MASS LOSS FROM π AQUARII

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SUMMARY: Fe III lines from metastable states have been detected in the UV spectrum of π Aqr (HD 212571). The line profiles are asymmetric and they are probably formed in a expanding envelope. From the observed line widths and using the Sobolev approximation we have derived a mass loss rate of about $2.5 \times 10^{-9} M_\odot \, y^{-1}$.

Bruhweiler et al.(1978) have shown that the UV features appearing at 2061, 2068 and 2079 Å in the spectrum of ϕ Per can be identified as transitions of Fe III originating from a metastable state (a^5S) with an energy of 5.01 eV above the ground level. The asymmetric profiles were interpreted as being formed in a expanding envelope and from the observed line widths they have derived a mass loss rate for ϕ Per of about $5 \times 10^{-11} \; M_\odot \, y^{-1}$. In their estimate Bruhweiler et al. have considered a "static" envelope to establish the equivalent width relationship with the column density and mass loss. However, if we consider the presence of a velocity gradient, a large number of atoms are necessary to produce the same absorption, resulting in a higher mass loss rate as we shall see later.

We have made a search for Fe III lines in the UV spectrum of π Aqr obtained on July 1979.High resolution IUE spectra in the short and long wavelength range (images SWP 5886 and LWR 5141) were obtained at the ESA tracking station at Villafranca del Castillo.

Besides the broad, rotationally enlarged, photospheric lines and the asymmetric lines formed in a expanding envelope,interstellar (maybe circumstellar) lines of Si II, NI, S II, CI, Cl I and Fe II are present in the spectrum, having an average radial velocity equal to -15 km s^{-1}.

The resonance lines of Si IV and C IV present strong asymmetries and striking differences when compared with the profiles obtained by Ringuelet et al. (1981) six months before. The blue-edge of these lines indicate velocities of -880 km s^{-1} and 1250 km s^{-1} respectively for the Si IV and C IV ions.

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The Fe III and Al III lines are also asymmetric with blue edge velocities of -116 km s^{-1} and 210 km s^{-1} respectively. The ionization excitation increases towards the outer region of the envelope since the ions with higher ionization potential display higher velocities.

If the highest velocity value (-1250 km s^{-1}) indicates the wind terminal velocity,we may consider that Fe III ions are not present in the envelope for distances corresponding to velocities greater than 116 km s^{-1}. On the other hand, we assume that inside such a region iron is essentially twice ionized. Under this simplifying hypothesis and using the Sobolev approximation, we have derived equation (1), which relates the line equivalent width with the mass loss rate in the case of non saturated lines:

$$W \simeq 1.61 \times 10^{13} \gamma f_{ij} \lambda^2_{ij} f_B A_{el} \frac{\dot{M}}{RV_\infty} \text{Å} \quad (1)$$

In the above equation f_{ij} is the oscillator strength of the ij transition, λ_{ij} is the wavelength (in Angstroms) of the considered line, f_B is the effective Boltzmann factor (equal to one if the ions are in the ground state), A_{el} is the abundance of the element, R is the stellar radius in solar units, V_∞ is the wind terminal velocity (in km s^{-1}) and $\dot{M}$ is the mass loss rate in solar masses per year. The factor γ is calculated numerically integrating the line profile on the blue side.

Using the data of the Fe III transitions $a^5S-z^5P^o$,from equation(1) we derived $\dot{M} \simeq 3.7 \times 10^{-9}$ $M_\odot$/year. Under the same assumptions, using the Al III resonance transition $3s^2S-3p^2P^o$, we have obtained a mass loss deduced of about 2.4×10^{-9} $M_\odot$/year. This value is comparable to that deduced for γ Cas (7×10^{-9} $M_\odot$ y^{-1}) by Hensberge et al. (1980) and to that deduced for the BOV star τ Sco by Lamers and Rogerson (1978). We have re-analysed the data of ϕ Per by Bruhweiler et al. (1978) using our theory and we have obtained a mass loss rate of about $6.5 \times 10^{-10} M_\odot$/year, assuming a terminal wind velocity equal to 1000 km s^{-1}.

All these results seem to indicate that, at least for the brighter Be stars, the mass loss rates are of the order of a few times $10^{-9} M_\odot y^{-1}$, which are two orders of magnitude smaller than the previous results obtained from the optical recombination lines, suggesting that such a lines are formed probably in a denser disk around the equatorial region and not in the expanding envelope.

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