PROPERTIES OF FAST WINDS IN HOT STARS IN THE MAGELLANIC CLOUDS

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ABSTRACT. We have studied with the SEI method (Sobolev approximation plus Exact Integration of the transfer equation) seven hot stars, five belonging to the Large Magellanic Cloud (LMC) and two to the Small Magellanic Cloud (SMC), which have been observed with IUE in high resolution. We present preliminary results of the work, i.e. the terminal velocities and the optical depth of the P Cygni profile. An evaluation of $q_i\dot{M}$ has been done, as well as a comparison with previous work.

1. Introduction

The study of winds in early type stars of the Magellanic Clouds (MCs) is important in several respects. Particularly relevant is the different metal content believed to occur in the atmospheres of these stars, relative to the corresponding galactic Population I stars.

Studies of the winds in early type stars of the MCs have been made by several authors (Hutchings 1980, Hutchings 1982, Bruhweiler *et al.* 1982, Savage *et al.* 1983, Garmany & Conti 1985, Willis *et al.* 1986, Kudritzki *et al.* 1987, Prinja 1987, Garmany & Fitzpatrick 1988, Leitherer 1988, Garmany *et al.* 1988, Moffat *et al.* 1989, Leitherer 1990).

Most of the work has been done using low resolution IUE spectra, but interesting work has been done also with the Hα line (Leitherer, 1988). Results show that the edge velocities of the winds are quite small (about 600 km s^{-1} in the LMC and 1000 km s^{-1} in the SMC) relative to their galactic counterparts. This agrees with the predictions of the improved radiation driven wind theory (Kudritzki *et al.* 1987). Regarding the mass loss rates, it is not clear at present whether $\dot{M}$ in the MC stars is smaller than the corresponding values in galactic stars (e.g Prinja 1987, Garmany & Fitzpatrick 1988, Leitherer 1988) as the theory predicts (Lucy & Salomon 1970, Castor *et al.* 1975, Pauldrach *et al.* 1986).

On the other hand, the low resolution IUE data, which give reliable v_{edge}, do not provide enough information for an accurate study of the line profile and therefore the best determination of $\dot{M}$. The use of the Hα line, while very promising, may suffer because of the difficulty in knowing precisely the velocity law close to the star where the line mostly forms.

It is, therefore, interesting to try to use all the information contained in high resolution spectra. Little work has been done so far with high resolution IUE spectra (Hutchings 1982, Willis *et al.* 1986, Garmany *et al.* 1988), and the conclusions reached have not fully clarified the matter.

With the present work, we intend to contribute to the subject by investigating, with the SEI method (Lamers *et al.* 1987), high resolution spectra of early type stars, taken from the IUE archive, of five stars belonging to the LMC and two to the SMC. The SEI method has been

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proved to be a fast and precise method of calculating P Cygni profiles of heavy ion lines, taking into account the turbulence across the wind and the effect of collisions in the source function.

2. The Method

The basic parameters of the theoretical profiles to be matched with the observed ones, are: β (exponent of the velocity law), α_2 (exponent of the opacity law), T (optical depth in the line), T_{rad} (only for excited lines), ε_0' (accounting for collisions in the source function), and W_G (accounting for thermal motion plus turbulence in the wind).

3. Results

The main preliminary results for the seven program stars are presented in Table 1, where v_∞, the optical depth, and $q_i\dot{M}$ ($M_\odot$ yr^{-1}) are given. In this preliminary work to derive $q_i\dot{M}$ we have made reference to an hypothetical star with $R/R_\odot$=10, T_{rad}=40,000 K, and chemical abundances of $Z=0.3Z_\odot$ for the LMC objects and of $0.1Z_\odot$ for the SMC stars. Figure 1 shows an example of the fit of the observed profiles with the theoretical profiles computed with the SEI method in HD 32228.

The only possible comparisons with previous studies is Sk 80, studied with IUE at high resolution by Willis *et al.* (1986) in the NIV line. These authors find an optical depth T=3, while we obtain the close value of T=2. We cannot compare the other properties of the wind for lack of details in that study. Willis *et al.* find $\dot{M}=2.5\times10^{-5}$ $M_\odot$ yr^{-1} (for solar abundance, comparing the NIV profile with that of a corresponding galactic star), while we get $q\dot{M}=3.2\times10^{-8}$ $M_\odot$ yr^{-1} (using solar abundance, T_{rad}=37,500 K and $R/R_\odot$=26.3). For this and for the other stars we have yet to address the problem of evaluating q_i.

Four of the stars in Table 1 have been studied by Leitherer (1990) using the Hα flux formed in the wind.

We feel that, when our analysis with the WEI method is completed, accurate information on the properties of the winds observed, at least in some of the considered stars, will be obtained.

Table 1. Mass loss rates and best-fit parameters.

Name	Sp. Type	v_∞	$\dot{M}q_i$ \ T --> C IV	Si IV	N IV	N V	O V
LMC							
HD 268605	O9.7Ib	2160	2.2 -8 \ 100	5.1 -8 \ 50	--	--	--
HD 269698	O4If+	2500	5.4 -8 \ 100	--	6.0 -7 \ 20	--	--
HD 32228	WC6+)8:	3400	2.0 -9 \ 1.2	1.6 -9 \ 0.5	--	--	--
Sk -67 111	O7Ib(f)	2450	3.6 -8 \ 70	4.8 -8 \ 20	1.2 -7 \ 2	--	--
HD 38268	O+WN	3560	4.2 -9 \ 3	--	--	--	--
SMC							
HD 5980	WN4+O7I:	3625	3.8 -8 \ 10	7.2 -9 \ 0.1	4.5 -7 \ 0.3	2.7 -6 \ 40	2.1 -7 \ 0.2
Sk 80	O6.5If	1590	5.3 -8 \ 100	1.6 -7 \ 50	6.6 -8 \ 2	--	--

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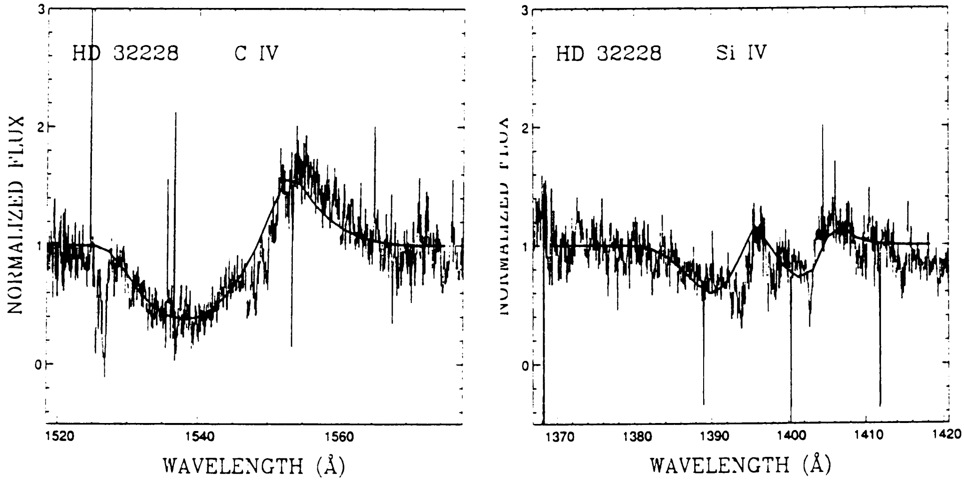

Figure 1. The theoretical best fit profiles are plotted over the observed profiles of CIV and SiIV in HD 32228.

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