COLLIMATED (FAST) WINDS SHAPING THE PLANETARY NEBULAE SH2-71 AND NGC6765

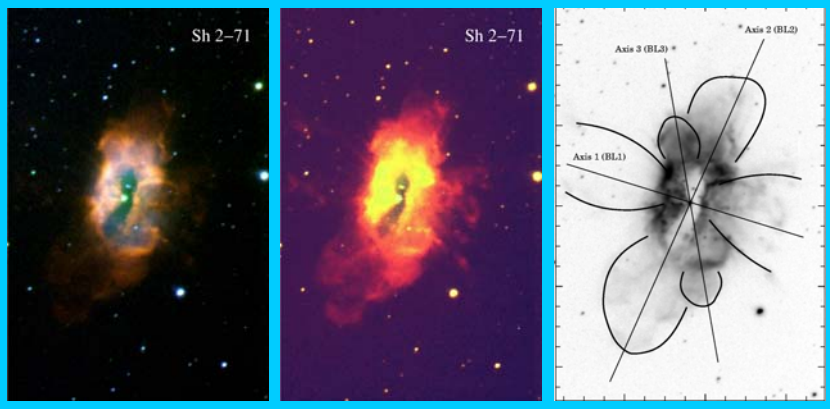
L. F. Miranda[1], S. Ayala[1,4], A. Ulla[2], L. Olguín[3], R. Vázquez[4]

(1) Instituto de Astrofísica de Andalucía (CSIC), Apdo. Postal 3004, E-18080 Granada, Spain
(2) Universidade de Vigo, Departamento de Física Aplicada, E-36310 Vigo, Spain
(3) Dept. of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, NY 10024, USA
(4) Instituto de Astronomía, UNAM, Apdo. Postal 877, 22800 Ensenada, B.C., Mexico

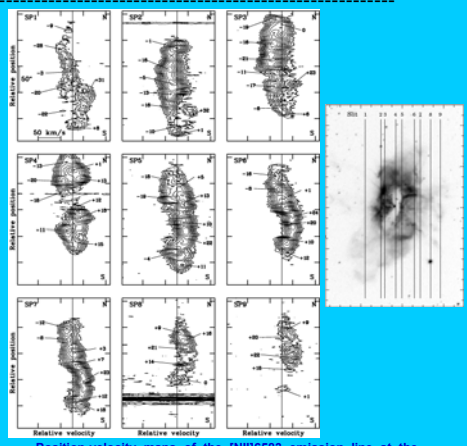
Observations: Direct images of these two PNe were obtained with the 1.5 m telescope at Observatorio de Sierra Nevada, Granada (Spain) on 2002 June and 2004 August. Narrow-band filters centered in Hα, [NII]6583 and [OIII]5007 were used. Seeing was 1.8"-2". Long-slit high resolution spectra were obtained with the Manchester Echelle Spectrometer on 2002 July and 2004 August at the 2.1m telescope at the Observatorio Astronómico Nacional San Pedro Mártir (Mexico). The spectral resolution is 12 km/s, the spatial resolution 1"-2". Long-slit low resolution spectroscopy of NGC6765 was obtained with the 2.1 m telescope of the OAN with the B&C specrograph on 2004 August.

Sh2-71

Introduction. Sh2-71 is a large PN consisting of a bright central region surrounded by many filaments and knots. On the basis of their long-slit spectra and the blue image of the POSS, Cuesta & Phillips (1993, A&A, 270, 379) suggest that the bright central region is an expanding disk. The faint filaments have not been analyzed yet and their kinematics and relationship to the bright central region has not been stablished. The central star is an eclipsing binary consisting of a A7V star (the visible one) and a hot (Te = 200.000 K) companion (the true central star) with a probable period of 70 days (Kohoutek 1979; Phillips & Cuesta 1993; Mikulášek et al. 2004; Sorensen & Pollaco 2004).



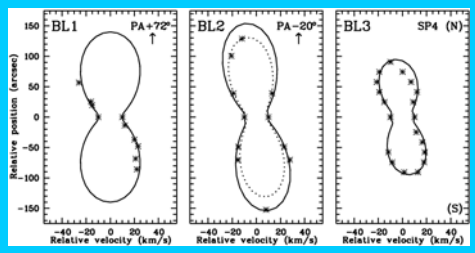
(left and middle) Colour images (red = [NII], green = Hα, blue = [OIII]) in different scales. (right) Schematic representation of the three pairs of bipolar lobes identified in the object overimposed on a grey-scale [NII] image (size 4.2x6.2 arcmin²). North is up, East to the left.



Position-velocity maps of the [NII]6583 emission line at the observed slit positions (sp1-sp9, figure at the right). Numbers are radial velocities (km/s) with respect to the systemic velocity ($V_\odot$ = -2.8 km/s, vertical line).

The data show that Sh2-71 is a multi-axis PN with three pairs of bipolar lobes (BL1, BL2 and BL3) along different axes, being two of them (Axis1 and Axis3) almost perpendicular to each other. Evidence exists for point-symmetric ejection along Axis1. The lobes are seen edge-on and expand at 75 km/s along the polar directions. The deduced kinematical ages (for a distance = 1kpc) are 9500 yr for BL1, 9100 yr for BL2 and 5600 yr for BL3, indicating episodic formation of the lobes. Equatorial structures (rings or toroids) have not been identified in the images and in the kinematics, neither have they been detected in molecular material (CO and H_2, Josselin et al. 2000; Bohigas 2001).

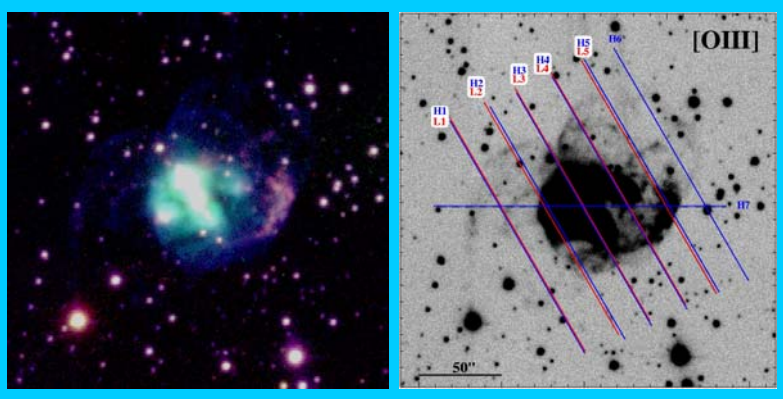
The bipolar lobes of Sh2-71 could be the result of a episodic fast wind which is already collimated at the binary central star of the nebula. The collimation axis should change with time so that the collimated fast wind interacts only with particular regions of a previously ejected (AGB) slow wind. The equatorial expansion velocity of the nebula (10 km/s) is comparable to the typical expansion of AGB envelopes, suggesting that the fast wind has not interacted with nebular regions located along the line of sight. In addition, the eclipsing binary central star defines a direction perpendicular to the orbital plane (that is oriented along the line of sight) compatible with the orientation of the bipolar lobes. Particularly interesting is the very broad (1000 km/s), double-peaked H emission from the central star of Sh2-71 (Sabbadin et al. 1985; Cuesta & Phillips 1993), which could be related to a bipolar outflow from the central star itself (Cuesta & Philips 1993) or, more speculatively, to an accretion disk in the system.



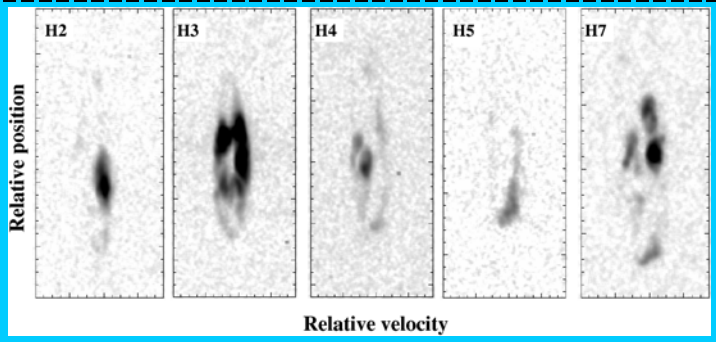
Radial velocity field along the three major nebular axis of the three bipolar lobes obtained from the long-slit [NII] spectra. The lines represente a fit using a Solf & Ulrich (1985) description of a bipolar nebula. The three major axes are located almost on the plane of the sky (< 7°). The polar expansion velocity is similar in the three lobes (70-80 km/s), while the equatorial velocity is only 10 km/s

NGC6765

Introduction. NGC6765 is a high-excitation PN with a peculiar morphology which has not been classified within the typical PN schema of round, elliptical and bipolar PNe (Sabbadin & Hamzaoglu 1981; Manchado et al. 1996). The central star is a hidrogen-poor PG1159 type star (Napiwotzki & Schönberner 1995).



(left) Colour image of NGC6765 (red = [NII], green = Hα, blue = [OIII]). (right) Grey-scale [OIII] image with the slit positions of the high (H) and low (L) resolution spectra. North is up, East to the left.



Grey-scale position-velocity maps of the high-resolution spectra of the [OIII]5007 emission line. The size of each panel is 445 km/s x 135".

$T_{e\,[OIII]}$	17 300 – 12 600 K	$O^+/H^+ x10^{-4}$	2.5-0.9
$T_{e\,[NII]}$	11 100 – 8 900 K	$He^{2+}/H^+ x10^{-2}$	6.7-2.1
$N_{e\,[SII]}$	600 – 50 cm^{-3}	$N^+/H^+ x10^{-5}$	6.1-0.2
c(Hβ)	0.3-0.1	$S^+/H^+ x10^{-6}$	2.8-0.2

Ranges in the physical parameters and ionic abundances deduced from the low-resolution spectra

Our images show that NGC6765 is a bipolar PN consisting of a bright equatorial ring-like structure and two faint bipolar lobes. Two bright blobs are distinguished in the lobes oriented perperdicular to the equatorial ring. In addition, a bow-shock like structure is observed towards the West. [NII] emission line is prominent in the equatorial ring and in the bow-shock like structure.

The high-resolution [OIII] spectra indicate that the ring is observed almost edge-on and expands at 40 km/s. The two blobs present a radial velocity of +/-23 km/s and are oriented such that the NW blob points towards the observer. The bow-shock like structure presents a radial velocity of +55 km/s. A faint counterpart of the bow-shock structure is observed towards the West in the spectrum H7 at a velocity of -57 km/s.

The formation of NGC6765 seems to be the result of two different winds: a spherical wind related to the formation of the bipolar shell through the interaction wind-equatorial ring and a collimated wind (or jet) which interacts with particular regions of the nebula. The collimated wind should change its direction as indicated by the different (spatial) orientations of the bipolar blobs and bow-show structure.

This work has been supported partially by grants PAPIIT-DGAPA-UNAM IN111903-3 (Mexico) and MEC(FEDER) AYA2002-00376 and AYA2003-09499 (Spain)