A Massive Star Odyssey, from Main Sequence to Supernova
Proceedings IAU Symposium No. 212, © 2003 IAU
K.A. van der Hucht, A. Herrero & C. Esteban, eds.

Insights into Wolf-Rayet WC9 stars from spectroscopy

Philippe Eenens

Departamento de Astronomía, Universidad de Guanajuato, Apartado 144, 36000 Guanajuato Gto, México

Luis J. Corral

Instituto de Astrofísica de Canarias, C/Vía Láctea s/n, E-38205 La Laguna, Tenerife, Spain

Abstract. We present new spectroscopic observations of WC9 stars. As predicted by Williams & van der Hucht (2000), O II lines are weak in the dust-free star WR 88, which also shows a high ionization. Spectral variability is detected in WR 106 and WR 121. These findings are briefly discussed in terms of the conditions for dust formation in Wolf-Rayet winds.

1. Introduction

It seems that no two Wolf-Rayet (WR) spectra are identical. This variety hides unexploited clues about the physical conditions in their winds. Even within the same subtype the spectral morphology is not uniform. However, it is not easy to give a physical interpretation of these differences. Here we report on the preliminary analysis of optical spectra of five WC9 stars (WR 88, WR 92, WR 103, WR 106, WR 121) observed in 2002 April at San Pedro Mártir.

2. To dust or not to dust

Williams & van der Hucht (2000) suggested that fainter O II lines were characteristic of WC9 stars which do not produce circumstellar dust. Although they did not observe WR 88 (a dust-free WC9 star), they predicted that in that star too O II lines would be fainter than in dusty WC9 stars. Our observations confirm their prediction: the O II λ 4416 Å/He I λ 4472 Å ratio is even fainter in WR 88 than in WR 92 (another dust-free WC9 star), thus strengthening the hypothesis that an environment less rich in *oxygen* is responsible for the lack of circumstellar dust and thus that oxygen is a key ingredient in the process of dust formation in WR stars.

3. Ionization

If the C IVλ 4441 Å/C IIλ 4267 Å ratio is an indicator of the wind ionization, then this is significantly higher in WR 88 than in the remaining WC9 stars. In the near-infrared infrared range, the spectrum of WR 88 is also set apart from the other stars of the same subtype: the C IVλ 2.078 μm/He Iλ 2.058 μm ratio is much

fainter in WR 88 than in other WC9 stars observed (see figure 4 of Eenens & Williams 1994.)

4. Variability

We also observed notable variations in the spectra of two of the five stars in our programme. A comparison of our spectrum of WR 121 with that taken in 1997 by Williams & van der Hucht (2000), reveals that the C IVλ 4441 Å/C IIλ 4267 Å ratio has increased by some 40 percent between the 1997 and 2002 observations, suggesting a change in the wind ionization. This reminds us of the spectral variations seen in WR 104, where an observed decrease in ionization was attributed to the obscuration of the inner WR wind by a dust cloud (Crowther 1997; more recent dust-obscurations have been reported by Kato *et al.* 2002a). Indeed, photometric observations have led to the conclusion that WR 121 too is episodically obscured by passing dust clouds (Veen *et al.* 1998). If such a cloud was present in the line of sight of the inner wind of WR 121 during the 1997 observations, this could explain the lower ionization observed then.

Although our 2002 spectrum of WR 106 is similar to that obtained in 1997 by Williams & van der Hucht (2000), the O II λ 4416 Å line was considerably fainter in a lower-resolution spectrum we observed at San Pedro Mártir in 2000 June. Since weak O II lines seem to be typical of WC9 winds that do not form dust, we conclude that the conditions favoring dust formation were not present at the time of our 2000 observation and that the amount of dust in the wind of WR 106 is likely to be variable, as evidenced recently by Kato *et al.* (2002b).

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https://doi.org/10.1017/S0074180900211881 Published online by Cambridge University Press