Astron. Astrophys. 178, 319–321 (1987)

ASTRONOMY AND ASTROPHYSICS

*Research Note*

# Extended filamentary structures in the halo of the Lyra planetary nebula NGC 6720

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Received November 25, 1986, accepted December 31, 1986

**Summary.** Very deep, photographic, narrow band images of the Ring planetary nebula, NGC 6720, have revealed the presence of a further extended filamentary structure in its halo. The morphology of this structure consists of fractured, concentric filaments that indicate the existence of several spheroidal shells of gas. The narrow band filters employed in this study show that the loop filaments present in the halo structure discovered by Duncan (1937) are related mainly to the [N II] emission.

**Key words:** planetary nebulae: general – NGC 6720

## 1. Introduction

The search and study of faint extended nebular structures (halos) in planetary nebulae has recently received a renewed interest (Jewitt et al., 1986; Hippelein et al., 1985); their formation is thought to be related to the first stages of the P.N. evolution (cf. Kwok, 1982; Sabbadin et al., 1984). Jewitt et al. (1986) have estimated from five P.N. halos with measured mean electron densities, that the amount of mass contained in these halos equals the estimated mass of the primary nebula. Therefore, a better knowledge of these secondary nebular structures is also significant in terms of the amount of processed material that is returned to the interstellar medium by P.N.

NGC 6720 is a well studied planetary nebula. Photographs of this object have appeared in most astronomical journals, astronomy textbooks and even postcards. Short exposure, unsaturated images clearly show a ring-like morphology with small scale structure when observed at different selected wavelengths (e.g. Capriotti et al., 1971; Louise, 1974). The presence of a faint extended nebular structure in this planetary nebula was discovered by Duncan (1937). Excellent images of this halo structure, in the light of H$\alpha$ + [N II] have been published by Minkowsky and Osterbrock (1960), Minkowsky (1964) and more recently by Jewitt et al. (1986). None of those images have apparently gone deep enough to reveal the faint filamentary outer structure discovered in the very deep, narrow band images presented here. For the first time deep images resolved in H$\alpha$ and [N II] show the variation of the halo structure when observed at these separate wavelengths.

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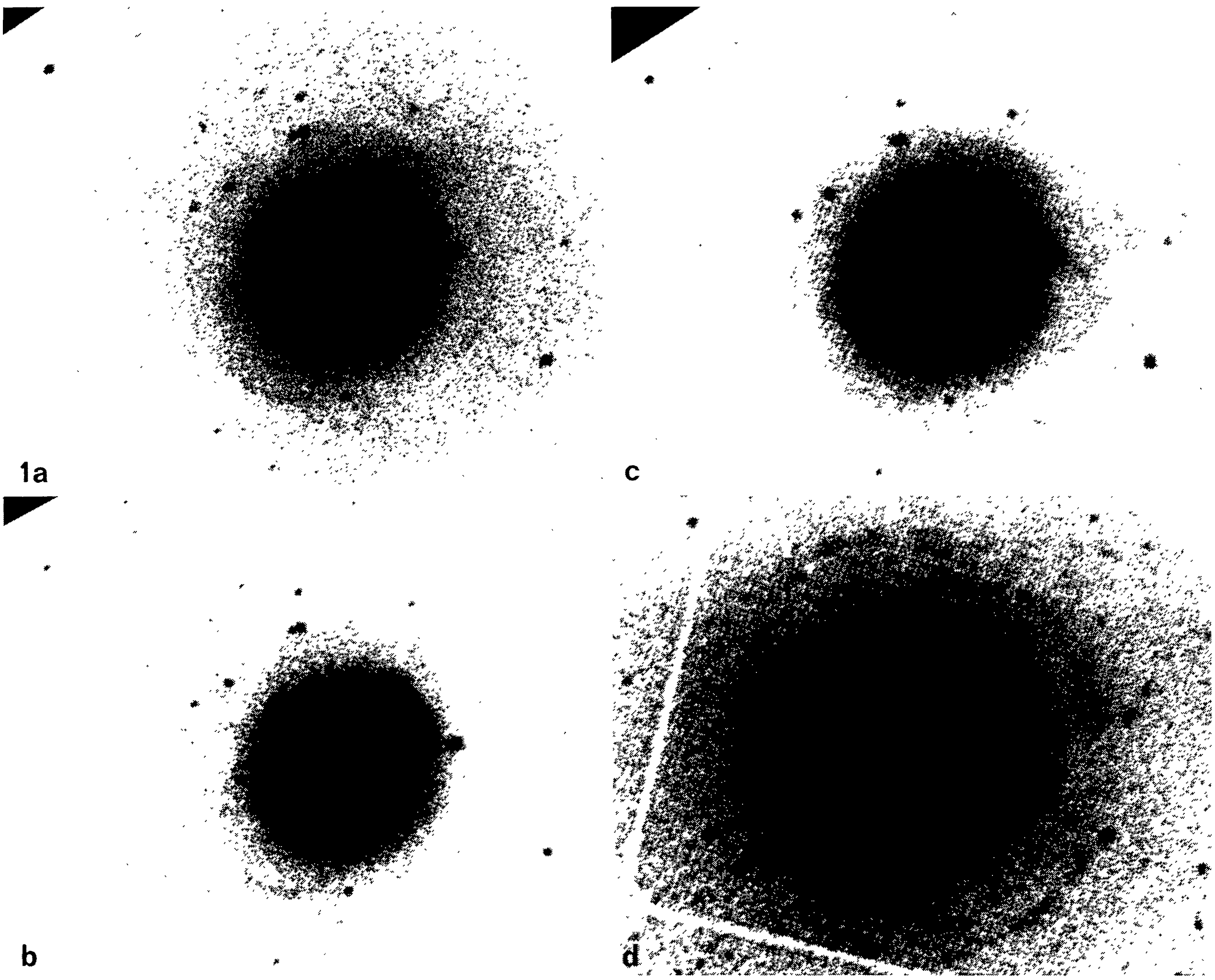
## 2. Observations

Direct photographs were obtained at the f/13.5 focus of the 2.12 m telescope of the Mexican National Observatory. A focal reducer, normally used for F-P interferometry, coupled to a one stage Varo image tube was employed to record the images on 103aG emulsion. Narrow band interference filters (FWHM $\simeq$ 8Å) centered at $\lambda\lambda$ 6563, 6584 and 4363 Å were used to observe in the H$\alpha$, [N II] and [O III] lines, respectively. A broader filter (FWHM = 25Å) centered on $\lambda$6723 was used to obtain [S II] images. Exposure times ranged from 3 to 30 minutes. In the [O III] and [S II] plates no significant information was recorded on the outer nebular structures.

## 3. Results and discussion

Plates 1 a–d and 2 a–d are images of increasing exposure time obtained in the light of H$\alpha$ and [N II], respectively.

Previously published photographs of NGC 6720 (see preceding section) have been obtained using broad band interference filters that included both the emission from H$\alpha$ and [N II]. By comparing the two sets of deep narrow band images in Plates 1 a–d and 2 a–d, it now becomes apparent that the "classical" image of the halo of NGC 6720 discovered by Duncan (1937) with its structure of loop filaments is mainly due to the emission from the low excitation [N II] line (see Plates 2 a–d). The deep images of H$\alpha$ in Plates 1 a–d show quite a different morphology, consisting mainly of only rather spherical or ellipsoidal shells with the loop filaments becoming apparent only in Plate 1 d, the deepest H$\alpha$ image. This image clearly shows a system of fractured, concentric filaments that had gone previously undetected in photographs of this P.N. These outer filaments can also be traced in the deepest [N II] image of Plate 2 d. They extend well beyond the limits of the previously known halo. In fact, a faint [N II] rim also present in the images of Minkowsky and Osterbrock (1960) and Minkowsky (1964) can now be associated with one of these external filaments.




**Figs. 1 and 2.** Plates 1 a to 1 d (Hα) and 2 a to 2 d ([N II]) are images of increasing exposure time taken through 8 Å FWHM interference filters centered on λ 6563 and λ 6584 Å, respectively. These images show clearly how different the structure of the halo of NGC 6720 is when observed separately at these wavelengths. Plates 1 a–d show a system of concentric shells whereas Plates 2 a–d show a halo with loop structures, as reported originally by Duncan (1937). The discovered outermost filaments are clearly seen in Plate 1 d. These filaments can also be traced in Plate 2 d. In all plates north is up and east right

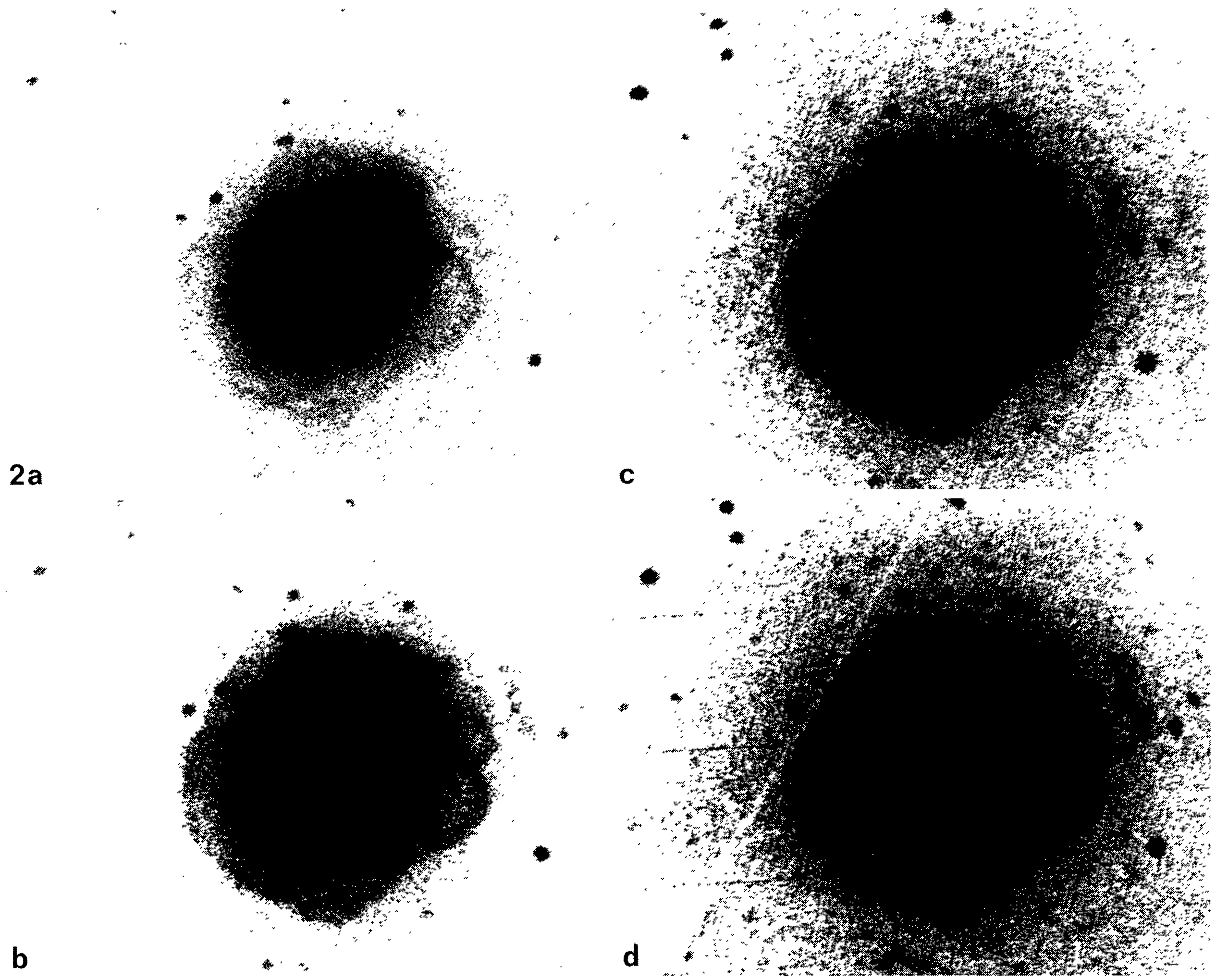



**Fig. 2**

The projected angular radius, *Rh*, of the external filaments is $\sim 108$ arcsec whereas the radius for the inner primary shell, *Ri*, is $\sim 37$ arcsec; this yields a ratio $Rh/Ri = 2.9$. For a distance of 400 pc to the object (Sabbadin, 1986), the projected linear radius for the external filaments is 0.21 pc. These dimensions make it plausible to assume that the amount of mass contained in the halo of NGC 6720 is greater, or at least similar to the mass contained in the primary nebula. Clearly, accurate measurements of mean electron densities of the nebular material in the halo would be needed to have a quantitative estimate in this respect.

The apparent stratification of the nebular material in the outer regions of NGC 6720, in particular the system of H$\alpha$ concentric shells (Plates 1 a–d), strongly suggests non-coeval ejection events. Furthermore, the strikingly different halo structures between the H$\alpha$ and [N II] images in Plates 1 a–d and 2 a–d indicates that these extended nebular structures are due to ionization effects (as opposed to dust scattering), in agreement with Hippelein et al.'s (1985) findings for three other P.N. with extended halos. An observational test similar to the one performed by these authors would clearly be worthwhile for NGC 6720.

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