

THE HELIUM λ 10830 LINE IN PLANETARY NEBULAE AND THE ORION NEBULA*

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ABSTRACT

Interferometric observations of profiles of He I λ 10830 emission lines in 11 planetary nebulae, and in selected regions of the Orion Nebula, are presented. In common with the Orion Nebula, the planetaries are shown to emit a P Cygni-like λ 10830 line, with the absorption component shifted toward the violet with respect to the laboratory wavelength in a frame of reference at rest in the centre of expansion of the gas. The emission components are shifted toward the red. In planetaries, the negative displacements of the absorption edges are, in general, approximately equal to the widths, β , of the emission components which, in turn, range from about 12 km/sec in IC 418 to about 28 km/sec in NGC 6210. The emission red-shift is about 0.7β on the average, but individual shifts vary from 0.5β in IC 2149 to 1.05β in NGC 6826. The line widths and shifts tend to increase in nebulae with larger expansion velocities. In Orion, the absorption edges in the λ 10830 line coincide in velocity with those in the line He I λ 3888 observed against the spectra of the Trapezium stars. In planetaries, the absorption edges in the λ 10830 line appear qualitatively similar to those in the line He I λ 3888, but a coincidence in velocity could not be demonstrated.

The observed profiles indicate that the nebulae are expanding, or that they contain expanding globules or filaments. Some form of circumnebular absorbing zone may be indicated. However, it is suggested that frequency redistribution associated with resonance-like scattering in a homogeneous expanding medium might in principle (even in the absence of stratification) account for the shifted λ 10830 profiles. (See Hummer, D. G. and Rybicki, G. B. (1968), *Astrophys. J. Letters* (in press), for a further discussion of this point.)

No trace of He³ is evident from the profiles. Quantitative conclusions are uncertain without a model which reproduces most of the phenomena, but an upper limit of He³/He⁴ \leq 0.05 or even 0.01 is suggested on the basis of conservative assumptions.

DISCUSSION

Underhill: There are several good reasons for believing BD + 30° 3639, Campbell's Hydrogen Envelope Star, to be a Wolf-Rayet Star enveloped in a gaseous shell. Therefore I doubt that your observations of He I λ 3888 absorption can be interpreted unequivocally as due to the surrounding nebula. Your He λ 10830 lines are quite broad and they appear to have P Cygni-type absorption displaced some 60 km/sec or more shortward. Can you demonstrate that this composite feature is not more closely connected to the underlying star than to the nebula? The He I line λ 10830 is one of the first lines one would expect to appear strongly in emission in a high-temperature extended envelope.

Vaughan: Wilson's spectra of BD + 30° 3639 show an extended nebula which expands at around

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16 km/sec. The violet absorption shift in 10830 is of the same order. In general, the observations do not indicate a connection between the profiles of λ 10830 and the properties of the central stars.

Münch: In a search for λ 3889 He I absorption in the spectra of central stars of planetary nebulae I made sometime ago, I convinced myself of its presence in IC 418. Unfortunately, the H8 stellar line is quite strong in IC 418, and the nebular absorption cannot be seen as clearly as in BD + 30° 3639.