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COMMISSION H3 Planetary Nebulae

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TRIENNIAL REPORT 2018-2021

1. Background

An IAU working group on Planetary Nebulae has existed since 1967, with as main task to organize regular symposia in the field. The IAU Commission on planetary nebulae started in August 2015 under the leadership of Letizia Stanghellini. In 2018 Albert Zijlstra took over as commission president, with Orsola de Marco as vice-president. The commission currently has 84 members.

Planetary nebulae trace the end phase of the life of low-mass and intermediate-mass stars. These stars evolve up the giant branches, and eject their envelopes at the tip of the Asymptotic Giant Branch (AGB). The star, now reduced to the C/O or Ne/O core, quickly evolves to higher temperatures, before nuclear burning ceases and the remnant joins the white dwarf cooling track. The expanding ejecta become ionized by the hot star, and the ionized ejecta forms the planetary nebula. Planetary nebulae are short lived (but much loved), are very bright, and can be detected out to very large distances where the original star would have been undetectable. The emission comes out in the form of strong forbidden lines, which further aids the visibility.

Planetary nebulae provide excellent tools for several important scientific problems, in stellar astrophysics, the interstellar medium and galaxies. The Commission supports research in planetary nebulae with particular emphasis on its applications in other fields.

(*a*) The ejection mechanism on the AGB is still very poorly understood. PNe provide a unique record of the mass-loss history of the progenitor star.

(*b*) The shaping of the ejecta is a topic of high scientific interest. PNe show a large variety in shapes, and in their structures can combine tori, disks, jets (sometimes with precession), globules, clumps and tails, halos and asterospheres. PNe are used to study the evolution of the structures, both using observations and hydrodynamic models. The origins of the asymmetries are studied, with a main focus on binary interaction, angular momentum, and magnetic fields.

(*c*) Common-envelope evolution plays an important in some PNe. A fraction of PNe contain short-period binaries with periods of order 1 day, which have passed through a common-envelope phase. The mass ejection during a common envelope is still very uncertain, and PNe are the best tracers of the end phase of their evolution, in terms of the final orbit and the ejecta.

(*d*) Abundances of light elements can be readily measured using both forbidden and recombination lines. These trace the abundances of the progenitor star, and any nuclear

processing. PNe provide accurate abundances tracers also for older stellar populations, and can be used in galaxies where HII regions are absent.

(*e*) PNe are strong dust emitters, and they show many dust components including some not seen elsewhere. They also contain large PAHs molecules and fullerenes. The dust and molecules are known to have formed in situ. PNe can thus be used to study their formation and evolution,

(*f*) The bright lines allow for accurate velocity determination to within a few km/s. PNe are used to measure velocity distributions of stellar populations in distant galaxies, to measure galaxy potentials and dynamics.

2. Developments within the past triennium

The most important task of the commission is to arrange for a general symposium covering the entire research area of planetary nebulae. These have been held approximately every 5 years, and are organized by and on behalf of the IAU commission and its predecessor, the IAU working group on planetary nebulae. The last such meeting was the IAU Symposium 323 - Planetary Nebulae: Multi-wavelength probes of stellar and galactic evolution, held on 10-14 October 2016, in Beijing, China.

The next general PN symposium is planned for June 2022, to be held in Krakow, Poland, although the dates may need to reconsidered if travel restrictions continue. The SOC has been appointed. The symposium aims to develop the connections with stellar and galactic evolution, and to put the research of planetary nebulae into the context of modern, integrated astrophysics.

The main science topics include:

(*a*) Stellar evolution: the AGB-white dwarf connection; stellar winds; binary interaction; eruptive events;

(*b*) Hydrodynamics: shaping of stellar winds, dusty winds, jet launching, jet-nebula interaction; the asterosphere; shaping by binary interactions;

(*c*) Astrochemistry: molecular evolution; PAHs and fullerenes; dust formation and destruction; PDRs;

(*d*) Abundances: atomic physics; photo-ionization and shocks; the forbidden-line vs recombination line abundance discrepancy; primary production and enrichment;

(*e*) Structure and evolution of galaxies: star formation histories, abundance gradients, structural components, galaxy dynamics, hierarchical mass assembly.

(*f*) Outreach and Education

The city of Krakow in Poland combines a strong historical, cultural and astronomical heritage. The city 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 has a living Jewish culture which is unmatched anywhere in Poland. The Symposium will be held at the main building of the historic Jagiellonian University in the Old Town, where Nicolaus Copernicus studied mathematical astronomy in the 1490's. Copernicus' personal original copy of De Revolutionibus is in the Jagiellonian library.

The comprehensive symposia are not the only meetings in the field. There are other meetings on particular aspects of planetary nebulae. An important series is the APN meetings which focus on shaping mechanisms in post-main-sequence stellar outflows. The commission is represented on the core SOC of the APN meetings. The commission has also worked on making planetary nebulae to be considered as relevant to other meetings.

In the past three years the web page of the commission has been moved to the IAU, on order to ensure continuity. A new initiative is to publish research primers, to help

research students with pointers at relevant research. Primers have been published on the evolution of the central stars Miller Bertolami 2020, and on planetary nebula surveys Parker 2020. They have been published on the commission web site.

The commission has been involved in discussions on popular names of astronomical objects. These are not regulated, for clear reasons, but there is a need to avoid names that are objectionable. A clear example is that of the so-called Eskimo nebula. The use of this particular name is discouraged by the commission. It is part of a wider subject and we recomend that the use of informal object names in the literature should be addressed by a wider working group in the IAU.

References

Miller Bertolami, M. 2020, A primer in Central Stars of Planetary Nebulae and related objects. https://www.iau.org/static/science/scientific_bodies/commissions/h3/primers/planetarynebulastellarevolution.pdf

Parker, Q.A, 2020 Planetary Nebulae and How to find them – A Review. arXiv:2012.05621. https://www.iau.org/static/science/scientific_bodies/commissions/h3/primers/pne-surveys.pdf