NEUTRAL OXYGEN IN HERBIG Ae STARS

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EXTENDED ABSTRACT. In stars with dense envelopes such as classical Be and T Tauri stars, the near infrared lines of OI have been observed : λ 8446 Å in emission, λ 7772 Å in absorption or in emission (e.g. Polidan and Peters, 1976 ; Herbig and Soderblom, 1980). In Herbig stars, only low resolution (2-7 Å) material is available on a few objects (Shanin et al. 1975 ; Andrillat and Swings, 1976).

We observed a sample of Herbig, intermediate mass, pre-main sequence stars in the near IR OI lines in view of studying the formation mechanism of these lines and of comparing them to the UV resonance triplet at λ 1302 Å.

The observations consist in high resolution ($\Delta\lambda \sim 0.2$ Å) spectra of the regions λ 7772 and λ 8446 Å in 7 Herbig Ae stars : BD + 61°154, AB Aur, HD 250550, HR 5999, HD 150193, HD 163296 and BD + 46°3471. These spectra were obtained at the Canada-France-Hawaii Telescope, Hawaii, and at the Coudé Auxiliary Telescope, ESO, Chile. We also obtained short wave, high resolution (0.1 Å) images from the International Ultraviolet Explorer for the star AB Aur only.

The remarkable characteristics of the lines are as follows :
1. Near infrared OI lines in 7 Herbig Ae stars. Three groups can be recognized among the stars observed.
Group I. Both the lines λ 8446 Å and λ 7772 Å are in emission (4 stars)
Group II. Both sets of lines are in absorption (2 stars)
Group III. λ 7772 Å is in absorption, λ 8446 Å in emission (1 star).
Group I contains the stars with the largest emission in other lines. The near IR OI line profiles are very different in shape from star to star, with more pronounced differences than observed in other spectral features (Catala et al., 1986).

2. The space UV OI lines in AB Aur. In the resonance multiplet (UV2), the λ 1302.17 Å line presents a wind profile without P Cyg emission.

I. Appenzeller and C. Jordan (eds.), Circumstellar Matter, 101–102.
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https://doi.org/10.1017/S0074180900156098 Published online by Cambridge University Press

The blue edge velocity is very similar to that observed in C IV and Mg II at the same date. We infer from this that OI resonance line blue wing traces depths of the wind where V_{max} has been reached. On 4 coadded spectra, we searched for the presence of the intercombination multiplet UV1 : the lines λ 1355.60 and λ 1358.51 Å are absent, whether in absorption or in emission.

An interpretation of the observed behaviour of the near IR and resonance OI lines is presented on the example of AB Aur. The ionization equilibrium of OI is studied in the expanding chromosphere of the star, for which a model has been constructed (Catala et al, 1984). The similarity of the blue edge velocity of the resonance lines of OI, C IV and Mg II favours a formation zone for the OI lines in the upper chromosphere, where OI is radiatively ionized but still abundant enough.

The formation of the near IR lines can follow a scheme where λ 8444 Å results from the fluorescent excitation of 3d $^3D^\circ$ by Ly β from $2p^4\ ^3P$ (the wavelength coincidence is to Δλ = 0.05 Å). λ 7772 Å in emission can be formed in the same way, first by excitation of 3d $^5D^\circ$ by Ly β from $2p^4\ ^3P$ but this time Δλ = 0.766 Å, or Δv = 216 km s^{-1}. A preliminary computation by one of us (C.C.) of the mean intensity of Ly β, centered at the wavelength of each of the $2p^4$ - 3d OI lines, expressed in the observer's frame, for the wind model of AB Aur, shows that the whole mechanism is possible. Full computations will be published as soon as the lacking transition probabilities in OI are available. Also, one can understand the lack of P Cyg emission in λ 1302 Å and the absence of λ 1355 Å by the consideration of the optical depth and of the major populating and depopulating processes in each of these lines.

The still partially qualitative mechanism invoked above to explain both λ 8444 and λ 7772 Å in emission involves the broadening of Ly β by the velocity field and is able to give account of cases where λ 7772 Å is in emission and of cases where it is in absorption, depending on the velocity law v(r) in these stars and on the possibility to fluorescently pump the 3d $^5D^\circ$ level in OI.

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https://doi.org/10.1017/S0074180900156098 Published online by Cambridge University Press