hull</i>	53
A wide and collimated radio jet in 3C 84 <i>Gabriele Giovannini</i>	55
Extragalactic relativistic jets <i>Monica Orienti</i>	61
Inflow and Outflow (Jets) in NGC 1275 <i>Hiroshi Nagai</i>	69

Observations of nearby relativistic jets with EAVN and EATING VLBI	73
<i>Kazuhiro Hada and EAVN/EATING VLBI Collaboration</i>	
Molecular gas filamentary structures in galaxy clusters	77
<i>Francoise Combes</i>	
Young radio jets breaking free: molecular and HI outflows in their centers	85
<i>Raffaella Morganti, Tom Oosterloo, Robert Schulz, Clive Tadhunter and J. B. Raymond Oonk</i>	
Ultra fast outflows, and their connection to accretion and ejection processes in AGNs	90
<i>Anna Lia Longinotti</i>	
AGN feedback and the origin and fate of the hot gas in early-type galaxies	97
<i>Silvia Pellegrini, Luca Ciotti, Andrea Negri and Jeremiah P. Ostriker</i>	
Numerical study of active galactic nucleus feedback in an elliptical galaxy with MACER	101
<i>Feng Yuan, Jeremiah P. Ostriker, DooSoo Yoon, Ya-Ping Li, Luca Ciotti, Zhao-Ming Gan, Luis C. Ho and Fulai Guo</i>	
Prodigious and Continuous Formation of Super Star Clusters from Cooled Intracluster Gas	108
<i>Jeremy Lim, Emily Wong, Youichi Ohyama, Tom Broadhurst and Elinor Medezinski</i>	
Characterizing the Outburst of the Supermassive Black Hole in M87	112
<i>William Forman, Eugene Churazov, Sebastian Heinz, Christine Jones, Paul Nulsen, Ralph Kraft, Scott Randall and Alexey Vikhlinin</i>	
X-ray probing of NGC 1275 nuclear region with Hitomi, Swift, and Suzaku	118
<i>Yasushi Fukazawa</i>	
Life-cycles & Energetics of Radio-Loud AGN	122
<i>V. H. Mahatma, M. J. Hardcastle, W. L. Williams + LOFAR Surveys team</i>	
Deep Chandra observations of the core of the Perseus cluster	127
<i>Jeremy S. Sanders</i>	
Close-up view of an ongoing merger between the NGC 4839 group and the Coma cluster	133
<i>Natalia Lyskova, Eugene Churazov, Congyao Zhang, William Forman and Christine Jones</i>	
Thermal and non-thermal connection in radio mini-halos	137
<i>A. Ignesti, G. Brunetti, M. Gitti and S. Giacintucci</i>	
Perseus – A Huge Reservoir of Dark Matter investigated with MAGIC	141
<i>Michele Doro, Joaquim Palacio, Javier Rico and Monica Vazquez Acosta</i>	
The AGN dependence on cluster mass	145
<i>Elias Koulouridis, Marina Ricci and the XXL collaboration</i>	
AGN Jets, Bubbles, and Heat Pumps	149
<i>Yi-Hao Chen and Sebastian Heinz</i>	

Intermediate-Mass Black Hole Feedback in Dwarf Galaxies: a View from Cosmological Simulations	154
<i>Paramita Barai and Elisabete M. de Gouveia Dal Pino</i>	
Gamma-ray emission in radio galaxies, from MeV to TeV	158
<i>Eleonora Torresi</i>	
Search for QPOs in Perseus with <i>Fermi</i> LAT	167
<i>Rodrigo Nemmen, Raniere de Menezes and Vasileios Paschalidis, on behalf of Fermi-LAT Collaboration</i>	
High Energy γ -ray variability of NGC 1275 and 3C 120	172
<i>Narek Sahakyan</i>	
Young radio sources at high-energies and the γ -ray CSO PKS 1718–649	176
<i>Giulia Migliori</i>	
Exploring the radio and GeV-TeV γ -ray connection in the different blazar sub-classes	180
<i>R. Lico, M. Giroletti, M. Orienti, L. Costamante, V. Pavlidou, F. D’Ammando and F. Tavecchio</i>	
Neutrino and γ -ray Emission from the Core of NGC1275 by Magnetic Reconnection: GRMHD Simulations and Radiative Transfer/ Particle Calculations	184
<i>J. C. Rodríguez-Ramírez, Elisabete M. de Gouveia Dal Pino and R. Alves Batista</i>	
Magnetic Fields in the Relativistic Jets of Active Galactic Nuclei	189
<i>Denise C. Gabuzda</i>	
The correlation between the total jet power and the Poynting flux at the jet base	197
<i>Elena E. Nokhrina</i>	
Why only a small fraction of quasars are radio loud?	201
<i>Xinwu Cao</i>	
Ratio of kinetic-to-bolometric luminosity at the “cold” disk accretion onto black holes	205
<i>Sergey Bogovalov</i>	
Emission modelling of hydrodynamic AGN jet simulations	209
<i>Isak P. van der Westhuizen, Brian van Soelen and Petrus J. Meintjes</i>	
The wind production from black hole hot accretion flow	214
<i>De-Fu Bu</i>	
Radio-loud AGNs with peculiar shape of hard X-ray spectrum: figuring out the reasons	218
<i>E. Fedorova, B. I. Hnatyk and V. I. Zhdanov</i>	
Expanding Radio Lobe associated with 3C 84	220
<i>Keiichi Asada, Makoto Inoue, Hiroshi Nagai and Seiji Kameno</i>	

Chandra view on the active nucleus of CGCG 292–057: Jet-ISM interactions . . .	222
<i>K. Balasubramaniam, L. Stawarz, V. Marchenko, R. Thimmappa, M. Sobolewska, A. Siemiginowska, C. C. Cheung, D. Kozieł-Wierzbowska and M. Jamrozy</i>	
Preliminary analysis of the X-ray emission from the central regions of the Pictor A	224
<i>R. Thimmappa, L. Stawarz, K. Balasubramaniam and V. Marchenko</i>	
Flip of the jet head position of 3C 84 in 2015	227
<i>M. Kino, H. Nagai, K. Wajima, N. Kawakatu, M. Orienti, G. Giovannini, K. Hada, K. Niinuma and M. Giroletti</i>	
AGN and Star Formation Feedback in Galaxy Outflows	229
<i>Elisabete M. de Gouveia Dal Pino, William Clavijo-Bohórquez and Claudio Melioli</i>	
Update on the Multi-Frequency Monitoring of Blazars with Medicina and Noto	234
<i>Simona Righini, Pietro Cassaro, Uwe Bach, Marcello Giroletti, Carla Buemi, Paolo Leto, Monica Orienti, Andrea Orlati, Claudia M. Raiteri, Corrado Trigilio, Grazia Umata and Massimo Villata</i>	
Hints of radio sources evolution	237
<i>Pietro Cassaro</i>	
Bending of the pc scale jet in 3C84	239
<i>A. Hirano, K. Fujisawa, K. Niinuma and GENJI Collaboration</i>	
Chandra Early-Type Galaxy Atlas	242
<i>Dong-Woo Kim, Craig Anderson, Douglas Burke, Raffaele D’Abrusco, Giuseppina Fabbiano, Antonella Fruscione, Jennifer Lauer, Michael McCollough, Douglas Morgan, Amy Mossman, Ewan O’Sullivan, Alessandro Paggi, Saeqa Vrtilek and Ginevra Trinchieri</i>	
Probing the B-fields of AGN jets on kiloparsec scales - NGC 6251	244
<i>Sebastian Knüttel and Denise Gabuzda</i>	
External blob radiation model for the TeV gamma-ray emission in radio galaxies	246
<i>Wlodek Bednarek and Piotr Banasiński</i>	
A negative correlation between R_{UV} and α_{OX} in low-luminosity AGNs	248
<i>Shuang-Liang Li</i>	
A precessing and nutating jet in OJ287	250
<i>Silke Britzen, C. Fendt, G. Witzel, S.-J. Qian, I. N. Pashchenko, O. Kurtanidze, M. Zjacek, G. Martinez, V. Karas, M. Aller, H. Aller, A. Eckart, K. Nilsson, P. Arévalo, J. Cuadra, M. Subroweit and A. Witzel</i>	
A jet proper motion study in the early Universe	252
<i>Krisztina Perger, Sándor Frey and Krisztina É. Gabányi</i>	

Evolution of the M_{\bullet} - σ relation	254
<i>D. Bhattacharyya and A. Mangalam</i>	
Simulations of the W50-SS433 system	257
<i>Dimitrios Millas, Oliver Porth and Rony Keppens</i>	
Black hole demographics from TDE modeling	260
<i>T. Mageshwaran and A. Mangalam</i>	
Multi-frequency monitoring of S5 0716+714	263
<i>Jee Won Lee and Bong Won Sohn</i>	
Survival of Population III stars	266
<i>Jayanta Dutta, Sharanya Sur, Athena Stacy and Jasjeet Singh Bagla</i>	
Infrared Diagnostics of the ISM in the Circumnuclear Environments of the Youngest Radio Galaxies	268
<i>E. Kosmaczewski, L. Stawarz, A. Wójtowicz, et al.</i>	
A Photoionization Method for Estimating Black Hole Masses in Quasars	270
<i>C. Alenka Negrete, Deborah Dultzin, Paola Marziani, Jack W. Sulentic and M. L. Martínez-Aldama</i>	
The role of stellar rotation in Tidal Disruption Events	272
<i>Andrea Sacchi and Giuseppe Lodato</i>	
On the likelihood of Gravitational Wave emission during the Tidal Disruption of stars by Super Massive Black Holes	275
<i>Martina Toscani and Giuseppe Lodato</i>	
Jet production efficiency in the sample of the youngest radio galaxies	278
<i>Anna Wójtowicz, Lukasz Stawarz and Emily Kosmaczewski</i>	
Author Index	281

Preface

The Perseus cluster has recently been the stage of ground-breaking discoveries, from the immediate vicinity of the black holes at the centres of its galaxies out to the dynamics of the gas on cluster scales. The importance and timeliness of discussing these and other topics was enhanced by developments in the fields of theory, numerical simulations, and imaging techniques. Multi-wavelength observers and theoreticians, experts from the event horizon out to the Megaparsec scales, were invited to the beautiful Sicilian city of Noto, a location rich in history, culture, nature, and science, near to the INAF 32m radio telescope and the CTA-ASTRI prototype on Mt. Etna.

The symposium has thus seen a broad participation, with science highlights ranging across several wavelengths and spatial scales, and including observations, interpretation, numerical simulations and pure theory. The organisers have been particularly pleased with the diversity of the involved communities, as is really in the spirit of IAU symposia. Talks and speakers came from different astrophysical backgrounds, as well as broad age, gender, and geographical distributions, but shared the common trait of giving excellent presentations.

A recurring quote was that “Perseus is weird”, although it eventually remained open to debate whether this weirdness were intrinsic or rather the consequence of an unparalleled level of detail that we have gathered for this system.

On the **finest linear scales**, approaching the event horizon scales, the main novelty has been the **discovery of a wide and collimated radio jet in 3C 84 on the scale of a few hundred gravitational radii**, thanks to new space very-long-baseline-interferometry observations including the RadioAstron satellite. This finding has important implications on the formation of relativistic jets in active galactic nuclei, as discussed in a series of sessions devoted to general relativity magneto-hydrodynamic numerical simulations and to the technical and computational development required by the operations of the Event Horizon Telescope.

The (sub-)parsec scale properties have also been relevant for the connection to the high and very high energy (VHE) **gamma-ray** emission. 3C 84 is reaching **record level emission among just a handful of radio galaxies detected** in gamma rays. The time scales and the spectral properties have been debated in order to constrain the location and the physical properties of the region responsible for the gamma-ray emission in the jet or in the immediate vicinity of the black hole itself. Another Perseus galaxy, IC 310, has been reported to have very short time scale activity at VHE, which can possibly be explained with phenomena occurring on the black hole magnetosphere scale. Alternative acceleration processes involving multi-structures or turbulent magnetic reconnection have been proposed in order to explain current puzzles on the origin of VHE emission, particularly when it is highly variable.

On somewhat larger scales, starting from a few tens of kiloparsecs, amazing images in terms of resolution and dynamic range have been presented, thanks to new observations with Jansky VLA and other instruments. These datasets probe the non-thermal emission in the Perseus and other clusters over a broad range of wavelengths and reveal **a multitude of new structures** extending to hundreds of kpc in size. Their irregular morphology seems to have been influenced both by **the AGN activity and by the sloshing motion of the cluster’ gas**. The gas properties have been the subject of X-ray focused talks, with exquisite energy and space resolution by Hitomi and Chandra, respectively. The former, in particular, has revealed a **mostly uniform and low velocity dispersion**.

How the AGN influences the host galaxy and the surrounding environment was also the subject of much debate, with discussions on the relative role of **AGN and supernovae-driven winds**, on the presence of persistent **filaments** both based on recent X-ray and sub-millimetre observations, and on **numerical simulations**. In this context, 3C 84 again appeared as an important prototype.

In terms of future breakthroughs, it has been important to hear about projects such as the X-ray observatory Athena, the Square Kilometre Array radio telescope, and the VHE Cherenkov Telescope Array, which will provide a transformational contribution to the above areas, besides many other topics. They shall eventually reveal whether “Perseus is weird” or if many more systems present similar peculiarities. We also had a look at the recent past, with a rich, brilliant, and moving talk about the legacy of Ger de Bruyn for the study of the Perseus system, of galaxy clusters in general, and ultimately the passion for astrophysical research.

This rich science program was interleaved with a busy set of social activities, aimed at creating a good atmosphere among the participants, facilitating interactions about the science themes but also giving a flavour of the scientific, historical, naturalistic, and gastronomic richness and diversity of the host region. At the end of the sessions on Monday, which took place in the historical Tina di Lorenzo theatre, participants assisted to “Lu cuntu di Perseu”, an emotional play based on the myth of Perseus. Other activities included a guided tour of the Baroque palaces in historic downtown Noto, the main social excursion to historic Syracuse, and a night of science, music, and food with live jazz music accompanying a buffet dinner by the INAF 32m radio telescope near Noto. At the very end of the symposium, on Friday night, participants had the chance to assist to the opening of the yearly traditional *Infiorata*: a cascade of thousands of flowers, expertly arranged on the road, filling the city with scents and colours. In parallel, the symposium has offered the opportunity to bring astrophysics to the general public: local high schools were involved in the design of a lithograph given to each participant, as well as in the adaptation of the play for the international audience. A conference on “The sense of discovery” was offered to the general public, followed by a stargazing session.

We are grateful to the IAU for sponsoring this event and providing generous support to the participation of participants with more limited travel means. We also acknowledge significant funding from the RadioNet consortium, from the Italian National Institute of Astrophysics (INAF), and the local government in Noto.

Editors

Keiichi Asada (Academia Sinica, Institute of Astronomy and Astrophysics)

*Elisabete Maria de Gouveia Dal Pino (Instituto de Astronomia,
Geofisico e Ciencias Atmosfericas)*

Marcello Giroletti (Italian National Institute for Astrophysics)

Hiroshi Nagai (National Astronomical Observatory of Japan)

Rodrigo Nemmen (Astronomy Department – Universidade de Sao Paulo)

Editors

Keiichi Asada
Academia Sinica, Taiwan

Elisabete de Gouveia Dal Pino
University of São Paulo, Brazil

Marcello Giroletti
Italian National Institute for Astrophysics, Italy

Hiroshi Nagai
National Astronomical Observatory of Japan, Japan

Rodrigo Nemmen
University of São Paulo, Brazil

Organising Committee

Scientific Organising Committee

SOC Co-Chairs

Elisabete de Gouveia Dal Pino	(IAG – Universidade de Sao Paulo, Brazil)
Marcello Giroletti	(Institute of Radioastronomy, Italy)
Christine Jones	(USA, Smithsonian Astrophysical Observatory)
Hiroshi Nagai	(National Astronomical Observatory of Japan, Japan)

SOC Members

Keiichi Asada	(Academia Sinica Institute of Astronomy and Astrophysics, Taiwan)
Roger Blandford	(Stanford University, USA)
Geoff Bower	(Academia Sinica Institute of Astronomy and Astrophysics, Taiwan)
Shep Doeleman	(Harvard University, USA)
Andy Fabian	(University of Cambridge, UK)
Paola Grandi	(Institute of Space Astrophysics and Cosmic Physics, Italy)
Chung-Pei Ma	(University of California, USA)
Rodrigo Nemmen	(Astronomy Department – Universidade de Sao Paulo, Brazil)
Lawrence Rudnick	(University of Minnesota, USA)
Aneta Siemiginowska	(Smithsonian Astrophysical Observatory, USA)
Lukasz Stawarz	(Jagiellonian University, Poland)
Feng Yuan	(Shanghai Astronomical Observatory, China)

Local Organising Committee

LOC Co-Chairs

Marcello Giroletti	(INAF Istituto di Radioastronomia, Bologna)
Barbara Neri	(INAF Istituto di Radioastronomia, Bologna)
Carlo Nocita	(INAF Istituto di Radioastronomia, Noto)
Grazia Umata	(INAF OsservatorioAstrofisico di Catania)

LOC Members

Giancarlo Bellasai	(INAF Osservatorio Astrofisico di Catania)
Milena Bufano	(INAF Osservatorio Astrofisico di Catania)
Eugenio Martinetti	(INAF Osservatorio Astrofisico di Catania)
Pier Raffaele Platania	(INAF Istituto di Radioastronomia, Noto)
Gina Santagati	(INAF Osservatorio Astrofisico di Catania)

Participants

- 1) Akiyama, Kazunori, United States
- 2) Asada, Keiichi, Taiwan, R.O.C.
- 3) Bacchini, Fabio, Belgium
- 4) Balasubramaniam, Karthik A, Poland
- 5) Barai, Paramita, Brazil
- 6) Bednarek, Wlodek, Poland
- 7) Bellassai, Giancarlo, Italy
- 8) Bhattacharyya, Dipanweeta, India
- 9) Bogovalov, Sergey, Russia
- 10) Bourne, Martin, UK
- 11) Bower, Geoffrey, United States
- 12) Brentjens, Michiel, Netherlands
- 13) Britzen, Silke, Germany
- 14) Bu, Defu, China
- 15) Bufano, Milena, Italy
- 16) Cao, Xinwu, China
- 17) Cassaro, Pietro, Italy
- 18) Chen, Yi-Hao, United States
- 19) Chernoglazov, Alexander, Russia
- 20) Churazov, Eugene, Germany
- 21) Ciotti, Luca, Italy
- 22) Clavijo Bohórquez, William E., Brazil
- 23) Combes, Françoise, France
- 24) de Gouveia Dal Pino, Elisabete, Brazil
- 25) Doro, Michele, Italy
- 26) Duc Thong, Le, Viet Nam
- 27) Dutta, Jayanta, India
- 28) Ehlert, Kristian, Germany
- 29) Fedorova, Elena, Ukraine
- 30) Forman, William, United States
- 31) Fukazawa, Yasushi, Japan
- 32) Gabuzda, Denise, Ireland
- 33) Gebhardt, Karl, United States
- 34) Gendron-Marsolais, Marie-Lou, Canada
- 35) Giovannini, Gabriele, Italy
- 36) Giroletti, Marcello, Italy
- 37) Glawion, Dorit, Germany
- 38) Govoni, Federica, Italy
- 39) Grandi, Paola, Italy
- 40) Guainazzi, Matteo, Netherlands
- 41) Hada, Kazuhiro, Japan
- 42) Hirano, Ayumi, Japan
- 43) Hodgson, Jeffrey, South Korea
- 44) Hull, Charles, Chile
- 45) Ignesti, Alessandro, Italy
- 46) Johnston-Hollitt, Melanie, Australia
- 47) Jones, Christine, United States
- 48) Kale, Ruta Prabhakar, India
- 49) Kim, Minsun, South Korea
- 50) Kim, Dong-Woo, United States
- 51) Klein, Uli, Germany
- 52) Knuettel, Sebastian, Ireland
- 53) Kosmaczewski, Emily, Poland
- 54) Koulouridis, Elias, France
- 55) Lakhchaura, Kiran, Indian
- 56) Lee, Jee Won, South Korea
- 57) Li, Shuangliang, China
- 58) Li, Yuan, USA
- 59) Lim, Jeremy, Australian
- 60) Lindfors, Elina, Finland
- 61) Longinotti, Anna Lia, Mexico
- 62) Lyskova, Natalia, Russian
- 63) Mahatma, Vijay, United Kingdom
- 64) Martinetti, Eugenio, Italy
- 65) Massaro, Francesco, Italy
- 66) Migliori, Giulia, Italy
- 67) Millas, Dimitrios, Belgium
- 68) Mizuno, Yosuke, Germany
- 69) Morganti, Raffaella, The Netherlands
- 70) Moscibrodzka, Monika, Netherlands
- 71) Nagai, Hiroshi, Japan
- 72) Negrete, Alenka, Mexico
- 73) Nemmen, Rodrigo, Brazil
- 74) Neri, Barbara, Italy
- 75) Nocita, Carlo, Italia
- 76) Nokhrina, Elena, Russia
- 77) Oh, Junghwan, South Korea
- 78) Orienti, Monica, Italy
- 79) Panessa, Francesca, Italy
- 80) Park, Jongho, South Korea
- 81) Pellegrini, Silvia, Italy
- 82) Perger, Krisztina, Hungary
- 83) Pezzulli, Edwige, Italy
- 84) Platania, Pier Raffaele, Italy
- 85) Popovic, Luka, Serbian
- 86) Reynolds, Christopher, United Kingdom
- 87) Rodriguez Ramirez, Juan Carlos, Brazil
- 88) Roelofs, Freek, Netherlands
- 89) Sacchi, Andrea, Italy
- 90) Sahakyan, Narek, Armenia
- 91) Sanders, Jeremy, Germany
- 92) Sani, Eleonora, Chile
- 93) Santagati, Gina, Italy
- 94) Savolainen, Tuomas, Finland
- 95) Sijacki, Debora, United Kingdom
- 96) Sohn, Bong Won, South Korea
- 97) Tamilan, Mageshwaran, India
- 98) Tamura, Takayuki, Japan
- 99) Thimmappa, Rameshan, Poland
- 100) Torresi, Eleonora, Italy
- 101) Toscani, Martina, Italy
- 102) Trippe, Sascha, South Korea
- 103) Umana, Grazia, Italy
- 104) VahdatMotlagh, Armin, Iran
- 105) Vaidya, Bhargav, India
- 106) Van der Westhuizen, Izak, South Africa
- 107) Varano, Stefania, Italy
- 108) Vijayaraghavan, Rukmani, United States
- 109) Webster, Brendan, United Kingdom
- 110) Wójtowicz, Anna, Poland
- 111) Younsi, Ziri, Germany
- 112) Yuan, Feng, Chinese
- 113) Yuan, Zhong-Sheng, China
- 114) Zdziarski, Andrzej, Poland
- 115) Zhang, Congyao, Germany
- 116) Zhuravleva, Irina, United States