New Distant Planetary Nebulae

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Discovering New Planetary Nebulae

The number of known galactic Planetary Nebulae (PN) is at present above 1600. Even so, they are thought to be only 10% of all PN present in the Galaxy, the rest being hidden due to heavy absorption. In fact, the known PN are concentrated in the solar neighbourhood at distances which are usually smaller than 3 to 4 kpc and the PN statistical parameters such as kinematics, luminosity functions, chemical abundance, etc. have been derived for this local sample and extrapolated to the whole Galaxy population. Therefore, it appears important to extend the observations to PN at larger distances.

It is not a surprise that the improving instrumentation allows to find new PN even in regions of sky that have previously been carefully searched. The search we are performing, however, does not require last-generation instruments, but involves a comparative analysis of plates taken, in some cases, more than 20 years ago.

The starting point was the realization that, due to differential absorption, all distant, *normal* stars tend to be fainter in the red (6000–7000 Å) than in the near infrared (7500–8500 Å) prints of the Palomar Near Infrared Photographic Survey of the Galactic Plane (PNIPS). Only emission-like objects can appear brighter in the red. Following this idea, Sabbadin (1986) was able to identify a number of misclassified Planetary Nebulae in existing catalogues.

A quick look at some of the prints suggested that this comparison was very effective also for the identification of hitherto unknown PN. In particular, it appears well suited for faint, compact PN which were missed by other types of searches.

The first attempts at a systematic work in this direction made clear that, in order to diminish the number of candidate PN (excluding plate faults, variable stars, etc), the simultaneous examination of the blue and red prints of the Palomar Observatory Sky Survey (POSS) was very useful. The efficient comparison of the four different images of the same sky region (B, R of POSS; R, IR of PNIPS), allowing for slightly different field centres, print scales and quality, required a devoted system as result of a considerable experimentation.

In the procedures developed at the Astronomical Observatory of Padua, each Palomar print is automatically digitized, by means of a fixed CCD camera, as 216 adjacent fields, exploiting, for the X and Y movements, the carriage of the PDS machine, after a proper alignment on some reference stars. The

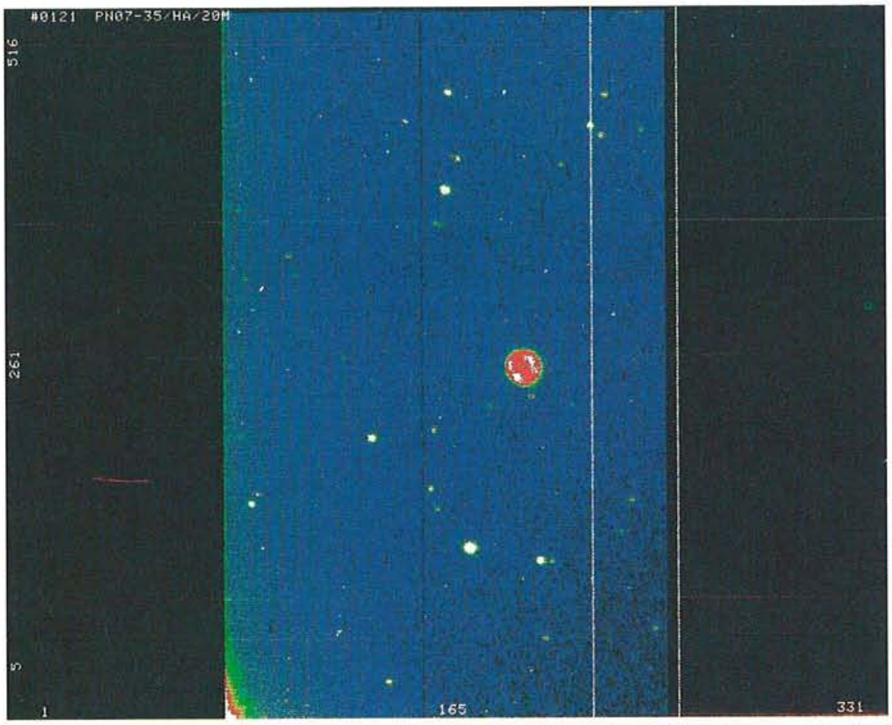

Figure 1: *Hα + [NII] image of the PN at α = 07ʰ55ᵐ20ˢ, δ = −35°58′ (ESO filter # 694, CCD RCA # 15, 20-min. exposure). North is at the top, east is right.*

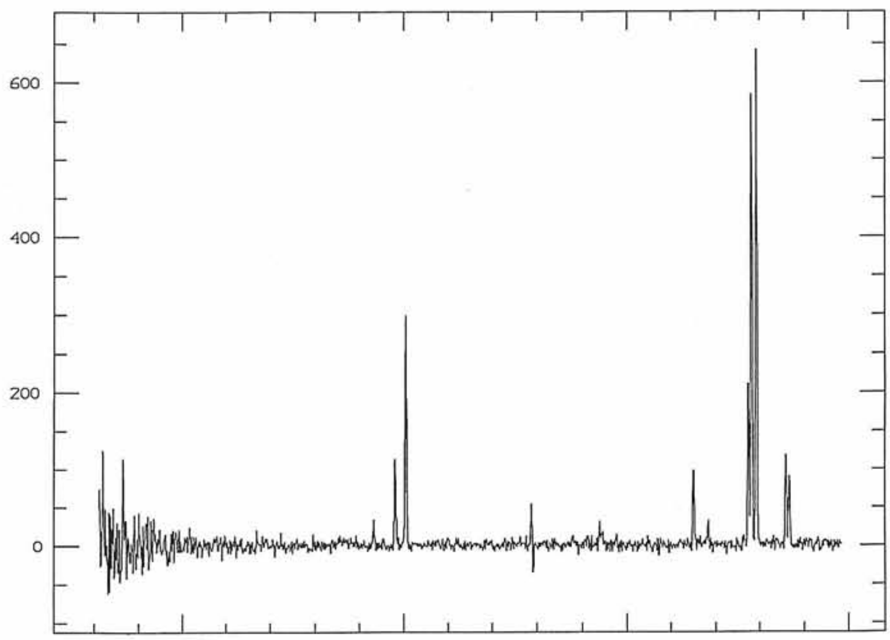

Figure 2: *B&C spectrum of PN α = 07ʰ55ᵐ20ˢ, δ = −35°58′ (B&C ESO grating # 2, CCD RCA # 15, 60-min. exposure). In the x-axis is wavelength in Å, in the y-axis is flux in erg cm^{-2} s^{-1} $Å^{-1}$ × 10^{-16}.*

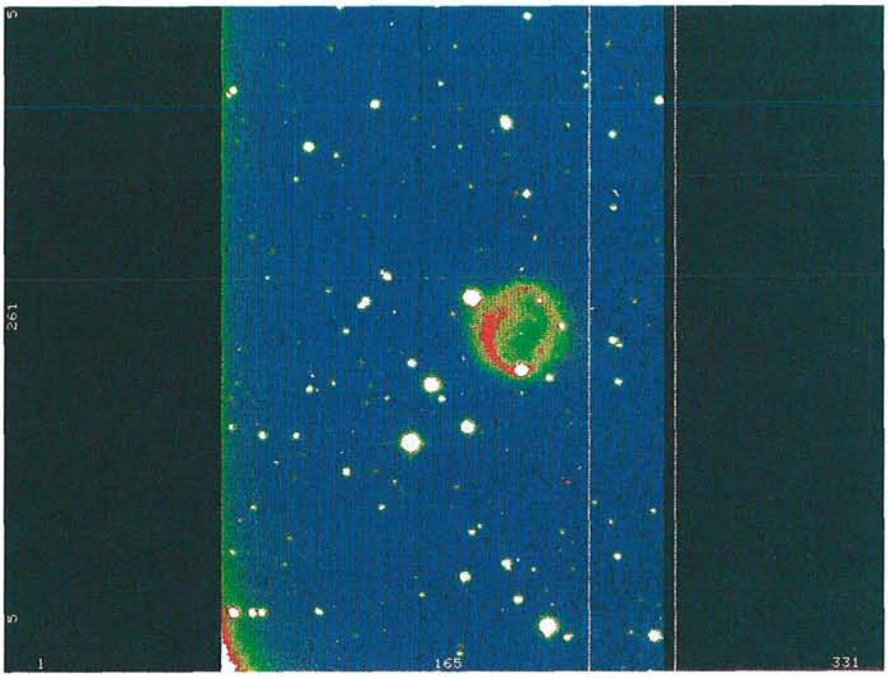

Figure 3: *Hα + [NII] image of the PN at α = 08ʰ11ᵐ23ˢ, δ = –32°52′) (20-min. exposure).*

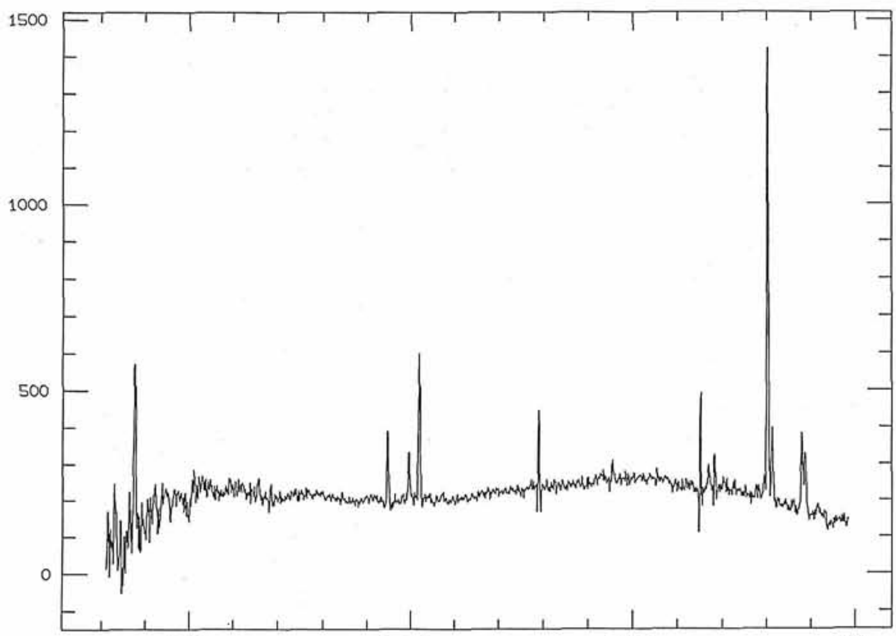

Figure 4: *B&C spectrum of the PN at α = 08ʰ11ᵐ23ˢ, δ = –32°52′) (60-min. exposure).*

4 × 216 images are stored on tape, and then examined by means of a devoted software which allows the subtraction and blinking of the different images of each field. When a candidate is found, using a cursor, we can measure its rectangular coordinates that, with reference to a sample of SAO stars, can be promptly converted to right ascension and declination.

With the aim to extend our search to the southern hemisphere, we conceived a proposal for the ESO Schmidt telescope at La Silla, to obtain red and near-infrared plates of selected fields centred at the position of the ESO-Survey plates (which will be used for confirmation of the candidates). The proper plate-filter combination and exposure times, and the comparison of plates of each field taken in the same nights, will allow to distinguish more effectively stars of unusual colour from PN candidates (the first six pairs of plates have been recently delivered to us and will be analysed in the near future).

Verification

With this method we found up to now almost one hundred new PN candidates. Of course, the identification is only the first step of an effective scientific programme. Candidates need first a spectroscopic confirmation and, later, true PN deserve detailed morphological and spectroscopical investigation.

The first results of the search are very encouraging. Thanks to the effectiveness of the method and the careful examination of the different images of the field, the number of candidates which do not turn out to be emission-line objects is virtually zero. In fact, most candidates can be positively identified as PN (cf. Turatto et al., 1990; Cappellaro et al., 1990).

While northern sky objects can be investigated at the Asiago 1.82-m telescope, a first sample of southern sky PN was observed at ESO using the 2.2-m telescope last February. In principle, EFOSC is the best instrument to observe these faint nebular objects lost in crowded galactic fields. At the start, an interference filter image can been obtained, which allows both the morphological classification of the nebula and the accurate pointing for the following long-slit spectroscopy, needed for the final confirmation and the study of the physical condition of the PN. Moreover, broad-band photometry in different bands of the central star can also be promptly assured allowing to derive absolute magnitude and colour temperature for the ionization source.

Unfortunately, in the first run we got in February this year, EFOSC2 was not yet available, and we had to perform the spectroscopic programme with the Boller and Chivens spectrograph and the imaging with the CCD camera. This implied the selection of a subsample of the brighter PN.

As an example, in Figures 1 and 2 are shown the Hα image and spectrum of the PN candidate at $\alpha = 7^h55^m20^s$ $\delta = -35°58'$ (1950.0). The spectrum, with strong [NII] and [OIII] emissions, is typical of a heavily absorbed PN. In fact, the observed ratio $H\alpha/H\beta \simeq 17$ compared to the recombination value of 2.85 (Aller, 1984) allows to estimate the extinction $A_V \simeq 4.8$ mag. The nebula appears as a roundish disk of about 15 arcsec diameter.

A second example is illustrated in Figures 3 and 4. This object (at $\alpha = 8^h11^m23^s$, $\delta = -32°52'$) is another typical PN, suffering a smaller extinction. From the observed $H\alpha/H\beta \simeq 6.5$ can be derived $A_V \simeq 2.4$ mag. This fact and the larger apparent dimension of the Hα image (about 30 arcsec) suggest that this PN is closer than the previous one. The

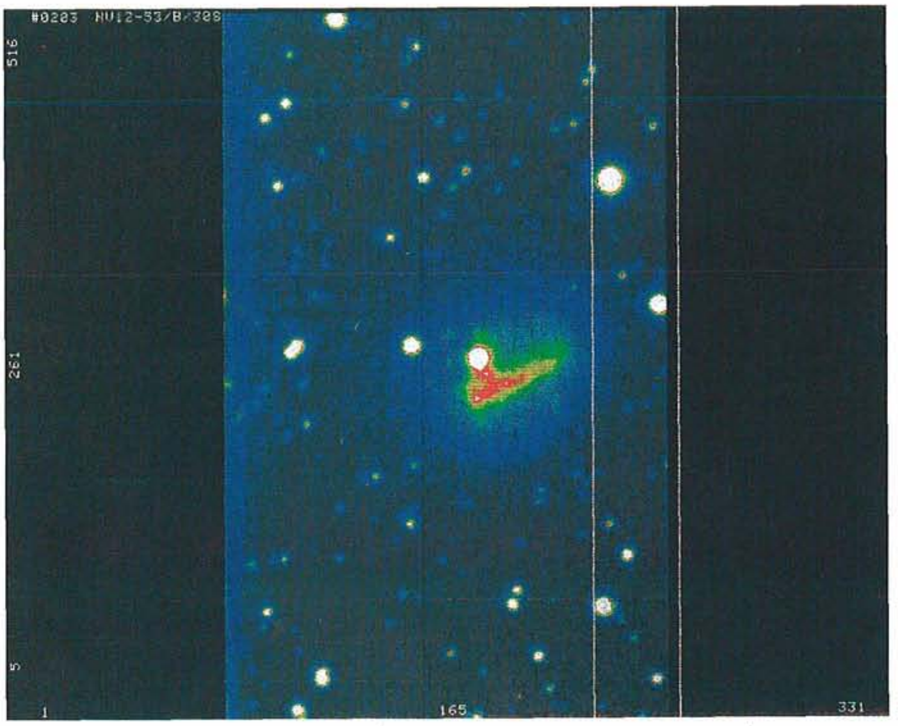

Figure 5: *Image of the galaxy at α = $12^h44^m16^s$, δ –53°17′) (30-sec. exposure).*

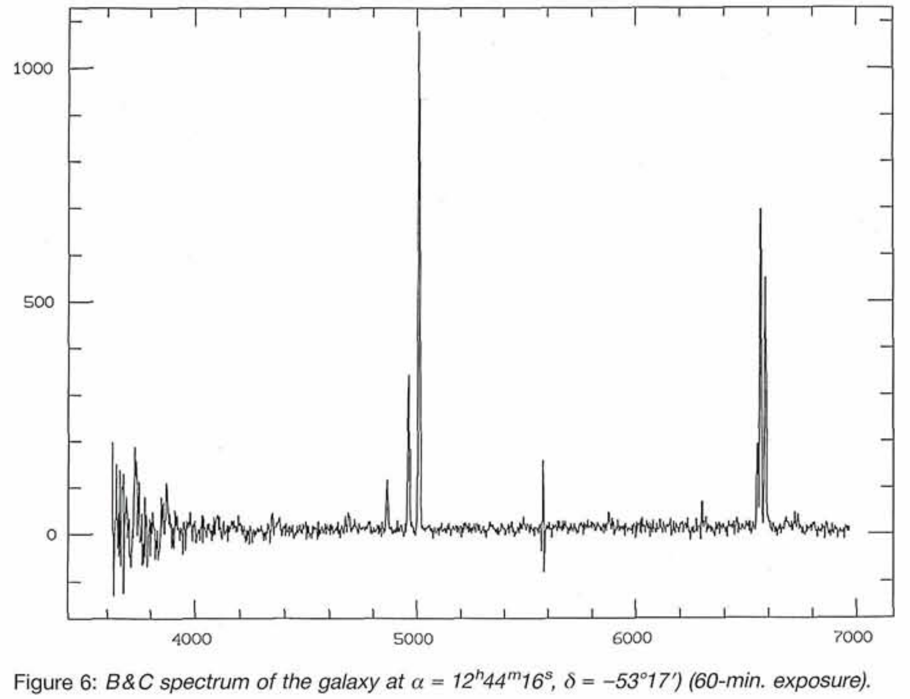

Figure 6: *B&C spectrum of the galaxy at α = $12^h44^m16^s$, δ = –53°17′) (60-min. exposure).*

latter object was later found to be included as possible PN in the Atlas of Galactic Nebulae (Neckel and Vehrenberg, 1990).

Among the candidates that are not PN, a few are identified as emission-line galaxies, at relatively small redshift (cf. Sabbadin et al., 1989). This is especially interesting as our search concentrated on low galactic latitude fields where the extinction is usually very high, some of these galaxies may be nearby "backyard" objects.

The spectrum of one of these galaxies is shown in Figure 5. This galaxy (α = $12^h44^m16^s$, δ = –53°17′) has redshift v $\simeq$ 1800 km s^{-1}, from the position of the emission lines typical of HII regions. The extinction, implied by the ratio Hα/Hβ $\simeq$ 3.6 is quite small. Finally, the preliminary investigation suggests an irregular morphology (Fig. 6).

The full reduction of the first run of observations is now in progress, and we are confident to collect much more material in the future. We hope therefore to be able, in a relatively short time, to perform a statistical analysis of the physical properties of this class of compact PN.

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