# THE RADIAL VELOCITY VARIATIONS IN IC 418

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The present observations are part of a search for spectral and radial velocity variations among central stars of planetary nebulae (Méndez 1980). The spectrograms were taken with the image-tube spectrographs of the 1-m and 4-m telescopes at the Cerro Tololo Inter-American Observatory (CTIO). The emulsion was always IIIa-J baked in "forming gas" ($N_2$+$H_2$). The "blue" spectrograms extend from 3600 to 5000 Å at 45 Å $mm^{-1}$; the "red" ones extend from 5000 to 7000 Å, at 45 Å $mm^{-1}$ (4-m plates) and 90 Å $mm^{-1}$ (1-m plates). All plates were calibrated with a spot sensitometer. Seven "blue" and seven "red" spectrograms, all obtained with the 4-m telescope, were traced with the PDS microphotometer of the David Dunlap Observatory. The intensities from each plate were stored in computer memory and were later added together, in order to improve the signal-to-noise ratio. The resulting intensity tracings reveal more details than had previously been observed (Swings and Struve 1941, Aller and Wilson 1954, Andrillat 1957, Aller and Kaler 1964). We cannot present a complete description here, but will just mention the following new data:

1) Weak, previously undetected C III emissions are visible at 4056, 4186, 4516, 5270 and 5826 Å. We also find the famous unidentified emissions at 4485 and 4503 Å.
2) The He I absorptions at 4471 and 5875 Å are blue-shifted relative to the nebular emissions. The same happens with $H_\delta$ and $H_\gamma$, although in this case the shift can be at least partly attributed to blends with the strong He II absorptions, which we estimate to contribute about one half of the equivalent width at $H_\delta$ and $H_\gamma$.
3) We also find O III $\lambda$5592 and C IV $\lambda\lambda$5801, 5811 in absorption.

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*C. Chiosi and R. Stalio (eds.), Effects of Mass Loss on Stellar Evolution, 83–86.*

The radial velocity measurements were made with a Grant comparator-microphotometer, and the nebular lines were used as a velocity standard to check the behavior of both spectrographs. From a total of 21 "blue" and 12 "red" plates, the average nebular velocity is +64 km $s^{-1}$, in good agreement with previous studies (see Perek and Kohoutek 1967). The standard deviation of one spectrogram is 5 km $s^{-1}$. The observational uncertainty for the best stellar absorptions (C IV) and emissions (He II) is smaller than 15 km $s^{-1}$.

The radial velocities of the C IV absorptions are definitely variable, sometimes departing from the nebular velocity by as much as 100 km $s^{-1}$, always towards more negative values. The time scale of these variations is of the order of one day.

Since the stellar emissions do not follow a similar trend,we initially tried to ascribe this behavior to a variable velocity field, which would imply that the layers where the C IV lines originate are sometimes expanding, sometimes at rest. But a more careful analysis has led us to favor the alternative of orbital motion in a binary system. Figure 1 shows, as a function of the C IV velocities, the velocities of a few stellar features from the "red" spectrograms, including C IV itself. We find that the He II $\lambda$5411 absorption gives a similar slope, but is shifted as a whole towards more positive values. We have not plotted the O III $\lambda$5592 absorption, which seems to vary in the same way. On the other hand, the C III $\lambda$5695 emission would appear to vary in antiphase.

Turning now to the "blue" plates, Figure 2 shows the He II $\lambda$4685 emission velocity as a function of the He II absorption velocities, represented by the average of $\lambda\lambda$4199 and 4541; again we find a tendency to vary in antiphase. Finally, in Figure 3 we have the He II $\lambda$4685 emission as a function of the C IV absorptions; the data are from the six opportunities in which one "blue" and one "red" spectrogram were taken consecutively. Here the effect is more clearly visible, which is to be expected since we use the most reliable lines.

This variation in antiphase does not necessarily disprove a variable velocity field. $O_f$ and WR stars are known to display redshifted emissions which can be understood as a consequence of velocity fields; therefore, a variable field might conceivably produce such an antiphase effect. However, now we have good reasons to suggest a double-lined spectroscopic binary as an alternative possibility. Our data appear to exclude periods shorter than 6 hours and longer than 2 days.

Although we cannot consider the binary hypothesis to be confirmed until we find a period, let us meanwhile advance the following interpretation:

a) One of the components shows strong He II, O III and C IV absorptions, and would appear to be hydrogen-deficient. The He I absorptions should also belong to this star, because absence of He I would imply a very high surface temperature and the nebula is of low excitation. We can

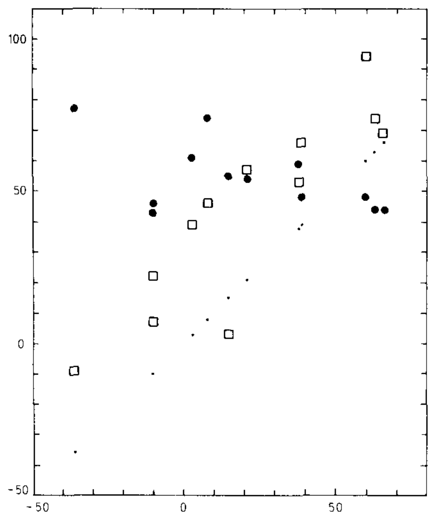


Fig.1. The radial velocities (km $s^{-1}$) of the 5801, 5811 C IV absorptions (points), the 5411 He II absorption (squares) and the 5695 C III emission (circles), plotted as functions of the C IV absorption velocities.

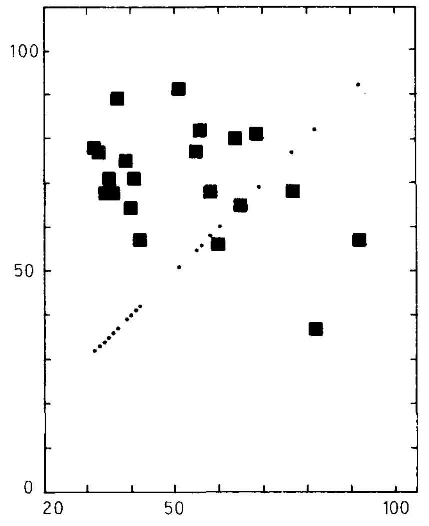


Fig.2. The radial velocities of the 4199, 4541 He II absorptions (points) and the 4685 He II emission (squares) plotted as functions of the He II absorption velocities.

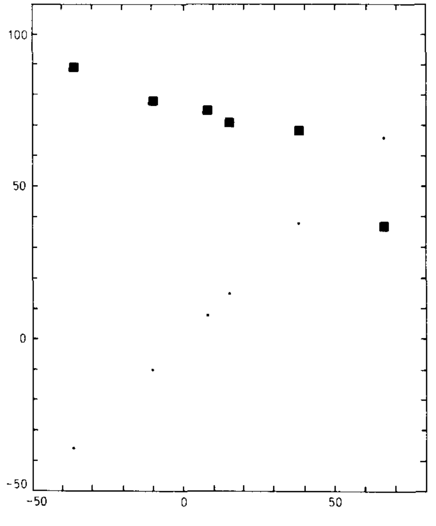


Fig.3. The radial velocities of the C IV absorptions (points) and the 4685 He II emission (squares), plotted as functions of the C IV absorption velocities.

https://doi.org/10.1017/S0252921100094653 Published online by Cambridge University Press

not decide if this star is contributing to some of the emissions until high dispersion studies are made. The blueward displaced $\gamma$-velocities of the absorptions indicate a strong stellar wind; probably this star is the main contributor to the C IV $\lambda$1549 P Cygni-like profile observed with the IUE (Harrington et al. 1980).

b) The stellar emission lines should originate mainly at or near the other component. Perhaps some of the mass lost by the companion has produced an envelope around this second star.

It is interesting to note that another WR-$O_f$ central star, NGC 6543, has been reported to be a double-lined spectroscopic binary with a period of less than 2 hours (Acker 1976). Further work on these objects is clearly desirable.

Acknowledgements: We are indebted to V.S. Niemelä and O. Ferrer for taking some of the spectrograms. One of us (RHM) would like to thank the Director and staff of CTIO for their hospitality, and also J.D. Fernie and C.T. Bolton for permission to use the David Dunlap PDS, and R. Lyons for his expert assistance with that instrument.

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## DISCUSSION

Van Der HUCHT: First, I would like to propose to call stars by their HD numbers, even if they are central stars of planetary nebulae. The central star of IC 410 is HD 35914. Next, what spectral type do you assign to this star? Bohm (1968) and Perek Kohoutek (1967) said it was WC 7. Aller (1968, 1976) said it is O7fp. You say it is a Of-WR binary, but couldn't you give a more specific spectral type?

MENDEZ: I think it is not possible to be more specific about the spectral type. This spectrum is "intermediate" between Ofp and WR. It is not "WC-like" because it has NIII emissions. Besides, I would not attempt any classification before we confirm its binary nature and decide which features belong to each star.