The ORFEUS Far Ultraviolet Spectrum of the LMC Binary Star HDE 269546

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Abstract. Far UV high resolution spectra of 3 LMC and SMC stars were obtained with the Echelle spectrograph during the second *ORFEUS* mission in Dec. 1996. We present the first results from observations of the LMC star HDE 269546. We find definitely components of very hot gas identified as OVI and SVI absorption in the galactic halo of the Milky Way and in the LMC. Additionally, more than 30 ions of the most abundant elements in different stages of ionization can be identified in both our galaxy and the LMC. For the first time we can identify a significant absorption component of molecular hydrogen in the *ORFEUS* II Echelle spectrum with a redshift of 200 km s^{-1}, doubtlessly to be attributed to the LMC.

1 Introduction

With the *Copernicus* satellite the first detection of OVI (Rogerson 1973) showed the presence of a widely spread hot ISM component in the Milky Way. *IUE* and more recently *HST* spectra from distant, high galactic latitude stars and from many extragalactic objects, including stars in the LMC and SMC, gave insight into the structure of the ISM in the disc and halo of our galaxy (Savage 1987, Spitzer 1990, Danly 1991) and the existence of a hot corona surrounding the Magellanic Clouds. *Copernicus* observations of the Lyman and Werner bands of molecular hydrogen gave a first insight into the distribution of this most abundant molecule in the ISM (Spitzer & Jenkins 1975, Shull & Beckwith 1982). *ORFEUS* offered the first opportunity to study the very hot OVI, and the very cool H_2 ISM component in greater distances and with sufficient spectral resolution for ISM studies. Results from *ORFEUS* I observations of the hot halo gas were published by Hurwitz et al (1995) and Hurwitz & Bowyer (1996).

2 Instrumentation, Observations, and Data Reduction

The *ORFEUS* 1m-telescope is equipped with two alternatively operating spectrometers. The details about the telescope and the Echelle spectrometer

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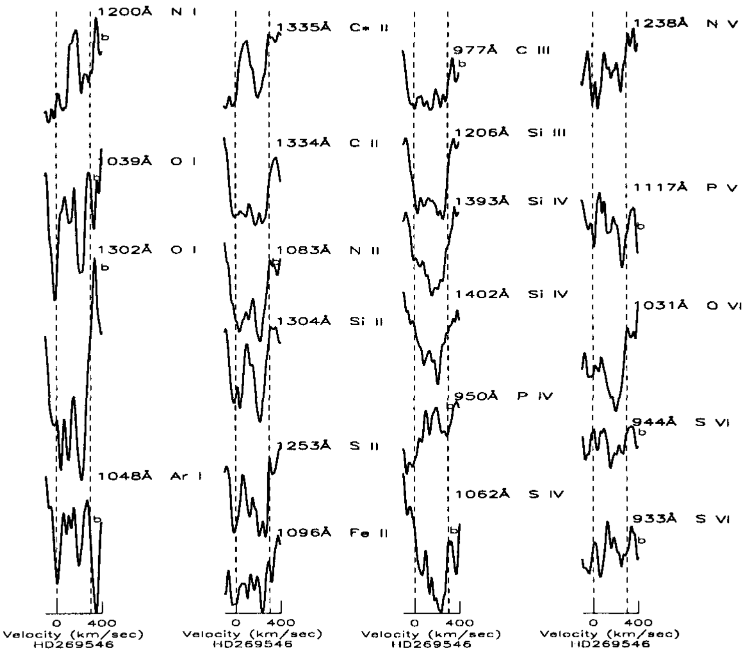

Fig. 1. A compilation of several absorption lines from neutral, singly and multiply ionized elements, including the most important O VI doublet. (b: blends)

Table 1.

Ions	center velocities km s^{-1}				
N I 1200 Å; O I 1039 Å; O I 1302 Å Ar I 1048 Å; C* II 1335 Å; C II 1334 Å N II 1083 Å; Si II 1304 Å; S II 1253 Å Fe II 1096 Å	-50	0	100	200-250	
C III 977 Å; Si III 1206 Å; Si IV 1393 Å Si IV 1402 Å; P IV 950 ÅS IV 1062 Å	-30	0	70	220	270
N V 1238 Å; P V 1117 Å; O VI 1031 Å S VI 944 Å; S VI 933 Å		0(?)	150	200-300	

are discussed in Krämer et al (1990), the Berkeley spectrometer is described in Hurwitz & Boywer (1995). The main properties of the Echelle spectrometer used for the measurements discussed herein are: spectral range: 912 Å to 1410 Å; spectral resolution: $\frac{\lambda}{\Delta\lambda} > 10,000$; effective area: $1\,\mathrm{cm}^2$. *ORFEUS* has been flown in orbit twice with the free flying carrier *ASTRO-SPAS*, launched and retrieved onboard the Shuttles STS 51, Discovery in Sept. 93 , and STS 80, Columbia in Nov.-Dec.96. During the *ORFEUS* II Mission several background stars in the LMC and SMC have been observed, three of them with

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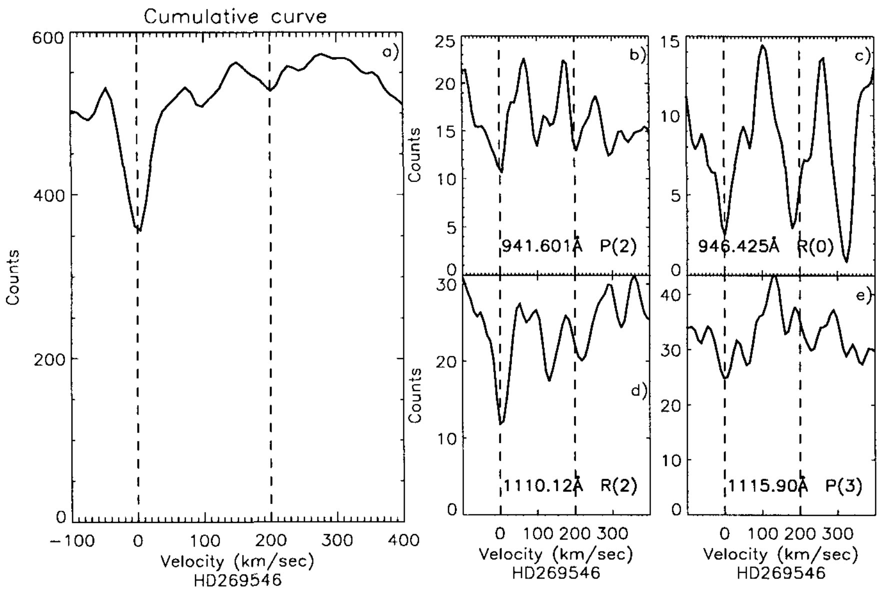

Fig. 2. a: Coaddition of 25 Lyman and Werner lines. b–e: Velocity plot of 4 different Lyman or Werner lines of molecular hydrogen.

the Echelle spectrometer. Here we present the first results from the observation of the background source HDE 269546, a B3Ia-WN3 binary that belongs to the superbubble Hen 144 (Grewing & Schulz-Lüpertz (1980)). The total integration time of this target was 110 min. We used a preliminary data reduction package: The intrinsic wavelengths scale is correct to about 0.1 Å. The velocity scale is not yet finally corrected, according to *IUE* spectra the scale should be shifted by about $-30\,\mathrm{km\,s^{-1}}$ (Chu et al (1994)). The flux scale is arbitrary.

3 Discussion of the ion spectra

We find in our spectrum more than 50 interstellar lines. Some of these are blended mostly with molecular hydrogen lines, but there are more than 30 lines of many important elements in different ionization stages, most of them not accessible with *HST*. Figure 1 shows a velocity plot of some of these lines, the spectra are smoothed with a 3 pixel boxcar, the pixel size is 0.03 Å. We identify between 4 and 5 significantly different components at each ionization stage with slightly different center velocities (Tab. 1). There is also strong indication that at least at low and intermediate stages there is some material in all velocity ranges. Qualitatively we can state that the highest column densities for the neutral and weakly ionized material are found at 0

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and around 200 km s^{-1} to be attributed to the LMC. For the highly ionized material especially OVI and SVI the column densities are much higher at $200 - 250\,\mathrm{km\,s^{-1}}$. Summarizing the preliminary results, our measurements show a much more detailed picture about the temperature and velocity ranges of the ISM in the direction of HDE 269546 than could be derived from *IUE* spectra. We are working on a quantitative analysis of this spectrum and are curious about the differences and similarities in the results from the other line of sight spectra towards the LMC and SMC.

4 Discussion of Molecular Hydrogen Lines

In Fig. 2a-e we have compiled velocity plots of 4 different Lyman and Werner band lines of H_2. In each plot we see the v=0 km s^{-1} component and with low significance components at about 100 and 200 km s^{-1}. The 946 Å line is blended at 200 km s^{-1} with another H_2 line. Actually also all other lines of the rotational levels 0 and 1 are too close to each other to identify different spatial components unambigously without careful deconvolution. In order to identify significant H_2 components with nonzero velocities we selected 25 H_2 lines from higher rotational levels which are not contaminated by any other known line within a range from -200 to +400 km s^{-1} and coadded them. The result, seen in Fig. 2a, shows definitely an H_2 component at about 200 km s^{-1} and, less significantly another component at about 90 km s^{-1}. At least the higher velocity material belongs to the LMC, consistent with the neutral gas discussed in Sect. 3.

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