THE MODELING OF THE CHROMOSPHERE OF THE R CrB STAR

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ABSTRACT. An attempt is made to model some spectral properties of the stars with the R Coronae Borealis variability.

Key words: Stars: variable; stars: individual: R CrB.

The variability of R Coronae Borealis stars is usually explained as a consequence of the circumstellar carbon-rich dust formation. Absorption lines are replaced by emission lines when star is obscured by the dust cloud (see review by Clayton 1996, Rosenbush 1996) or by the dust envelope (Rosenbush 2000). The absorption by the dust decreases the photospheric radiation, but the extended chromosphere remains visible and it produces the emission lines.

We calculated the profiles of chromospheric lines in time of the obscuration and compared them to the profiles observed at minima. As a starting model chromosphere we used the model of Eps Gem star which is similar to R CrB by the T_{eff} and gravity. As a model photosphere we took Asplund model (Asplund et al. 2000 and private communication). We used non-LTE program with a plane-parallel layers approach when calculating the source function but took into account the curvature of layers when calculating the emerging intensity. After trying many models we came to the conclusion that the model chromosphere in hydrostatic equilibrium is not suitable for the explanation of the observed emission of chromospheric lines. The extension and the mass of hydrostatic models are not big enough and the line emissions are too small. For the explanation of the observed emission the mass of chromosphere must be two orders higher as compared to that of hydrostatic models. The density of the chromosphere must be rather low, so that the extension of chromosphere would be 2-3 radii of the star. With such models we have received good agreement between observed and calculated profiles of H_{alpha} and H and K Ca II lines both for undisturbed state of the star and for the minima of different depth. But we could not get the agreement for the D lines of Na I. The calculated profiles of D lines are much too narrow as compared to the observed ones for maximum and show very low emission for minimum.

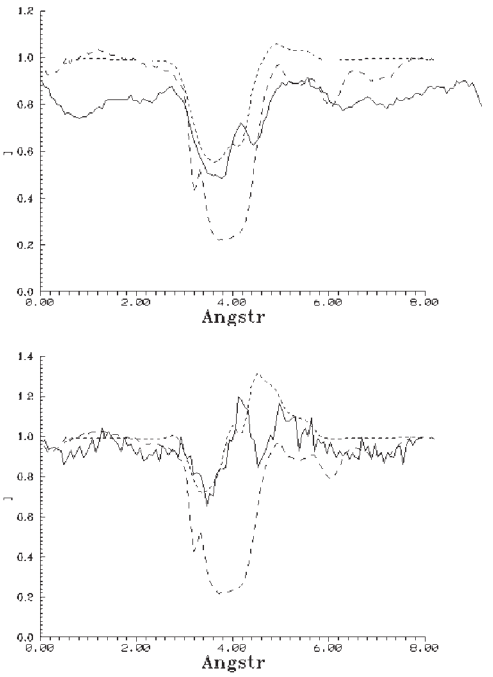

Figure 1: Calculated (short dashed) and observed (solid) profiles of D 2 Na I in minima with 2.4^m and 3.5^m weakening; long dashed- undisturbed profile.

We could get the agreement of the D line profiles only with the assumption that there exist around the star the cold envelope of Na I atoms. In the undisturbed state the envelope produces the additional absorption in the D lines. In the minimum the envelope, illuminated by the star radiation produces also the emission in the D lines induced by the resonance scattering in the D lines. The optical thickness of the envelope in the D 2 line is about 2-2.5. Nearly all radiation of the star in the D lines is absorbed in the envelope and after scattering goes away from star. In the minimum the dust cloud screens the star but the envelope remains visible. The emission from the envelope is calculated by the same non-LTE program as by the emission from chromosphere, only in this case the primary source is determined by the scatter of star radiation on the Na I atoms.

The existence of Na I atoms beyond the chromosphere of the star is connected with mass loss of this star. Na I atoms are just a constituent of the material that flowed from the star and cooled to temperature below 1000 K.

We obtained the best agreement for D lines profiles with the envelope having the radial velocity 30-35 km/sec directed away from the star. In the final model the density is equal to 1.2^8 in upper chromosphere and 1.0^{10} in low chromosphere, the turbulent velocity varies from 6 km/sec to 1.2 km/sec, the temperature from 7000 K to 5000 K. The extension of the chromosphere is about 3 star radii.

The comparison between the calculated and observed profiles of D 2 line for minimum is shown on fig.1.

References

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