

(i) Final scientific program, list of invited review speakers and session chairs

Monday, May 14 – Teatro Comunale

	Welcome speeches
Session 1 – Black Hole masses. Chair: Geoffrey Bower	
Karl Gebhardt	Measurements of masses in supermassive black holes
Eleonora Sani	NGC 1275: An Outlier of the Black Hole-Host Scaling Relations
Luka Popovic	Black hole mass measurements in AGN: Polarization in broad emission lines
	Coffee break
Session 2 – Black Hole vicinity – theory and simulations. Chair: Sasha Tchekovskoy	
Monika Moscibrodzka	Black Hole Accretion in Low Luminosity Active Galactic Nuclei
Yosuke Mizuno	Testing Theories of Gravity via BH Shadows and Modeling of Relativistic Jets
luca ciotti	Fully analytical solutions for Bondi accretion in galaxies with a central black hole
Ziri Younsi	Modelling the polarised emission from black holes on event horizon-scales
Elisabete de Gouveia Dal Pino	Particle acceleration and the origin of the very high energy emission around black holes and relativistic jets
	Lunch
Session 3 – Black Hole vicinity – observations. Chair: Denise Gabuzda	
Kazunori Akiyama	Imaging and Filming Black Holes with the Event Horizon Telescope
Geoffrey Bower	Probes of Accretion and Outflow in Low Luminosity AGN Using Millimeter Polarimetry
Jongho Park	Substantial winds from hot accretion flows confining the relativistic jet of M87
Fabio Bacchini	Numerical methods for particle and ray tracing in general relativity
Freek Roelofs	On the Prospects of Imaging Sagittarius A* from Space
	Coffee break
Session 4 – Past and future legacy. Chair: Christine Jones	
Michiel Brentjens	Ger de Bruyn legacy work on the Perseus cluster
Melanie Johnston-Hollitt	Observations of clusters and AGNs with the SKA
Matteo Guainazzi	The Hot Universe with XARM and Athena
Elina Lindfors	Observations of AGNs and the Cluster in Perseus with the Cherenkov Telescope Array
	Outreach event: Theatre play by “Il cuore di Argante”

Tuesday, May 15 – Grand Hotel Sofia

Session 5 – Radio observations of Perseus & clusters. Chair: Melanie Johnston-Hollitt	
Ruta Kale	Low frequency observations of radio relics and halos: windows to the non-thermal phenomena
Marie-lou Gendron-Marsolais	Probing the non-thermal emission in Abell 2146 and the Perseus cluster with the JVLA
Chat Hull	High-dynamic-range 21 cm JVLA observations of the Perseus Cluster

	Coffee break
Session 6 – VLBI observations of 3C 84. Chair: Hiroshi Nagai	
Gabriele Giovannini	Radioastron observations of the jet launch region in 3C84
Tuomas Savolainen	Mini-cocoon around the parsec-scale jet in 3C84
Junghwan Oh	Double nuclear structure discovered in 3C84
Jeffrey Hodgson	3C 84 and a solution to the “Doppler crisis”?
	Lunch
Session 7 – 3C 84 and the radio-gamma connection. Chair: Rodrigo Nemmen	
Monica Orienti	On the radio and gamma-rays connection in extragalactic relativistic jets
Alastair Edge	The AGN activity of NGC1275 and the ubiquity of AGN in cool core BCGs
Hiroshi Nagai	Inflow and Outflow in NGC1275
Kazuhiro Hada	Observations of nearby relativistic jets with EAVN and EATING VLBI
Bong Won Sohn	EATING VLBI observations of 3C84, Mrk501 and TXS 0506+056
	Coffee break
Session 8 – Outflows and feedback (1). Chair: Elisabete de Gouveia dal Pino	
Francoise Combes	Molecular gas filamentary structures in galaxy clusters
Raffaella Morganti	Young radio jets breaking free: tracing molecular and HI fast outflows in the central regions
Francesco Massaro	Deciphering the large-scale environment of radio galaxies in the local Universe: where do they born, grow and die
	Tour of the city

Wednesday, May 16 – Grand Hotel Sofia

Session 9 – Outflows and feedback (2). Chair: Raffaella Morganti	
Anna Lia Longinotti	Ultra fast outflows, and their connection to accretion and ejection processes in AGNs
Silvia Pellegrini	AGN feedback and the origin and fate of the hot gas in early-type galaxies
Kiran Lakhchaura	Cold gas in giant elliptical galaxies
Yuan Li	The Effects of Ram Pressure on the Cold Clouds in the Centers of Galaxy Clusters
Feng Yuan	Numerical study of AGN feedback in an isolated elliptical galaxy
	Coffee break
Session 10 – Outflows and feedback (3). Chair: Feng Yuan	
Debora Sijacki	AGN feedback: from $z \sim 6$ protoclusters to massive galaxy clusters in the local Universe
William Eduardo Clavijo Bohórquez	AGN and Star Formation Feedback in Active Galaxies
jeremy lim	Prodigious and Continuous Formation of Super Star Clusters from Cooled Intracluster Gas
Rukmani Vijayaraghavan	The Physics of Galaxy Transformation during Cluster Assembly: Clues from the Perseus Cluster
William Forman	Characterizing the Outburst of the Supermassive Black Hole in M87
	Poster presentations. Chair: Monika Moscibrodzka

	Lunch
	Excursion and social dinner

Thursday, May 17 – Grand Hotel Sofia

Session 11 – X-ray observations of 3C84 & AGNs. Chair: Francesco Massaro	
Christopher Reynolds	An X-ray view of the active galactic nucleus in NGC1275
Yasushi Fukazawa	X-ray probing of NGC 1275 nuclear region with Hitomi, Swift, and Suzaku
Francesca Panessa	Jets and outflows in AGN: a radio and X-ray view
Vijay Mahatma	Probing the dynamics and energetics of radio galaxies
	Coffee break
Session 12 – X-ray observations of Perseus & clusters. Chair: Eugene Churazov	
Jeremy Sanders	The deep Chandra view of the core of the Perseus cluster
Takayuki Tamura	High energy resolution X-ray spectroscopy of the Perseus core with Hitomi
Natalia Lyskova	Close-up view of an ongoing merger between the NGC 4839 group and the Coma cluster
Alessandro Ignesti	Thermal – non-thermal connection in radio mini halos.
	Lunch
Session 13 – Galaxy cluster dynamics and energetics. Chair: Irina Zhuravleva	
Eugene Churazov	Gas structure and dynamics in galaxy clusters
Kristian Ehlert	Dynamics of AGN bubbles and cosmic rays in cool core clusters
Michele Doro	Constraints to dark matter lifetime with deep observations of Perseus with the MAGIC telescopes
Elias Koulouridis	The XXL survey: The role of cluster mass in AGN activity
	Coffee break
Session 14 – The AGN-cluster interaction in Perseus. Chair: Francoise Combes	
Irina Zhuravleva	AGN-driven Perturbations in the Hot Gas in the Perseus Cluster
Martin Bourne	Moving mesh simulation of jet feedback in galaxy clusters
Yi-Hao Chen	Feedback in the Perseus Cluster: Magnetized Jets, Bubbles, and Heat Pumps
Congyao Zhang	Generation of Internal Waves by Buoyant Bubbles in Galaxy Clusters and Heating of Intracluster Medium
Paramita Barai	Intermediate-Mass Black Hole Feedback in Dwarf Galaxies: a View from Cosmological Simulations
	Visit and dinner at the radio telescope

Friday, May 18 – Grand Hotel Sofia

Session 15 – Gamma-ray observations of 3C 84 & AGNs (1). Chair: Paola Grandi	
Eleonora Torresi	Gamma-ray emission in radio galaxies, from MeV to TeV
Rodrigo Nemmen	Searching for QPOs in the gamma-ray emission of NGC 1275
Narek Sahakyan	Rapid Gamma-Ray Variability of NGC 1275
Giulia Migliori	Young radio sources in gamma-rays: 3C 84 and PKS 1718-649
	Coffee break
Session 16 – Gamma-ray observations of 3C 84 & AGNs (2). Chair: Monica Orienti	
Rocco Lico	Exploring the the radio and GeV-TeV gamma-ray connection in the different blazar sub-classes
Dorit Glawion	IC 310: Lightning from the Black Hole?
Juan Carlos Rodriguez Ramirez	Very High Energy and Neutrino Emission from NGC1275 and IC310: GRMHD Simulations of Magnetic Reconnection and Radiative Transfer/Particle Calculations.
	Lunch
Session 17 – Magnetic fields and relativistic jets. Chair: Keiichi Asada	
Denise Gabuzda	Magnetic fields in relativistic jets
Elena Nokhrina	The correlation between magnetic flux and jet power
Andrzej Zdziarski	What is the power of jets?
Xinwu Cao	Why only a small fraction of quasars are radio loud?
	Coffee break
Session 18 – Simulations of jets and winds. Chair: Gabriele Giovannini	
Alexander Tchekhovskoy	Black hole accretion and relativistic jets
Sergey Bogovalov	Ratio of kinetic-to-bolometric luminosity at the “cold” disk accretion onto black holes
Izak van der Westhuizen	Monte-Carlo emission modelling of hydrodynamic AGN jet simulations
Bhargav Vaidya	Hybrid Framework for modelling non-thermal emission and particle acceleration from magnetised relativistic flows.
Defu Bu	Wind production from central black hole accretion flow and region beyond AGNs
	Concluding remarks

List of invited speakers

- Karl Gebhardt: Measurements of masses in supermassive black holes
- Monika Moscibrodzka: Black Hole Accretion in Low Luminosity Active Galactic Nuclei
- Kazunori Akiyama: Imaging and Filming Black Holes with the Event Horizon Telescope
- Michiel Brentjens: Ger de Bruyn legacy work on the Perseus cluster
- Melanie Johnston-Hollitt: Observations of clusters and AGNs with the SKA
- Matteo Guainazzi: The Hot Universe with XARM and Athena
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- Ruta Kale: Low frequency observations of radio relics and halos: windows to the non-thermal phenomena

- Marie-lou Gendron-Marsolais: Probing the non-thermal emission in Abell 2146 and the Perseus cluster with the JVLA
- Gabriele Giovannini: Radioastron observations of the jet launch region in 3C84
- Monica Orienti: On the radio and gamma-rays connection in extragalactic relativistic jets
- Françoise Combes: Molecular gas filamentary structures in galaxy clusters
- Anna Lia Longinotti: Ultra fast outflows, and their connection to accretion and ejection processes in AGNs
- Debora Sijacki: AGN feedback: from $z \sim 6$ protoclusters to massive galaxy clusters in the local Universe
- Christopher Reynolds: An X-ray view of the active galactic nucleus in NGC1275
- Jeremy Sanders: The deep Chandra view of the core of the Perseus cluster
- Takayuki Tamura: High energy resolution X-ray spectroscopy of the Perseus core with Hitomi
- Eugene Churazov: gas structure and dynamics in galaxy clusters;
- Irina Zhuravleva: AGN-driven Perturbations in the Hot Gas in the Perseus Cluster
- Eleonora Torresi: Gamma-ray emission in radio galaxies, from MeV to TeV
- Denise Gabuzda: Magnetic fields in relativistic jets
- Alexander Tchekhovskoy: Black hole accretion and relativistic jets

Sessions and chairs

- I. Black Hole masses: Geoffrey Bower
- II. Black Hole vicinity, theory and simulations: Sasha Tchekovskoy
- III. Black Hole vicinity, observations: Denise Gabuzda
- IV. Past and future legacy: Christine Jones
- V. Radio observations of Perseus & clusters: Melanie Johnston-Hollitt
- VI. VLBI observations of 3C 84: Hiroshi Nagai
- VII. 3C 84 and the radio-gamma connection: Rodrigo Nemmen
- VIII. Outflows and feedback (1): Elisabete de Gouveia Dal Pino
- IX. Outflows and feedback (2): Raffaella Morganti
- X. Outflows and feedback (3): Feng Yuan
- XI. Poster presentations: Monika Moscibrodzka
- XII. X-ray observations of 3C84 & AGNs: Francesco Massaro
- XIII. X-ray observations of Perseus & clusters: Eugene Churazov
- XIV. Galaxy cluster dynamics and energetics: Irina Zhuravleva
- XV. The AGN-cluster interaction in Perseus: Françoise Combes
- XVI. Gamma-ray observations of 3C 84 & AGNs (1): Paola Grandi
- XVII. Gamma-ray observations of 3C 84 & AGNs (2): Monica Orienti
- XVIII. Magnetic fields and relativistic jets: Keiichi Asada
- XIX. Simulations of jets and winds: Gabriele Giovannini



(ii) Summary of the scientific highlights of the meeting

As intended, the symposium has seen a broad participation in several domains, with science highlights ranging across several wavelengths and spatial scales, and including observations, interpretation, numerical simulations and pure theory. 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 this 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 breakthrough, 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 system 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.



(v) Executive Summary of the Meeting to be published in the IAU website.

The organisers have been particularly satisfied of the diversity of the involved communities, as we believe is really in the spirit of IAU symposia. Many participants have explicitly stated the feeling that they were hearing and learning something new from colleagues working on similar topics but with different methodology and goals. This was put in sharp contrast to the feeling of communities “talking to themselves” that is sometimes felt in other more focused meetings. The quality and diversity of the talks and speakers was also excellent, with a fair representation of different astrophysical backgrounds, ages, genders, and geographical provenance, but with the common trait of giving excellent presentations. The social programme has also helped to create the conditions for 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.

Our SOC was composed of 16 scientists from nine countries in four continents, with the four chairs from Brazil (Elisabete de Gouveia Dal Pino), Italy (Marcello Giroletti), Japan (Hiroshi Nagai), and the United States (Christine Jones). The SOC made a selection of Invited Speakers so to balance the science topics and to represent a wide range in age, gender, and geographical distributions. The invitation acceptance rate has been very high and the final list (presented in Sect. i of this document) included 12 females and 10 males, from 13 different countries, all of which delivered excellent presentations on observational, theoretical, and technological topics. Most invited talks were the opening presentations in each session. We arranged sessions so that the program would be varied in topics but not chaotic, mixing the small and the large scale, the observations and the interpretation and always keeping the door open to the interplay between the different sizes and methodologies. As a consequence, most attendees effectively participated in all sessions on each day.

Besides the 22 presentations on invite, we scheduled 53 oral contributions of 20 minutes each. Having relatively long contributed talks was generally perceived positively as it allowed the speakers to develop their ideas in depth and the audience to have time for discussion at the end. We also want to mention here the excellent work done by the chairing persons, which are also listed in Sect. i. Since the relatively long slots for oral presentations did not allow us to allocate talks to all the participants who had requested them, we also scheduled a poster session, where all the poster presenters had the chance to advertise their paper with a 1' slide each. This was also well attended and most of the presenters found it to be a good opportunity for them. All the posters were also on display in the main conference room throughout the entire duration of the symposium, with a good visibility and opportunity for discussion during coffee breaks. The conference was opened by a welcome from local authorities and by Prof. Tavani in representation of the INAF managing board, and closed by an excellent concluding remarks talk jointly presented by W. Forman, I. Zhuravleva, and E. Churazov.

The generous travel grants offered by the IAU have allowed 25 participants (10 females, 15 males) from 15 different countries to participate in the symposium. All of them presented a contribution in the final program, mostly (60%) a contributed talk. Besides the kind support offered by the IAU, funding was obtained through several channels, including the Italian national institute for astrophysics (INAF), the RadioNet consortium, and the local government of Noto. This has allowed us to keep the regular registration fee as low as 280 €, inclusive of all coffee breaks, lunches on each day and dinners on three evenings, shuttle transportation between the airport and the conference venue, a conference package, a copy of the proceedings in electronic format, and a rich social program (see below). Moreover, we were allowed to set the sessions of the first day in



the historical Tina di Lorenzo theatre downtown Noto, a setting that was greatly appreciated by all speakers of the day.

At the end of the sessions on Monday, the theatre was also the stage for the play “Lu cuntu di Perseu” by the company “Il cuore di Argante”, a show based on the myth of Perseus. This short emotional play was open to all participants and accompanying persons and marked the first (after the welcome cocktail on Sunday night) of a number of events aimed at connecting the astrophysical theme to other branches of human culture. On Tuesday evening, the participants were offered a guided tour of the Baroque palaces in historic downtown Noto; on Wednesday afternoon, the main social excursion took the participants to either historic Syracuse, visiting the archaeological and architectural heritage of what was the birthplace of Archimedes, or to beautiful and naturalistic San Lorenzo beach, based on each participant’s taste; the two groups then merged together for the official conference dinner. On Thursday night, science, music, and food got together in a visit to the INAF 32m radio telescope near Noto, where live jazz music was played while local traditional food was served in a buffet. At the very end of the symposium, on Friday night, participants had the chance to assist to the opening of the yearly traditional *Infiolata*: a cascade of thousands of flowers, expertly arranged on the road, making the vision of the city full of 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 which was then given to each participant, as well as in the adaption of the play on Monday for the international audience. A conference on “The sense of discovery” was offered to the general public on Tuesday night, led by outreach expert Dr. Stefania Varano, and followed by a stargazing session.

The symposium has received visibility on social media through two dedicated accounts (<https://www.facebook.com/PerseusinSicily> and <https://twitter.com/iaus342>), on local newspapers and web pages, and by MediaInaf TV (<https://www.youtube.com/watch?v=YkZdCetYej4>), the institutional outreach channel of INAF. Further details can be obtained on the symposium web site available at <http://www.ira.inaf.it/iaus342/>.

