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DEEP WFC IMAGES OF THE REGION AROUND NGC 7027

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RESUMEN

Presentamos imagenes profundas en los filtros Hα+[NII] y λ5007 de [OIII] de la región circundante a NGC 7027, obtenidas con la cámara de campo amplio (WFC) del telescopio Isaac Newton (INT). En ellas observamos la compleja estructura del medio interestelar en el que se encuentra proyectada esta planetaria e identificamos una estructura esféricamente simétrica rodeándola. Es necesario realizar un análisis cinemático detallado para determinar con exactitud si se trata de material físicamente ligado a la nebulosa planetaria. En ambas imágenes podemos observar los anillos alrededor de NGC 7027, detectados anteriormente por el telescopio espacial Hubble.

ABSTRACT

We present deep images in Hα+[NII] and [OIII] λ5007 of the region around NGC 7027 obtained with the wide field camera (WFC) at the Isaac Newton Telescope (INT). We observe the complex structure of the interstellar medium where the planetary is projected and identify a large spherically symmetric structure around the planetary nebula. A detailed kinematic analysis must be made in order to determine its physical link with the planetary. In both images we detect the rings around NGC 7027, previously observed with HST.

Key Words: **PLANETARY NEBULAE — PLANETARY NEBULAE : INDIVIDUAL (NGC 7027) — STARS : AGB AND POST-AGB**

1. INTRODUCTION

In the last years, with the evolution of detectors, it has become possible to observe very faint haloes around many planetary nebulae (PNe). NGC 6543, NGC 6826 and NGC 7662 are examples of PNe with faint giant haloes, near one parsec in size (Middlemass, Clegg and Walsh, 1989a, Middlemass et al. 1991). Corradi et al. (2003) present an extensive catalogue of these objects. The mass determined for some of these haloes exceeds the core mass of the PNe, demonstrating the importance of the halo contribution to the total mass of the system and to the enrichment of the interstellar medium.

NGC 7027 is a young PN, with a dynamical age of 600 years (Masson, 1989). Due to its distance (880 $\pm$ 150 pc; Masson, 1989) it is one of the best studied PN although its high surface brightness in nebular lines makes difficult the detection of a faint halo that can be 4 or 5 orders of magnitude weaker.

Middlemass, Clegg & Walsh [1989b, (MCW89)] on spectroscopic observations of NGC 7027 detected [OIII] emission between 12 and 20 arc-sec offset, they conclude that it can be due to a real reflection nebula, but they prevent on the problems in the spectroscopic detection of diffuse weak haloes around bright PNe. Walsh & Clegg (1994) confirm the existence of a dusty halo in this nebulae finding a high degree of polarization at offsets of 20$''$. Recent near infrared observations (Cox et al. 2002) revealed the morphology of the (H_2) molecular envelope of this object: it is located in a thin layer that can represent the inner boundary of a more extended molecular envelope. Bieging, Wilner & Thronson (1991) observed CO emission in a radii of 35$''$ from the ionized nebula.

In previous spectroscopic observations of the field stars around NGC 7027, made with the LDSS multislit spectrograph mounted on the WHT, we observed nebular lines in the background spectra up to 4 arcminutes of angular distance to the PN (Navarro, Mampaso & Corradi 2002). MCW89 call attention on the necessity to evaluate the scattered light (atmospheric and instrumental) and the diffuse galactic background contributions before make any definite conclusion. In fact, we found that the combination of the emission from the diffuse galactic background and scattered light (following the King profile: King, 1971) can reproduce the radial decay observed in the ratio of nebular lines, like [OIII]/Hβ.

2. OBSERVATIONS

In order to determine the origin of the detected emission lines we obtained deep images in 5007[OIII] and Hα+[NII] with the WFC, mounted at the Isaac

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Newton Telescope (INT) at La Palma. The observations were made in service time on June 1st, 2002.

The Wide Field Camera consists of a 4 CCD mosaic covering a 34′x34′ field with angular resolution of 0.33″/pix. To avoid the saturation of the CCD's, we located the PN in the gap between the CCD number 1 and number 4.

We obtained three images of 20 minutes in each of the filters: Hα, λ5007[OIII] and Stromgren B, with central lambda: 6568, 5008 and 4695 Å and FWHM: 95, 100 and 210 Å respectively. The images were bias subtracted and flatfield corrected. Images were shifted to a common center before combining them to eliminate cosmic rays.

3. RESULTS AND DISCUSSION

To evaluate the importance of the contribution by scattered light and diffuse galactic background on our previous observations, we extrapolate the King profile (Figure 3 in MCW89) up to 5 arc minutes and add the contribution from the interstellar background reported by Reynolds (1985) for the nearest region (l=96°, b=0°) to NGC 7027.

In Figure 1 we present the logarithmic profile of the measured flux in the 5007Å [OIII] line. Since our observations are not flux calibrated, we scale our data to equate the nearest observed point (at 42 arcsec from the PN) with the extrapolation of the data of MCW89 -following the King profile-, whose last point is at 30 arc-sec. In the outer region (r> 2.5′) our data are above the line representing the King profile (solid line), in spite of the addition of the interstellar background contribution (dashed line). This imply that there must be another source that could be: a PN reflecting halo or background emission in excess of the interstellar background.

Our spectroscopic observations also included [SII] 6717Å and 6731Å, Hα, [NII] 6548Å and 6583Å lines but they are not observed in all spectra due to the characteristics of the multi-slit observations. In the spectra where the [SII] lines were observed, we calculated the 6717/Hα ratio obtaining values between 0.05 and 0.2, typical of HII regions and not of the diffuse galactic background (between 0.2 and 0.6, Reynolds 1988). This suggest the existence of some reflecting or emitting material in addition to the warm interstellar medium.

On the other hand, the WFC images show a complex region around NGC 7027. We observed large emitting and several dark nebulae. There are two known dark nebulae south of NGC 7027: LDN932 and LDN934=[DBY94]33 (Lynds 1962, Dobashi et al. 1994), located at a distance of 0.8 Kpc.

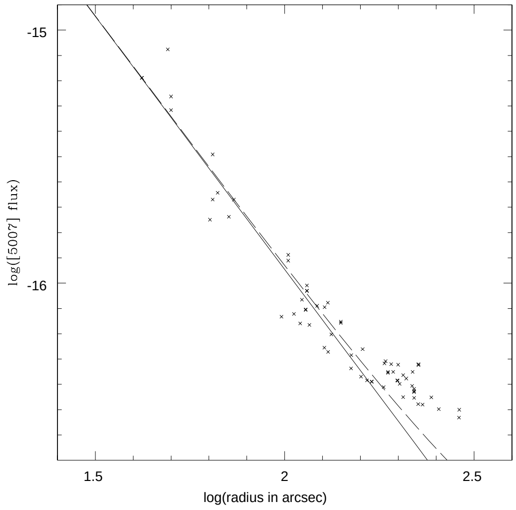

Fig. 1. Observed [OIII] flux (see text) as a function of the distance to NGC 7027. The continuous line represent the extrapolation until 300 ″ of the King profile and the dashed line, the sum of the King profile and the diffuse galactic background.

In the Hα image (Figure 2), a faint circular structure is revealed around NGC 7027 up to a radius of 4 arc-minutes. Due to the characteristics of the region and the polarization observed near NGC 7027, (Walsh & Clegg, 1994) there must be reflected light by dust, but to determine if the reflecting material is (or is not) associated with the PN we are doing a kinematic analysis of this region. In Figure 2 we present part of the Hα+[NII] image, it corresponds to the CCD's number 4 and 1, between which the PN was located. The field of this image is 22$'\!.$5 x 22$'\!.$5.

The rings around NGC 7027, previously observed with the HST Wide Field Planetary Camera (WFPC, Project No. 6280, PI Westphal), can be seen in both WFC images (Figure 3). The outermost ring that we can observe clearly is located at 36″ from the center of the PN. We note that the two outer rings can be traced completely but the inner rings are fragmented and irregularly spaced.

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REFERENCES

Bieging, J. H., Wilner, D. & Thronson H. A. 1991, ApJ 379, 271

Corradi, R. L. M., Schonberner, D., Steffen, M. & Perinotto, M. 2003, MNRAS in press

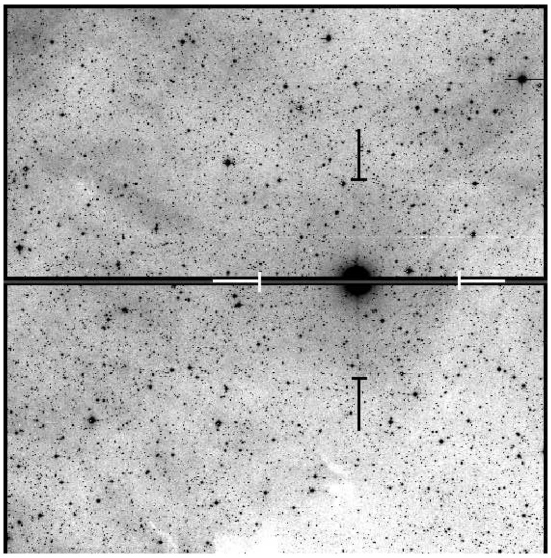

Fig. 2. Hα+[NII] deep image of the region around the PN NGC 7027. The WFC cover a total field of 34′ x 34′ but we present here only the image in the CCD's number 4 and 1, between which the PN was located. The lines mark the circular region detected (not well seen in this b/w image). North at the top.

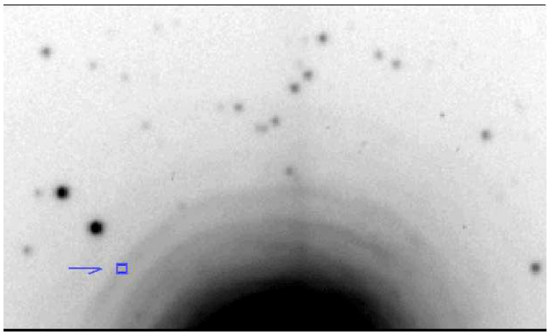

Fig. 3. [OIII] image of the rings around NGC 7027. The rings are observed in both images, but in [OIII] the contrast is better. The marked ring is at 36″ from the center of the PN (at 11″ below the limit of the image).

Cox, P. et al. 2002, A&A, 321, 907

Dobashi, K., Bernard, J. P., Yonekura, Y. & Fukui, Y. 1994, ApJS, 95, 419

King, I. R. 1971, PASP, 83, 199

Lynds, B. T. 1962, ApJS, 7, 1

Masson, C. R. 1989, ApJ, 336, 294

Middlemass, D. 1990, MNRAS,244, 294

Middlemass, D., Clegg, R. E. S., & Walsh, J. R. 1989a, MNRAS, 239, 1

Middlemass, D., Clegg, R. E. S., & Walsh, J. R. 1989b, MNRAS, 239, 5P

Middlemass et al. 1991. MNRAS, 251, 284

Navarro, S. G., Mampaso, A., & Corradi, R. L. M. 2002 RMxAC, 12, 171

Reynolds, R. J. 1985, ApJ, 298, L27

Reynolds, R. J. 1988, ApJ, 333, 341

Walsh, J. R. & Clegg, R. E. S. 1994, MNRAS, 268, 41