DO THE VARIOUS TYPES OF PNE KNOTS DIFFER IN TERMS OF THEIR PHYSICAL PROPERTIES? THE CASE OF NGC 7662

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Abstract

Years ago we have compiled all the available optical data in the literature to build a comprehensive classification of the low-ionization structures (LIS), as knots, jets and jet-like structures in planetary nebulae (PNe). This classification highlighted a number of questions that 6 years later still remain open, such as, what is the role of magnetic fields and of the binary systems on the formation of collimated LIS, or, how do collimated low-velocity LIS survive throughout the PNe evolution? Other very puzzling properties were found in a few cases and need to be explained: i.e., the fact that highly supersonic LIS are mainly photoionized (e.g., in NGC 7662 and NGC 7009) or the lack of significant density contrasts found in collimated and isolated knots. In an attempt to provide an answer to the questions above we have undertaken a systematical exploration of the physical properties of the LIS. By using our own optical long-slit spectra for 20 PNe, we have estimated the electronic temperature and density of the LIS and compared them with those of the their surrounding nebula. Here we discuss our newly found correlations between the type of the LIS and its physical properties for NGC 7662.

Key Words: planetary nebulae: general — planetary nebulae: individual (NGC 7662) — ISM: jets and outflows

1. THE CHARACTERIZATION OF LIS IN PNE

The PNe macro-structures, easily seen in Hα and [O III], are: (i) the rim, that results from the AGB and post-AGB winds interaction (Kwok et al. 1978); (ii) the attached shell, whose density structure is defined by the ionization front (IF) (Mellema 1994; Villaver et al. 2002); and (iii) the halo, which is the ionized AGB matter (Villaver et al. 2002).

On the other hand, small-scale structures of PNe (the LIS) can tell us much about the formation and evolution of PNe, i.e., shedding light on: (i) the collimation processes; (ii) the effect of the IF on the fossil AGB features; (iii) the mass-loss processes during the AGB and post-AGB phases; and (iv) whether or not disks and magnetic fields are needed to explain PNe jets. Moreover, does the presence of LIS affect the chemical enrichment given by low- to intermediate-mass stars? So far, we have investigated different aspects of this project, such as, the optical morphology and kinematics of LIS (Corradi et al. 1999, 2000a,b; Gonçalves et al. 2001; Gonçalves 2004), the physical and chemical properties of a few PNe that contain LIS (Gonçalves et al. 2003, 2004, 2006; Gonçalves 2004); and we just started to investigate the LIS’s near-IR properties.

In short, what we already know about these structures (knots, jets and jet-like structures of low-ionization, either in pairs or isolated) is that around 10% of the Galactic PNe are known to possess LIS. In
Addition: (i) they are indistinctly spread among all the PNe morphological classes; (ii) 50% of these PNe have highly collimated, high-velocity jets, and/or high-velocity pairs of knots (FLIERs); (iii) most of them are mainly photoionized (Goncalves et al. 2001; Gonçalves 2004).

2. THIS SURVEY: SAMPLE AND RESULTS

This survey is based on long-slit optical spectroscopy of medium resolution, taken at the 2.5 m INT, with $\Delta \lambda = 3650 - 7000$ Å, a reciprocal dispersion of 3.11 Å per pixel, and a spatial resolution of 0.70′′ per pixel.

Diagnostic emission line ratios we adopt for this analysis –roughly representing the low- as well as high-ionization regions within a typical PN– are:

- $N_e[S\ II] \propto I(\lambda 6717)/I(\lambda 6731)$;
- $N_e[Cl\ III] \propto I(\lambda 5537)/I(\lambda 5518)$;
- $T_e[O\ III] \propto I(\lambda 4959+5007)/I(\lambda 4363)$;
- $T_e[N\ II] \propto I(\lambda 6548+6583)/I(\lambda 5755)$;
- $T_e[S\ II] \propto I(\lambda 6717+6731)/I(\lambda 4069+4076)$.

In Figure 1 (NGC 7662) we show LIS that share the expansion of the rim and shells, SLOWERs (position angle, PA=248°) as well as the highly supersonic FLETHERs (PA=175°). The symmetrical (inner and outer) pairs of FLETHERs do not differ from each other in terms of $N_e$, but at a given region of the nebula (Northern or Southern) the inner FLETHERs are at least a factor of 2 denser than the outer. Rim densities differ significantly from those of both pairs of FLETHERs. The pair of SLOW-

REFERENCES