A SEARCH FOR SPECTROSCOPIC BINARIES AMONG PLANETARY NUCLEI

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The present paper is a progress report on a search for spectroscopic binaries among central stars of planetary nebulae. In the last few years it has become clear that such a program may result in a significant improvement of the available information about the central stars, and, whatever the outcome, it will certainly help to test current theoretical work on the origin of planetary nebulae.

The spectrograms used in this project are being taken mostly by the writer and Virpi S. Niemela at the Cerro Tololo Inter-American Observatory (CTIO) with the image-tube spectrographs of the 1-m and 4-m telescopes, on IIIa-J baked plates, at dispersions around 45 Å mm^{-1}. Several earlier spectrograms were obtained from 1970 to 1976 with the conventional spectrographs of the CTIO 90- and 150-cm telescopes, on IIa-O plates, at dispersions from 40 to 125 Å mm^{-1}. The radial velocity measurements are made with a Grant comparator-microphotometer.

I have chosen the nebula IC 418 as the velocity standard. A detailed analysis of the image-tube nebular velocities will be published elsewhere; the main result is that no significant deviations have been found. The errors in the stellar radial velocities depend mainly on the amount and quality of the available lines. For A-type stars we would be able to detect orbital motion with a total amplitude $\gtrsim$25 km s^{-1}; for O subdwarfs the limit is of the order of 50 km s^{-1}.

Table I shows the present status of the program; some comments on individual stars follow.

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TABLE I

OBJECT	SPECTRAL TYPE	NUMBER OF PLATES	ORBITAL MOTION	PERIOD
NGC 246	O VI	18	not detected	
NGC 1360	sdO	79	confirmed	30 d?
NGC 1535	O	18	not detected	
IC 418	O7fp	31	not detected	
NGC 2346	A5	34	confirmed	16 d
He 2-36	A2 III	19	not detected	
NGC 3132	A2 V	49	not detected	
NGC 4361	O	5	probable	
A 36	sdO	7	very probable	
He 2-131	O8fp	9	not detected	
He 2-138	BCO Ib	7	not detected	

NGC 1360. The 8-day period reported 2 years ago (Méndez and Niemela 1977) is not correct. Figure 1 shows the distribution of radial velocities. The observed distribution is consistent with a very eccentric orbit, with periastron near the ascending node. Our wrong estimate of the period can be understood as a consequence of assuming a circular orbit. The new data bring the system velocity in agreement with the nebular velocity, which is approximately +60 km s^{-1}. At least another velocity maximum (we have two) is needed to determine the period.

IC 418. This is an interesting by-product of the program. The stellar emissions do not seem to vary, but the velocitiesof the strong C IV absorptions λλ5801, 5811 sometimes depart from the nebular velocity by as much as 70 km s^{-1}, always towards more negative values. The time scale of the variations is one day or less. Other stellar absorptions (He II, O III) would appear to show the same behaviour, but with a much smaller amplitude. Apparently there is a variable velocity field in the atmosphere of this Of central star.

NGC 2346. The A-type central star was reported last year to be a spectroscopic binary (Méndez et al. 1978). New spectrograms indicate a period of 16 days with a semiamplitude K=18 km s^{-1}. Unfortunately the system would seem to be a foreground object (Méndez 1978).

NGC 4361. On two plates the H and He II stellar absorptions are found to be shifted redwards relative to the superimposed nebular emissions by about 60 km s^{-1}.

A 36. The radial velocity of this star appears to be variable, with a period of perhaps several days (see Figure 2).

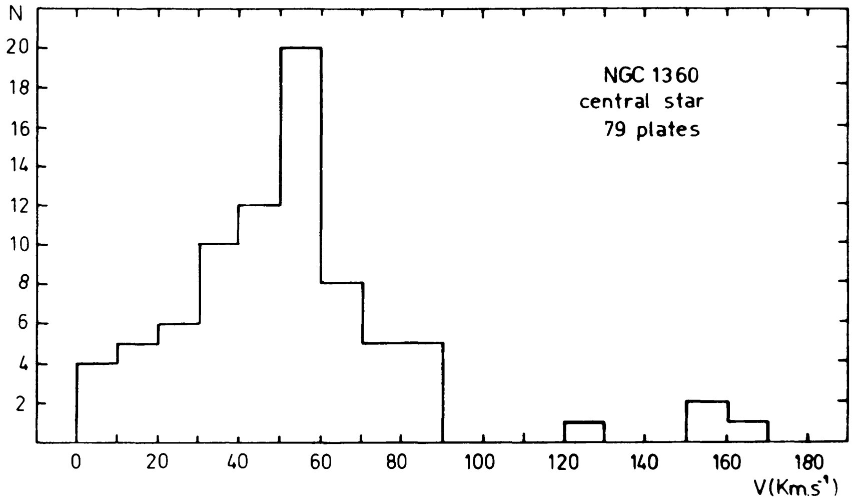

Fig. 1. NGC 1360: the distribution of radial velocity determinations, $\frac{1}{2}(H\delta+H\gamma)$. N is the number of plates.

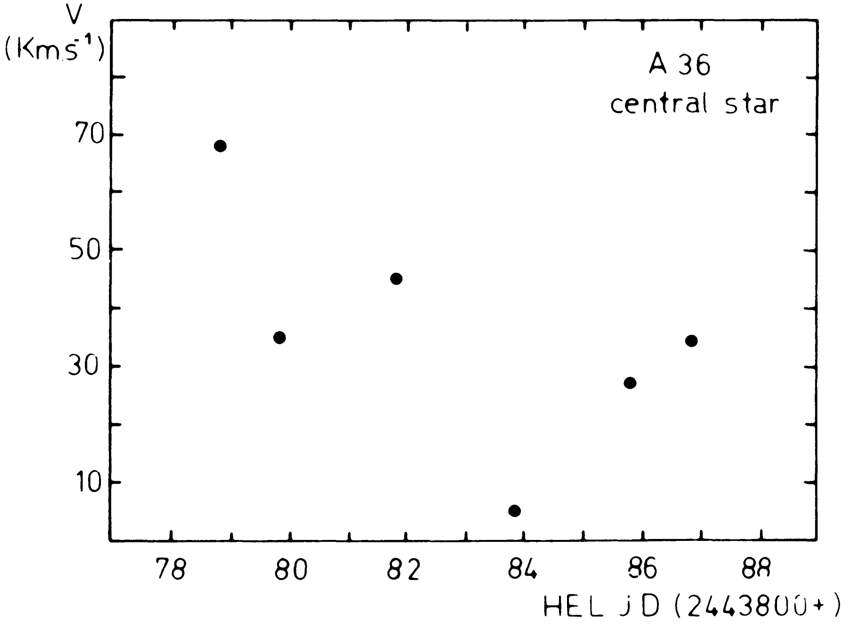

Fig. 2. A 36: the heliocentric radial velocities, $\frac{1}{2}(H_{\delta}+H_{\gamma})$, of the central star.

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DISCUSSION FOLLOWING MÉNDEZ

Popper: What is the perception of those working in this field? Are binary star processes considered to be important contributors to the totality of planetary nebulae?

Shaviv (response to Popper's question): The PN stage originates in a very special situation when the mass losing star heats up and succeeds to ionize the nebulae before it fades away. Hence you refer to a special stage and circumstances.

We believe that all single RG stars of mass $\lesssim 6M_{\odot}$ become WD via the formation of PN. Actually, the statistics of WD formation and PN formation seem to confirm this assumption.

The PN with a CBS should therefore be a rare event and it happens only for a special combination of parameters.

Popper(response to Shaviv): It appears to be widely accepted that all M giants (int he appropriate mass range) produce planetaries. If a large fraction of planetaries is produced by binary processes, is there a possible contradiction?

Niemela (responses to Shaviv/Popper): The reason why many people have been saying that the central stars are single simply is that nobody had observed them for radial velocity variations, mostly because they are so faint. Only recently with the more effecient image-tube spectrograph has it been possible to begin a search for spectroscopic binaries among planetary nuclei.

Mayo: What can you say about the spectral types of these suspected (and confirmed) binaries in planetary nebulae nuclei? Do you see the spectra of both the companion star and the hot component? If the companion is an early type star, it could contribute significantly to the irradiation of the nebula. Finally what type of binary do these seem to be, or are they perhaps some new type of binary?