Analysis of IUE spectrograms for Be stars

T. Eversberg[1], J. Dachs[1], T. W. Berghöfer[1,2], C. Huilai[1,3], U. Lemmer[1,4]
[1] *Astronomisches Institut der Ruhr-Universität Bochum, D-44780 Bochum, Germany*
[2] *Max-Planck-Institut für Extraterrestrische Physik, Giessenbachstrasse, D-85748 Garching, Germany*
[3] *Beijing Astronomical Observatory, Chinese Academy of Sciences, Beijing 100 080, China*
[4] *Fischbachauer Str. 8, D-81539 München, Germany*

Archival high-dispersion spectrograms obtained by the International Ultraviolet Explorer satellite in the short-wavelength ($\lambda\lambda$1150-2000Å) region were inspected and analyzed for a total of 33 Be stars, including one Oe star (HR 6397) and three stars showing shell-type spectra in the optical region (48 Lib, ε Cap, o Aqr). The following atomic and ionic transitions were investigated: HI-Lyα, CII-UV1, CIII-UV4, CIV-UV1, NV-UV1, SiII-UV1...-UV4, SiIII-UV2, SiIV-UV1.

Measured line parameters include absorption equivalent widths, central line depths, full widths at half-maximum intensity, and short-wavelength edges for asymmetric profiles indicating the presence of a stellar wind. As far as possible, photospheric, circumstellar, and interstellar contributions to line absorption in these multiplets were identified according to their different line widths and evaluated separately. By means of curve-of-growth methods, column densities were derived for interstellar HI and SiII in the line of sight to program stars. HI column densities were then used to determine interstellar contributions to $(B-V)$ colour excesses measured for these stars.

For Be stars showing shell-type spectra in the optical region, a strong circumstellar contribution to HI and SiII column densities is revealed by the appearence of SiII resonance absorption line transitions arising from excited fine-structure levels of its ground state (e.g., SiII λ1265, 1533, 1814 Å). Shell absorption in these SiII lines is also distinctly visible in one spectrum obtained for HR 4140 on 1980 January 23, but not in another one measured for the same star 1983 April 02. All these shell stars, including HR 4140, also show strong narrow absorption lines in the FeIII-UV34 multiplet (λ1895Å, 1914Å and 1926Å).

Photospheric absorption lines in the spectra of Be stars are characterized by strong symmetric broadening due to rapid rotation of the star. Equivalent widths measured for photospheric components of SiII , SiIII and SiIV lines were compared to results of theoretical line strength predictions found in the literature (e.g., by Kamp (ApJ Suppl. **36**, 143, 1978) and Lennon et al. (Mon. Not. R. Astr. Soc. **222**, 719, 1986)). For SiII λ1533Å(UV2) we generally observe higher values of equivalent widths as calculated for photospheric lines at an adopted Si abundance of $N(Si)/N(H) = 3 \cdot 10^{-5}$ (Fig. 1). The largest values of SiII absorption are found for stars also showing strongest, usually asymmetric SiIV absorption lines (with their asymmetry due to stellar wind).

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 280–281.

Photospheric and interstellar components in CII and SiII resonance lines are separated and discussed, and the spectral type dependence of CIII-UV4 and SiIII-UV2 multiplets is investigated.

Stellar wind was studied as indicated in the spectra of Be stars by the presence of extended blue wings in the resonance lines of SiIV-UV1 and CIV-UV1. Our data clearly show the CIV resonance doublet equivalent widths to increase both with increasing T_{eff} and with increasing $v \sin i$ of the stars. For the equivalent widths of SiIV-UV1 absorption, we find a similar correlation with T_{eff} but no firm correlation between terminal velocity and stellar latitude (Fig. 2).

Equivalent widths and terminal velocities measured for the SiIV λ1393Å(UV1) line were used to determine mass loss rates $\dot{M}$, starting from equation (37) of Dachs and Hanuschik (A&A **138**, 140, 1984). Optical depths in the wind flow at wind velocity $V_\infty/2$ were derived by fitting observed line profiles to theoretical P Cygni-type profiles calculated by Castor & Lamers (ApJ Suppl. **39**, 481, 1979), with resulting values of optical depth $T_{1/2}$ ranging between 0.2 and 0.8. For the ion density fraction, N_{SiIV} / $N_{Si,total}$, the maximum value of 0.35 obtained in the calculations by Arnaud & Rothenflug (A&A Suppl. **60**, 425, 1985) was adopted as a uniform ratio, while the relative Si abundance in the wind, N_{Si}/N_H was taken to equal $4 \cdot 10^{-5}$.

Resulting mass loss rates derived from SiIV profiles range between 10^{-11} and 10^{-9} solar masses per year and, on the average, distinctly increase with increasing effective temperature of the star. Evidence for extended blue wings due to stellar winds is also detected in the photospheric components of SiII λ 1526 Å resonance lines. For several Be stars, time variations of the stellar wind were studied. Spectacular changes were noted in particular for HR 2855 between 1981 and 1987 in the NV and CIV doublet resonance absorption profiles.

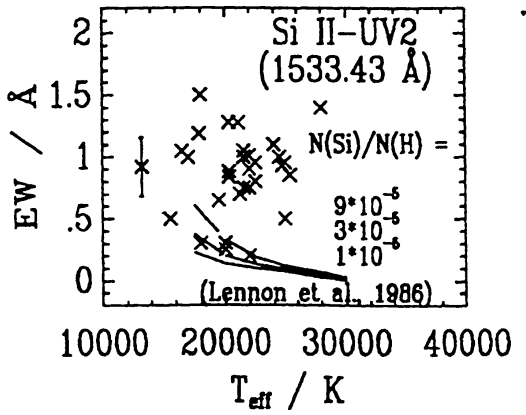

Figure 1

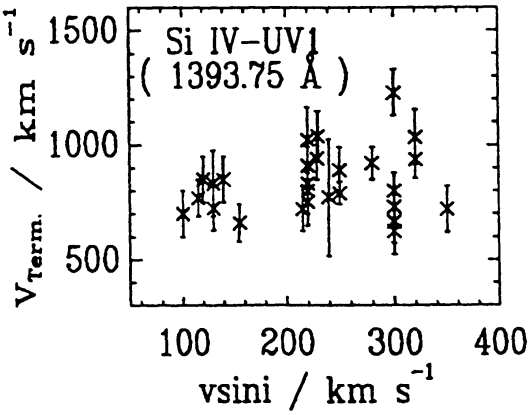

Figure 2