THE MASS LOSS RATE OF SK 80 (O7Iaf) IN THE SMALL MAGELLANIC CLOUD

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The star SK 80 in the SMC is classified as O7Iaf by Walborn (1976) who notes that it is the only confirmed Of star in that Galaxy known to date. A knowledge of the mass loss properties of OB stars in the Magellanic Clouds is of interest because of the recent evidence that such stars show reduced mass loss properties than their galactic counterparts (Hutchings 1980) and for Of stars because of the possible link between such stars and Pop I transition WNL stars (Conti 1976).
We have secured HIRES IUE and optical spectra of SK 80 and have attempted to derive the mass loss rate from these data.

The IUE spectrum of SK 80 shows the usual P-Cygni profiles in the resonance lines of NV, SiIV and CIV, and additionally in NIV 1718 and HeII 1640. The resonance lines indicate a terminal velocity of -1550 km/s which is significantly less than the typical values of -2500 for galactic O7 stars (Garmany et al. 1981), consistent with other evidence of systematically lower wind speeds in SMC early-type stars. To derive estimates of the mass loss rate we have used the NV and NIV profiles.

Using the first moment, W_1, of the unsaturated absorption component to the NV 1240 P-Cygni profile, we use the simple expression for estimating mass loss rates developed by Howarth (1984):

$$\dot{M}\ (M_\odot/y) = 3.1\times10^{-13}\ W_1^{0.373}\ (R_*/R_\odot)^{1.627}\ (v_\infty/\mathrm{kms}^{-1})^{1.373}$$

The NV 1240 profile yields $W_1 = 0.6$ which, adopting $E_{B-V} = 0.05$, $T_{eff} = 35000$ K and a distance to the SMC of 65 kpc, a comparison Kurucz model atmosphere scaled to V = 12.35 gives $R_* = 26\ R_\odot$ and with the above v_∞ we deduce $\dot{M}$ (NV) = $1.1\times10^{-6}\ M_\odot$ /y.
This simple estimate relies on the same scaling between $N(N^{4+})$ and $\dot{M}$ as derived empirically for galactic OB stars and the assumption of a normal SK 80 wind composition. The latter may be particularly suspect and the above rate could be higher by a factor of up to x10 given the SMC metallicity deficiences quoted in the literature. An additional uncertainty is introduced in the assumption that the wind ionisation structure in SK 80 is similar to galactic counterparts.

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This latter uncertainty can partially be circumvented by analysing P-Cygni profiles in excited transitions which almost certainly arise in the dominant parent ion of the species in the wind - eg NIV 1718.

Olsen (1981) has produced an Atlas of such line profiles, specified by a fit parameter T given by the relation:

$$T = \frac{\pi e^2}{m_e c} f \lambda_o \frac{w_i}{w_g} \frac{\lambda_1^3}{2hc} F_{\nu 1} (A_E \dot{M} / 4\pi\mu m_H) R_*^{-1} v_\infty^{-2} g_i$$

where λ_1 is the wavelength of the photoexciting line (755Å for NIV 1718) and $F_{\nu 1}$ is the monochromatic stellar flux at λ_1. The observed NIV profile gives T = 3 which with the value of $F_{\nu 1}$ taken from Kurucz models gives $\dot{M} = 7 \times 10^{-7} M_\odot y^{-1}$ - at first sight in agreement with the NV result.

However, Garmany et al. (1981) have found systematic differences in mass loss rates derived from excited and resonance lines indicative of a significant oversetimate of $F_{\nu 1}$ in the Kurucz models. Inspection of their data suggests a correction factor of $\Delta \log \dot{M} = 1.3$, implying a mass loss rate of $1.4 \times 10^{-5} M_\odot y^{-1}$ for SK 80 from the NIV line. However the scatter in $\Delta \log \dot{M}$ is large and this result is thus uncertain.

Alternatively (and probably most reliably) we can estimate $\dot{M}$ for SK 80 by comparing its NIV 1718 profile with those of galactic stars of the same type with accurate rates. From Garmany et al. (1981) we choose for comparison HD 167659 (O7I((f)) and HD 190864 (O7III((f))) and use a relation:

$$\dot{M}\,(\mathrm{SK}\ 80) = \dot{M}\,(\mathrm{standard})\ (T\ R^* v_\infty^2)_{SK80} / (T\ R^* v_\infty^2)_{std}\ \Delta A_e$$

where ΔA_E is the relative metallicity, which for simplicity we take as unity. The comparison with the two stars gives $\dot{M} = 2.5 \times 10^{-5}$ and $8.5 \times 10^{-6} M_\odot y^{-1}$ respectively. Of course ΔA_E is probably greater than 1. We are inclined to adopt these latter higher mass loss rates as real for SK 80 given the overall appearance of its wind spectrum and in particular the high wind density implied by P-Cygni absorption in HeII 1640. We thus propose for SK 80, a value $\dot{M} \gtrsim 10^{-5} M_\odot y^{-1}$.

Although the wind velocity of SK 80 is lower than normal, which would be consistent with low SMC metallicity and thus reduced radiative wind acceleration, any such metal deficiency does not appear to have retarded the mass loss rate itself.

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