

Final program

.....Invited review

.....Invited talk

List of invited review speakers:

Letizia Stanghellini

Grażyna Stasińska

Lucy Ziurys

Paolo Ventura

Martin A. Guerrero

Session/discussion chairs:

Chair: Magda Arnaboldi

Chair: Albert Zijlstra

Chair: Griet Van de Steene

Chair: Denise R Gonçalves

Chair: Miriam Penã

Chair: Carmen Sánchez Contreras

Chair: Laurence Sabin

Chair: Jesús Toalá

Chair: Bruce Balick

Chair: Miguel Santander-García

Chair: Krzysztof Gęszicki

Female/male invited review: 3/2

Female/male invited talk: 6/5 (with Joel Kastner counted: 6/6)

Female/male contributed talk: 34/13

Sunday, 3rd September

18:00 - 21:00 Registration and welcome cocktail party at Collegium Novum

Monday, 4th September

8:45 - 9:00 Welcome address

Chair: Magda Arnaboldi

Session I: Focus on PN as populations and as tools (extragalactic PN)

9:00 – 9:45 **Letizia Stanghellini**: Planetary nebulae as probes of abundances and kinematics to trace galaxy evolution

9:45 – 10:00 **Arianna Cortesi**: Planetary Nebula Spectrograph survey of disk galaxies: recovering the origin of lenticular galaxies

- 10:00 – 10:15 **Ana Ennis**: Planetary nebulae as tracers of stellar population properties: unlocking their potential with integral-field spectroscopy
- 10:15 – 10:30 **Martin Bureau**: SIGNALS: A Census of Planetary Nebulae in the Local Spiral Galaxy Population
- 10:30 – 11:00 coffee break/cold drinks
- 11:00 – 11:30 **Souradeep Bhattacharya**: Survey of Planetary Nebulae in the Andromeda galaxy (M31)
- 11:30 – 11:45 **Diego Hernandez-Juarez**: Analysis of distances to planetary nebulae
- 11:45 – 12:00 **Xuan Fang**: GTC Deep Spectroscopic Survey of Planetary Nebulae in the Milky Way and M31
- 12:00 – 12:15 **Nicholas Chornay**: Probing the Local Planetary Nebula Luminosity Function with Gaia
- 12:15 – 12:35 **DISCUSSION**
- 12:35 – 13:30 Lunch

Chair: Albert Zijlstra

- 13:30 – 14:00 **Martin Roth**: Integral Field Spectroscopy: a disruptive innovation for observations of Planetary Nebulae and the PNLF
- 14:00 – 14:15 **Azlizan Adhyaqsa Soemitro**: Precise spectrophotometry for PNLF distances: the case of NGC 300
- 14:15 – 14:30 **Lucas Valenzuela**: PICS: Planetary Nebulae in Cosmological Simulations – Revelations of the Planetary Nebula Luminosity Function from Realistic Stellar Populations
- 14:30 – 14:45 **George Jacoby**: Towards Precision Cosmology With Improved PNLF Distances Using VLT-MUSE
- 14:45 – 15:00 **Saskia Schlagenhauf**: Using adaptive-optics assisted MUSE observations to measure galaxy distances with the Planetary Nebulae luminosity function
- 15:00 – 15:30 coffee break/cold drinks
- 15:30 – 15:45 **Magda Arnaboldi**: Kinematics of the diffuse intragroup/intracluster light in groups and clusters of galaxies in the Local Universe (within 100 Mpc)
- 15:45 – 16:00 **Minia Manteiga**: A new population of stars between the Milky Way and the Large Magellanic Cloud from Gaia DR3 astrometry on Post-AGB star Candidates
- 16:00 – 16:15 **Quentin Parker**: When the Stars Align: A remarkable 5σ Concordance of Planetary Nebulae Major Axes in the Centre of our Galaxy
- 16:15 – 16:45 **Johanna Hartke**: Planetary nebulae populations in the haloes of nearby massive early-type galaxies
- 16:45 – 17:05 **DISCUSSION**
- 17:05 – 17:50 **POSTER VIEWING**

Tuesday, 5th September

Chair: Griet Van de Steene

Session II: Focus on PN abundances/chemistry/dust

- 9:00 – 9:45 **Grażyna Stasińska**: On determining the chemical composition of planetary nebulae.

- 9:45 – 10:00 **Michael Richer**: The structure of emission lines in planetary nebulae at very high spectral resolution
- 10:00 – 10:15 **Toshiya Ueta**: Precise Determination of Extinction Correction and Plasma Diagnostics - **online**
- 10:15 – 10:30 **Nicholas Sterling**: The s-process at subsolar metallicity: a case study of Magellanic Cloud planetary nebulae - **online**
- 10:30 – 11:00 coffee break/cold drinks
- 11:00 – 11:30 **José Eduardo Méndez Delgado**: The abundance discrepancy in ionized nebulae: which are the correct abundances?
- 11:30 – 11:45 **Christophe Morisset**: Abundance determination in PNe: how to deal with chemical inhomogeneities.
- 11:45 – 12:00 **M. Belén Mari**: Statistical framework for analyzing the low-ionization structures in planetary nebulae
- 12:00 – 12:15 **Stavros Akras**: What do we really know about low-ionization structures?

Chairs: Denise R Gonçalves / Miriam Peña

12:15 – 12:35 **DISCUSSION**

12:35 – 13:30 Lunch

Chair: Carmen Sánchez Contreras

13:30 – 14:00 **Hektor Monteiro**: Probing the physical and chemical properties of planetary nebulae using high-precision photoionization modeling

14:00 – 14:15 **Roger Wesson**: JWST imaging and spectroscopy of the Ring Nebula

14:15 – 15:00 **Lucy Ziurys**: Remarkable Chemical Complexity in Planetary Nebulae: A Molecule and Dust Perspective – **online**

15:00 – 15:30 coffee break/cold drinks

15:30 – 15:45 **John Black**: Planetary nebulae as astrophysical laboratories via ultraviolet absorption spectroscopy

15:45 – 16:00 **Denise R. Gonçalves**: CO - probing the molecular state of the low- ionization jets in PNe

16:00 – 16:15 **Paula Moraga Baez**: Observations of Molecular Line Emission from Nearby, High-excitation Bipolar Planetary Nebulae with ALMA and HST

16:15 – 16:30 **Miguel Santander-García**: Morpho-kinematical modelling in the molecular zoo beyond CO: the case of M 1-92

Chairs: Denise R Gonçalves / Miriam Peña

16:30 – 17:05 **DISCUSSION**

17:05 – 17:50 **POSTER VIEWING**

Wednesday, 6th September

Chair: Laurence Sabin

Session III: Focus on PN chemistry/dust

9:00 – 9:30 **Flavia Dell'Agli**: Dust production from low- and intermediate-mass stars: insights from post-AGB stars and planetary nebulae

- 9:30 – 9:45 **Teresa Huertas Roldán:** Deep radio observations of (proto-) planetary nebulae
- 9:45 – 10:00 **Sun Kwok:** Synthesis of Complex Organics in Planetary Nebulae
- 10:00 – 10:15 **Jan Cami:** A detailed IR study of the fullerene-rich planetary nebula Tc 1
- 10:15 – 10:30 **Domingo Aníbal García Hernández:** NanoSpace: networking as a tool to understand carbon molecular nanostructures in planetary nebulae
- 10:30 – 11:00 coffee break/cold drinks

Chair: Jesús Toalá

11:00 – 11:30 Mikako Matsuura: Dust formation in AGB stars and planetary nebulae

11:30 – 11:45 **Sophia Derlopa:** Planetary Nebula NGC 2818: 3D morphology and new detected structures

11:45 – 12:00 **Javier Alcolea:** The Red rectangle: a thin disk with big grains

12:00 – 12:15 **Luis Carlos Bermúdez-Bustamante:** Dust formation during the interaction of binary stars by common envelope.

12:15 – 12:35 **DISCUSSION**

12:35 – 13:30 Lunch

14:00. Excursions

Thursday, 7th September

Chair: Bruce Balick

Session IV: Focus on stellar evolution, evolutionary scenarios, including binaries

9:00 – 9:45 Paolo Ventura: The evolutionary path from the AGB to the PN phases: certainties and open issues

9:45 – 10:00 **Dimitris Souropanis:** Planetary nebulae hosting accreting white dwarfs: A possible solution for the mysterious cut-off of Planetary Nebula Luminosity Function?

10:00 – 10:30 Nicole Reindl: At the heart of the matter: current and future studies of central stars of planetary nebulae

10:30 – 11:00 coffee break/cold drinks

11:00 – 11:45 Martín A. Guerrero: Nova remnants, the high-velocity twins of planetary nebulae

11:45 – 12:00 **Rodolfo Montez:** Hot Bubbles in the Chandra Planetary Nebulae Survey

12:00 – 12:15 **Mark Siebert:** Clues to the PPN Chemical Evolution: The Unique Molecular Environment of V510 Pup

12:15 – 12:35 **DISCUSSION**

12:35 – 13:30 Lunch

Chair: Miguel Santander-García

13:30 – 14:00 Hyosun Kim: AGB-pPN Evolution: Whorled Patterns and Stellar Companions

14:00 – 14:15 **Roberto Mendez:** NGC 1514 and the post-AGB mass-luminosity relation

14:15 – 14:30 **Karlis Pukitis:** Monitoring of dynamical processes in outer atmospheres of cool protoplanetary nebulae

14:30 – 14:45 **Jesús Toalá:** Emerging planetary nebulae in 3D spiral pattern

14:45 – 15:00 **Jackeline Suzett Rechy-García:** The discovery of hidden jets in planetary

nebulae

15:00 – 15:30 coffee break/cold drinks

15:30 – 15:45 **Guillermo Quintana-Lacaci**: History of two mass loss processes in VY CMa.
Fast outflows carving older ejecta - **online**

15:45 – 16:00 **Bruce Balick**: NGC 6302: The Tempestuous Life of a Butterfly

16:00 – 16:15 **Carmen Sánchez Contreras**: Zooming on the emerging ionized regions of
pPNe with ALMA

16:15 – 16:30 **Raghendra Sahai**: High-Speed Outflows and Dusty Disks during the AGB to
PN Transition

16:30 – 16:45 **DISCUSSION**

17:00 – 17:50 **POSTER VIEWING**

19:15 Conference dinner

Friday, 8th September

Chair: Krzysztof Gęszicki

Session V: Focus on shaping, outflows, connection with transients

9:00 – 9:30 **Tomek Kamiński**: Red novae, stellar mergers in binary and triple systems,
and bipolar nebulae

9:30 – 9:45 **Andreas Ritter**: From an amateur PN candidate to the Rosetta Stone of SN
Iax research

9:45 – 10:00 **Noam Soker**: The common physics to planetary nebulae and supernova
progenitors and remnants

10:00 – 10:15 **Marcin Hajduk**: Radio continuum observations of born-again objects V4334
Sgr and V605 Aql

10:15 – 10:30 **Borja Montoro Molina**: Spectroscopic Investigation of Born-Again Planetary
Nebulae

10:30 – 10:45 **Lea Planquart**: Spectroscopic monitoring of V Hydrae: a binary eclipsed by a
jet?

10:45 – 11:15 coffee break/cold drinks

Chairs: Albert Zijlstra/Magda Arnaboldi

11:15 – 11:45 **Arianna Cortesi**: Astronomical outreach and education in marginalized and
indigenous communities: astronomy as a tool for social development

11:45 – 12:15 **Joel Kastner**: Summary talk

12:15 – 12:45 Town hall

IAU Symposium 384: Planetary Nebulae: a Universal Toolbox in the Era of Precision Astrophysics. 04 to 08 September 2023, Krakow, Poland

Science Highlights

Planetary nebulae trace the end phase of the life of low-mass and intermediate-mass stars, at the crossroads of stellar and galactic evolution. They result from AGB mass loss, itself a poorly understood process. The bright nebulae are significant drivers of the chemical evolution of galaxies: they are the dominant source of carbon in today's Universe, a significant source of nitrogen, and a source of half of all elements heavier than iron. Planetary nebula populations have been observed at distances of tens of Mpc, where the underlying lower-mass stars themselves are undetectable. They are important tracers of old stellar populations in galaxies. The beautiful nebular shapes have led to in-depth hydrodynamics studies with applicability in many fields. The central stars contain a large population of close binaries, which connect planetary nebulae to the developing field of transients. Astronomy outreach, publicity and education have made significant use of planetary nebulae.

IAU Symposium 384 covered all aspects of planetary nebula research. There are major advances in the field of extragalactic planetary nebulae. This is driven both by instrumentation, especially integral-field spectroscopy, and by improved models for the much-improved post-AGB stellar evolution. A number of talks show that the planetary nebula luminosity function (PNLF) can be explained well with realistic models for stellar populations, and allows for high-precision distance determinations. GAIA has opened up the study of the PNLF in our galaxy. A surprise was the new confirmation of alignment between planetary nebulae in our galactic bulge, perhaps driven by interaction with the Galactic magnetic field.

New JWST images of two Galactic planetary nebulae showed a wealth of structure. Both nebulae contained more than 10^4 dense globules, seen in H_2 but embedded in the ionized region, containing as much mass as the ionized gas. High-precision 3-d photoionization modeling is required to study such objects, aided by machine learning. The detection of internal extinction provides an opportunity for a major advance. S-process elements are being studied in the objects where many of them are formed: some abundances (e.g., Kr) are enhanced by as much as factor of 10. Many molecules are being found, including complex organics and fullerenes.

The kinematical structure of PNe ('morpho-kinematics') is being studied combining telescopes such as ALMA with 3-d radiative transfer models. They have revealed knots and hidden jets. The central stars are also being studied. Ultra-high excitation lines from species such as O VIII are being found in these hot white dwarfs, with unclear excitation mechanism. Evolutionary models for the AGB and post-AGB allow the simulation of planetary nebula populations and their dust emission. This was successfully done for the Magellanic Clouds, work that earned Silvia Tosi the poster prize. These models also feed into PNLF simulations.

There is strong evidence that many PN central stars have not evolved as single stars. There are strong links to other stellar categories, including novae and stellar mergers, processes that are now found to play important roles in some PNe. This opens an important future field with impacts in many areas of astrophysics.

IAU Symposium 384: Planetary Nebulae: a Universal Toolbox in the Era of Precision Astrophysics

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IAU Symposium 384 was the first IAU-sponsored meeting on planetary nebulae since 2016. It was coordinated by IAU Division H, and endorsed by Divisions C, G and J. The meeting was proposed by IAU Commission H3. The SOC was chaired by Orsola de Marco, Ryszard Szczerba and Albert Zijlstra; the LOC was chaired by Ryszard Szczerba and Staszek Zola. Financial support was received from the IAU and from the Polish Ministry of Education and Science under the program Excellent Science II.

The Symposium covered all aspects of planetary nebula research. Invited Reviews covered planetary nebulae as tracers of galaxy evolution, chemical abundances of planetary nebulae, molecules and dust in planetary nebulae, stellar evolution and planetary nebulae, Nova remnants and planetary nebulae. The planetary nebulae luminosity function was discussed in several talks: its origin from realistic stellar populations was discussed. It is a powerful tool for precision distance determination for a variety of galaxy types and for the study of stellar populations in galactic haloes. New observational techniques and instruments are being used, including integral field spectroscopy and adaptive optics. For Galactic planetary nebulae, molecular studies with ALMA and other telescopes are being used to study the morphology and kinematics of planetary nebulae. Complex molecules are seen, including organic molecules and fullerenes. New JWST images were presented of planetary nebulae, showing large numbers of highly dense, compact globules seen in molecular hydrogen by embedded in the ionized regions. High speed outflows and hidden jets were presented. There were several talks on transients and mergers, which created nebulae very similar to planetary nebulae, including the newly found counterpart to the supernova of 1181. There was also an invited talk on outreach program in deprived areas in Brazil, using planetary nebulae. All sessions included extended discussion sessions.

The Symposium was attended by over 100 people from 26 countries. A few people attended on-line, and two of the talks were given on-line, but the emphasis was on face-to-face talks and discussions. The IAU funding was used to support students and early-career scientists. 20 people from 15 countries received IAU travel grants. The prize for the best poster was won by Silvia Tosi, a PhD student from Italy.



The Symposium was held at the beautiful Collegium Novum of the historic Jagiellonian University in the Old Town of Krakow. The city of Krakow combines a strong historical, cultural and astronomical heritage. Nicolaus Copernicus studied mathematical astronomy at the Jagiellonian University in the 1490's; this year was the 550-year anniversary of Copernicus' birth. Krakow dates to the 7th century; the Old Town was one of two cities on the very first UNESCO World Heritage list. Many of the old buildings and churches in the city centre still survive. The Jewish quarter retains sacred architecture and a living Jewish culture which is unparalleled in Poland. The Yiddish culture was celebrated with a concert at the conference dinner.



The meeting hall at the Collegium Novum of the Jagiellonian University. Photo from the Jagiellonian University archive, reproduced by their permission