FeII AND FeIII LINES AS A DIAGNOSTIC OF THE PHYSICAL CONDITIONS IN THE ATMOSPHERES OF Be STARS

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Abstract. FeII lines are frequently observed in the optical spectra of early type emission line stars. Space observations of their ultraviolet spectra led to the discovery of a considerable line absorption due to ionized metal lines formed in the stellar envelopes. We describe some examples and show that spectral synthesis is required especially for the analysis of the low resolution spectra, and may provide information about the structure of the envelopes and the mass loss rates. We also discuss the FeIII lines in the UV spectra of a Herbig Be star and of β Lyrae.

Early type emission line stars frequently display in their optical spectra FeII emission lines of variable intensity and profile. They are likely formed in extended, optically thick, cool envelopes. Since the FeII spectrum is characterized by a large number of transitions with different oscillator strength and excitation, in a wide wavelength range, it is very useful as a diagnostic of the physical conditions in the stellar envelopes. We are especially interested in the space ultraviolet where the strongest FeII transitions occur. Beeckmans and Hubert-Delplace (1980) from a systematic study of the TD1 S2/68 spectra of Be and B-shell stars found a deficiency of the UV radiation which is correlated with the intensity of the visible emission/shell lines. This could partly be due to line absorption by single or doubly ionized metals. An interesting example is the peculiar Be star HD 50138 showing variable absorption near 2500 A (Savage et al. 1978) which we attribute to a variable shell FeII absorption.

The ultraviolet spectra of the luminous Be stars such as P Cyg, AG Car and the LMC star S22 described by Bensammar et al. (1983) are strongly affected by absorption and emission of envelope FeII lines. Their study requires the development of new techniques of spectral synthesis involving thousands of FeII lines and a model of the expanding envelope. From a systematic study of the UV spectra of Magellanic Cloud stars, Muratorio and Friedjung (1986) concluded that the optical FeII emission lines are formed in a dense region or disk, while the UV absorptions are due to a cool wind. The analysis of faint or largely reddened B-stars, whose UV spectra could be observed only at low resolution requires the use of refined techniques of spectral synthesis which would provide information on the mass loss rate and structure of the wind.

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FeIII is a powerful tool to investigate the structure of the hot stellar envelopes. HD 200775 is a well known Herbig Be star showing in the optical variable FeII and [FeII] emission (Viotti 1969). Despite the presence of a cool circumstellar envelope, the strong FeII absorption features are absent in the IUE spectra. We have analyzed the high resolution SWP spectrum of the star, and found that the FeIII UV-multiplet no.34 arising from the a7S metastable level, is strong and displays a narrow absorption at the star radial velocity, and a broad violet-shifted absorption extending from about -65 to -240 km/s which is formed in the diluted expanding envelope of the star. This structure is also visible in the resonance lines of CII, AlII and AlIII.

The ultraviolet of the eclipsing binary β Lyrae is one of the best examples of a spectrum dominated by emission lines. Observations with COPERNICUS and BUSS led to the identification of absorption and emission lines of once and doubly ionized metals. FeIII with P Cygni profile is particularly prominent near 2000 A and in the far-UV (Hack et al. 1976; Hack et al. 1983). Viotti (1976) noted that the UV energy distribution of β Lyrae between 1400 and 2300 A could mostly be accounted for by line emission from Fe III. Another possible contributor is NiIII whose line emission is characterized by a hump near 1700 A which is also present in the spectrum of β Lyrae. Synthetic spectra are required in order to derive the true contribution of these ions to the UV energy distribution, especially for the unresolved faint lines which might significantly raise the continuum level.

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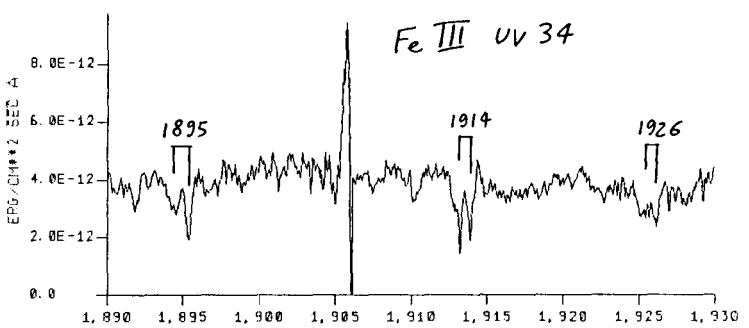

Figure 1. The high resolution IUE spectrum of the Herbig Be star HD 200775 near the multiplet UV 34 of FeIII. The narrow (0 km/s) and broad (-65 to -240 km/s) absorptions are indicated.

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