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High-Resolution Spectroscopy of PB 6

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Abstract. We use UVES spectroscopy of PB 6 to study the variation of its physical conditions as a function of position including: temperature, density, chemical composition and velocity. We present preliminary results from this work. In particular we want to find the relevance of the contribution of the wind from the central star to the chemical composition of the nebula; we find that the contamination due to the WR wind is small.

Keywords. planetary nebulae: general, planetary nebulae: individual (PB 6)

1. Introduction

PB 6 is an extreme type-I planetary nebula with He/H=0.17 and N/O≈1.2. It has a knotty and filamentary structure. The central star has a temperature of 103 000 K, and has been classified by different authors as WC3, WO1, and W(O VI); it belongs to the exclusive group of O VI stars that present O VI λ 3811 and λ 3840 Å in emission. The chemical composition of the atmosphere, by mass, is: He=0.617, C=0.240, O=0.140, and N=0.003.

2. Data

The observations were made with the Ultraviolet Visual Echelle Spectrograph (UVES) at the Kueyen telescope of the ESO VLT, Cerro Paranal, Chile. We used all 4 standard settings of the spectrograph covering the spectral region from 3100 to 10250 Å. The instrument resolution is approximately $\Delta\lambda/\lambda \sim 20000$. The average seeing during these observations was 0.4", considerably lower than the average seeing for this site.

The 9"×2" slit was oriented east-west; the center of the slit was placed 2" south of the central star. This slit was subdivided into nine 1"×2" regions to probe the spatial structure of the nebula.

A total of 354 lines were measured, most of them were permitted lines (H I, He I, He II, C II, C III, C IV, N I, N II, N III, N IV, N V, O I, O II, O III, O IV, Ne II) but 88 were forbidden lines ([C I], [N I], [N II], [O I], [O II], [O III], [F III], [F IV], [Ne III], [Ne IV], [Ne V], [Mg VI], [S II], [S III], [Cl III], [Cl IV], [Ar III], [Ar IV], [Ar V], [K IV], [K V], [Ca V], [Mn V], [Mn VI], [Fe II], [Fe III], [Fe IV], [Fe V], [Fe VI], [Ni II], [Kr III], [Kr IV]).

We have analyzed the data in two different ways: a) Using the integrated slit, we can clearly distinguish a blueshifted and a redshifted component for all bright lines. b) Dividing the slit in 9 regions, we detected for the bright lines at least two components for each region and a total of 24 components for the 9 regions.

Table 1. Temperatures and velocities for the 24 components.

Component	v	4363	4959	T[O III]	Component	v	4363	4959	T[O III]
1a	−18.9	0.132	2.530	14430	6a	−30.1	0.259	3.761	16480
1b	23.3	0.251	4.312	15180	6b	12.7	0.286	4.621	15640
2a	−19.6	0.196	3.136	15710	6c	34.1	0.160	2.719	15250
2b	25.8	0.205	3.889	14510	7a	−28.9	0.147	2.356	15690
3a	−18.9	0.193	2.799	16490	7b	−0.2	0.197	2.784	16720
3b	28.7	0.233	3.953	15280	7c	31.0	0.800	11.380	16660
4a	−27.7	0.146	2.128	16400	8a	−30.0	0.106	1.965	14640
4b	4.4	0.528	8.700	15490	8b	−6.2	0.471	6.425	17020
4c	32.8	0.195	3.097	15750	8c	31.1	0.104	3.756	14690
5a	−31.7	0.229	3.590	15870	9a	−24.2	0.141	2.127	16170
5b	7.2	0.206	3.024	16390	9b	−9.9	0.248	4.915	14220
5c	35.3	0.206	3.298	15690	9c	30.4	0.206	3.735	14790

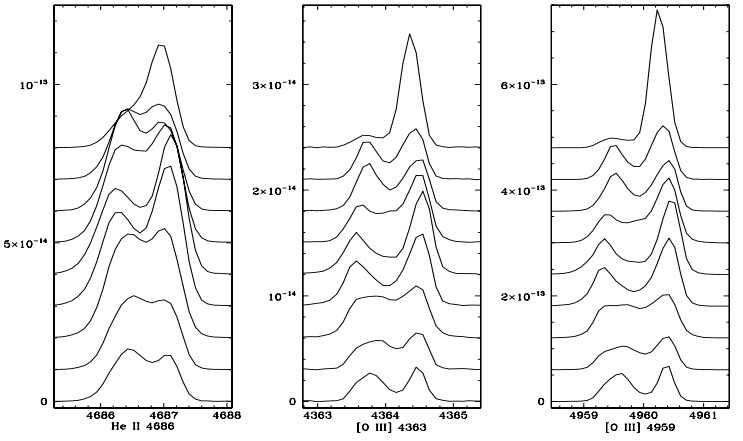

Figure 1. Selected line profiles.

3. Physical Properties

We have 7 temperature diagnostic ratios: [N II], [O II], [S III], [O III], [S II], [Ne III], and [Ne V]; of these the last 3 were only measured globally. We also have 4 density diagnostic ratios: [S II], [O II], [Ar IV], and [Cl III]; the last one was only measured globally.

In Figure 1 we present the velocity profiles of the He II λ 4686 Å line and the [O III] λ 4363 and λ 4959 Å lines, for each of the 9 regions.

In Table 1 we present the 24 identified components. For each component we show the velocity relative to the central star in km/s, the line intensities of λ 4363 and λ 4959 relative to Hβ, and the [O III] electron temperature. Typical temperature errors are ∼300 K, so the temperature differences are real.

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