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Editorial

Preface of "Asymmetric Planetary Nebulae 8e"

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Planetary nebulae (PNe) are the progeny of low- and intermediate-mass stars, at the exact time in their late evolution when they eject their hydrogen-rich envelopes and start their transition towards white dwarfs. It became evident in the late 1980's and mid 1990's that the simple notion of round PNe, based on the naïve assumption that the mass loss from their progenitor stars was mostly spherical, was not appropriate. The Asymmetrical Planetary Nebulae meeting series, which started in Haifa (Israel) in 1994, has attempted to provide a better understanding the shaping mechanisms of non-spherical PNe, including the phenomena of bipolar lobes resembling an hourglass and fast collimated outflows, i.e., jets. This volume presents the results of the eighth meeting in this series held in Granada, Spain, in October 2021.

The Scientific Organizing Committee of the meeting recognized the similarities between the shaping mechanisms of PNe and those involved in related nebulae, including nebulae around evolved massive stars, symbiotic stars, Herbig-Haro objects, novae, supernovae, and other eruptive objects and transients. Accordingly, the scope of the meeting was broadened to include outflows from evolved stars. COVID-19 prevented a physical gathering, so it was held virtually instead. The final title of the meeting, the Asymmetrical Post-Main Sequence Nebulae 8 e2021, or APN8 e2021 in short, included all these changes in its original scope and operation.

The APN8 e2021 meeting was then organized to present discussions on the morphologies and dynamics (i.e., the nebular architecture) of nebulae across stellar mass and wavelength and on including time evolution (i.e., the nebular sequences) of their physical structures. Furthermore, an understanding of the engine of the nebular shaping was key; thus, the different mass loss mechanisms at different evolutionary phases and across stellar mass, as well as their effects on the wind symmetry, were considered for discussions during the meeting.

The meeting gathered over 130 astrophysicist all over the world on a virtual meeting that was run from Granada, Spain, from 4 to 8 October 2021. Invited and contributed live talks, as well as short e-poster presentations, covered a number of topics arranged on sessions on hydro-dynamical simulations and observations of PNe, proto-PNe and born-again PNe, novae, and massive stars. Sessions were also dedicated to the important common envelope phase and to the innovative integral field spectroscopic technique.

The contributions compiled in this peer refereed volume represent a selection of new results presented during those meeting sessions. They showcase a number of different observational techniques across a wide spectral range, theoretical simulations, and shaping processes at different phases in the formation of a PN and across different progenitor masses (including massive stars).

Indeed, massive stars were one of the hot topics during the meeting. This volume includes one observational work and two simulations on the extended emission around massive stars. On the observational side, Liimets et al. present their investigation on

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extended shells around a sample of B[e] stars, i.e., massive B type emission line stars that experience heavy mass loss and significant ejection events that deposit huge amounts of mass and energy into their circumstellar media. The authors follow up previous Hα imaging surveys to assess the possible evolution in the plane of the sky of the few nebulae known around B[e] stars. There is also a new search for extended shells around B[e] stars using images in Hα and selected nebular lines to detect nebular structures around 15 more objects, resulting in a total of 27 B[e] stars possessing large-scale nebula. Here, they extensively discuss the nebulae around the two massive supergiants MWC137 and MWC 314, and the unclassified B[e] star MWC 819.

On the numerical side, Dwarkadas investigates the effects of photo-ionization on the formation of wind-blown nebulae around massive stars, demonstrating the important changes in the circumstellar gas dynamics, shell symmetry, and in the formation of filaments and clumps induced by the photons from the star. Similar effects can be expected for PNe. On the other hand, Kashi and Michaelis presented numerical simulations of the colliding wind structure in a colossal binary system. Their experiments reveal that the shape of the ejecta mainly depends on the momentum ratio, orbital motion, and orbital distance between the stars. The mass accretion rate onto the secondary is found to vary with the momentum ratio of the winds.

Integral field spectroscopic observations also became a hot topic during the meeting. Danehkar presented the kinematics in the Hα and [N II] emission lines of a sample of PNe around the hydrogen-deficient stars. The study shows that they mostly have elliptical morphologies, with collimated outflows present in many of them. Meanwhile Monreal-Ibero and Walsh presented a thorough investigation of the elliptical PN IC 418 using the multi-unit spectroscopic explorer (MUSE) at the ESO Very Large Telescope. The extinction, electron density, and electron temperature maps reveal the fine details of this well-known PN.

The interpretation of integral field spectroscopic observations poses a challenge that requires new analysis tools and strategies. Ueta noticed the interconnection between the extinction correction and plasma diagnostics, which is especially true in the context of spatially-resolved 2D spectroscopy. An iterative method was proposed to seek a converged solution of both extinction and physical conditions. On the other hand, Akras et al. presented the Python software "SATELLITE" (Spectroscopic Analysis Tool for intEgraL fieLd unIt daTacubEs) to be used in the analysis of integral field spectroscopic data cubes. Its application to VIMOS and MUSE data cubes of four Galactic PNe reveals that knots are characterized by strong emission from neutral gas that is weak or even absent from the main nebula. Their spectra thus resemble photodissociation regions.

From an observational point of view, the meeting showcased a number of observations in multiple spectral ranges and evolutionary stages of PN formation and evolution. Sahai et al. described their X-ray surveys of UV-emitting AGB stars. The hardest UV emitters have variable X-ray emission characterized by high plasma temperatures indicative of accretion associated with a close binary companion, whereas the softest UV emitters may also be binaries with active but weak accretion. On the other side of the spectral range, Uscanga et al. used millimeter observations to determine the molecular CO content of maser-emitting PNe, whereas Andriantsaralaza et al. investigated the deviation from spherical symmetry in the CO-emitting circumstellar envelopes of 70 AGB stars with the Atacama Compact Array, as part of the DEATHSTAR project. About one third of the sources are found to be likely aspherical, with large-scale asymmetries. This large project complements the detailed NOEMA observations (half arc-second resolution) of M 1–92 (Minkowski's Footprint) presented by Alcolea et al. M 1–92 is a textbook example of a massive pre-PNe and this study has revealed a wealth of molecules and confirmed the shock excitation of the nebula, also suggesting that the AGB evolution was likely interrupted by a huge mass loss event.

In addition to the DEATHSTAR project, another three contributions focus on the analysis of a large sample of objects. Santander-García et al. tested the hypothesis that PNe

ejected after a common envelope phase should be larger than those evolving from a single star. They found that only a post-common envelope PNe arising from double-degenerate systems are considerably larger. Meanwhile Parker et al. presented preliminary findings on the population of PNe whose central stars have been identified in the HASH catalogue, adding another 400 stars to the previously known sample of about 600 while adding a cautionary note on Gaia CSPN identifications. Finally, Sarkar and Sahai modeled the spectral energy distributions (SEDs) of a selected sample of post-RGB and post-AGB stars in the Large Magellanic Cloud (LMC) to quantify the total dust mass and constrain the compositions and sizes of the dust grain. Their shells are found to be significantly larger than their disks. Surprisingly, the dust of some post-RGB sources appears to be carbon-rich, supporting the hypothesis of binary interactions and leading to the formation of dusty post-RGB objects.

The last observational work described here is that presented by Fragkou et al. Further evidence on the physical association of PN BMP J1613–5406 with the open cluster NGC 6067 was given. Planetary nebulae (PNe), i.e., the physical members of Galactic open clusters, are powerful probes that can precisely and crucially determine their distance and their initial mass on the main sequence. The spectral data permit the calculation of a precise radial velocity and the reddening of the PN, presenting a tight consistency with those of the cluster parameters. Since the cluster has a turn-off mass of around 5 solar masses, a PN initial mass of around 5.6 solar masses is indicated.

A summary of the meeting ends with two theoretical contributions on the formation of PNe and their small-scale structures. Icke presented numerical simulations of the formation of PNe with cylindrical shapes. He proposes that the source of the outflow is the evaporation of the disk at its base. Meanwhile, Raga et al. presented axisymmetric simulations of a high velocity clump in a photoionized region traveling through a uniform low-density environment, but also through a high-density medium, before then emerging into a low-density one. Only in the second case can the simulations form axial tails.

The APN8 e2021 was a real celebration of the research on the formation of asymmetrical nebulae around post-main sequence stars. More than 130 researchers had the opportunity to exchange their latest works and discuss them virtually. We are now hoping for a new future meeting in Granada before end 2024, with in-person attendance, where the community will present new progress on this topic, hopefully advancing in our theoretical understanding and contributing the new observational opportunities provided by ALMA, JWST, and instruments on the largest ground-based telescopes.

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