Ionization fractions and mass-loss in O stars

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Introduction – The most sensitive indicators of mass-loss for stars in the upper left part of the HR diagram are the UV P Cygni profiles observed in the resonance lines of common ions such as N V, Si IV, and C IV. We present here some results from a study of these lines in the high resolution *IUE* spectra of 197 O stars. Profile fits were carried out in the manner described by Prinja & Howarth (1986) for all unsaturated P Cygni resonance doublets. The parameterisations adopted enable the product of mass-loss rate ($\dot{M}$) and ion fraction (q_i) to be determined at a given velocity, such that $\dot{M}\ q_i \propto N_i\ R_* \ v_\infty$, where N_i is the column density of the observed ion i, v_∞ is the terminal velocity, and R_* is the stellar radius. The accompanying figures illustrate the behaviour of $\dot{M}\ q_i$ (evaluated at 0.5 v_∞) for N V and C IV.

Figures 1 and 2 – The product $\dot{M}\ q_i$ is plotted as a function of luminosity for N V and C IV in Fig. 1 and 2 respectively. Almost the same linear relation of the form Log $(\dot{M}\ q_i) \propto$ Log $((L_*/L_\odot)^{1.6})$ is observed for both ions. This dependence on luminosity of $\dot{M}\ q_i$ is in turn almost exactly the same as that found between $\dot{M}$ and L_* from radio observations of thermal OB stellar sources (which give an almost model independent estimate of $\dot{M}$; see *e.g.* Abbott *et al.*, 1984). These figures suggest, therefore, that the ionization fractions of N V and C IV are, in a statistical sense, constant as a function of luminosity.

Figures 3 and 4 – The residuals from a linear fit of Log($\dot{M}\ q_i$) *vs.* Log(L_*) are plotted against effective temperature in Figures 3 and 4, for N V and C IV respectively. If we assume that the scatter observed in Figures 1 and 2 is primarily due to differences in the ionization fractions, then surprisingly, the ion fractions are not a simple function of T_{eff}.

This result – and the conspicuous luminosity class dependence of the Si IV doublet – reveals the inadequacy of current models to accurately predict the ion fractions. The determination of mass-loss rates from UV resonance lines (which do not normally represent the dominant stages of ionization) is therefore severely restricted by the uncertainty in the ionization fractions.

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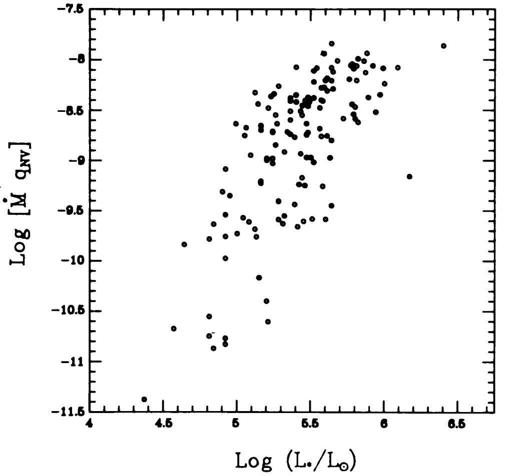

Fig. 1 – *The product of mass-loss rate ($\dot{M}$) and N V ionization fraction (q_{NV}) versus luminosity. $\dot{M}$ is in $M_\odot$ yr^{-1}.*

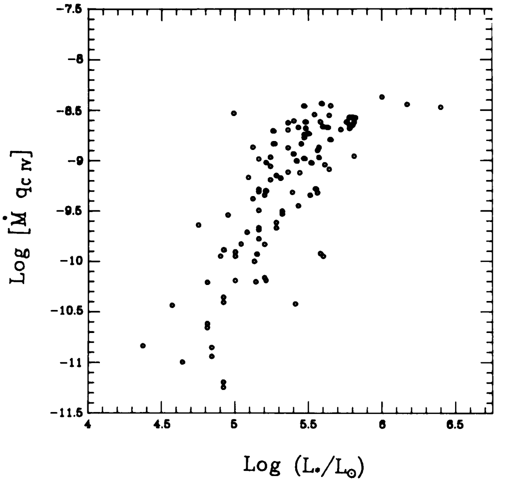

Fig. 2 – *The product of mass-loss rate and C IV ionization fraction versus luminosity.*

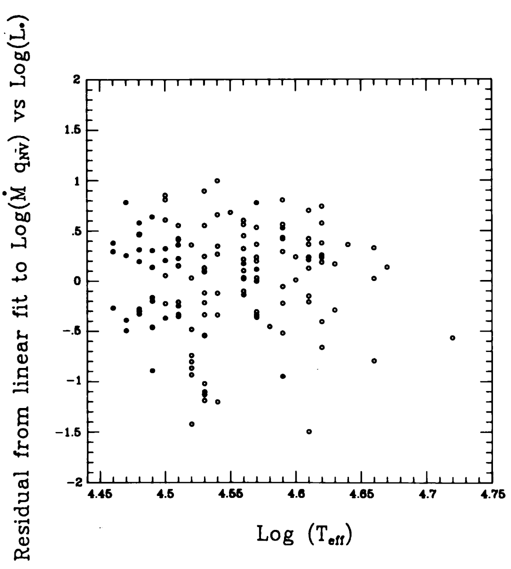

Fig. 3 – *Residuals from the linear fit to Log ($\dot{M}$ q_{NV}) vs. Log (L_*) (Fig. 1) plotted against effective temperature.*

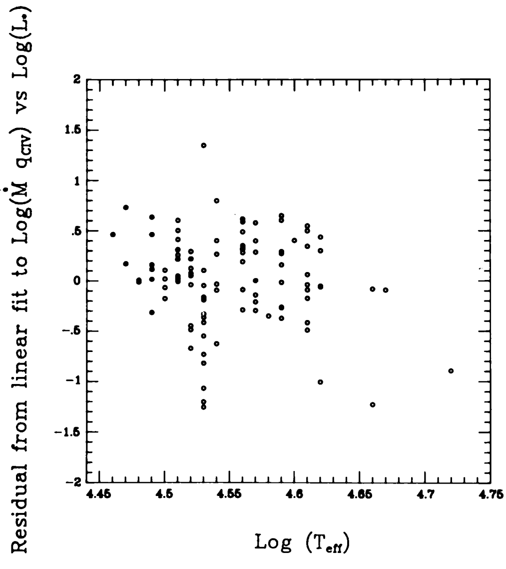

Fig. 4 – *Same as Fig. 3, except for C IV. In neither case is the dispersion about a straight-line fit substantially reduced.*

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