Spectroscopic Analysis of HR 1099

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Abstract: We have calculated synthetic spectra for HR 1099 for the wavelength region
$\lambda 6425$–6445 Å, which includes the CaI $\lambda 6439$ Å and FeI $\lambda 6430$ Å lines, often used for
the surface imaging of rapidly rotating late-type stars. The best agreement between the
theoretical and observed spectra can be achieved with solar abundances in the both
components of the system, except for Ca in the primary. Theoretical calculations give
the possibility of estimating the influence of microturbulence, damping and blending on
Ca I and Fe I line profiles.

HR 1099 (V711 Tau) is one of the most investigated RS CVn type stars. Our
spectroscopic analysis is based on the spectra of HR 1099 that can be found in
the literature (Fekel, 1983; Vogt, 1983). Observations were analysed using model
atmospheres from a grid of Bell *et al.* (1975) with additional models obtained from
K. Eriksson for the temperature range 5500–4000 K and gravities 3.00–4.50. Fol-
lowing the results by Fekel (1983), we used models with the following parameters:
$T_{\mathrm{eff}} = 4500$ K, $\log g = 3.75$ for the primary and $T_{\mathrm{eff}} = 5500$ K, $\log g = 4.5$ for the
secondary. The values of $v \sin i$ were adopted from Vogt and Penrod (1982): 38
km/s for the primary and 13 km/s for the secondary.

A composite spectrum of the double system at arbitrary phase was synthe-
sized by the methods described by Lyubimkov and Samedov (1987) – see Fig. 1.
The radii of the components and the radial velocity curve were published by Fekel
(1983). From the results of our calculations for the spectral region $\lambda 6425$–6445 Å
(Fig. 2) we can conclude that elements such as Fe and Ca, the lines of which are
best represented in this region, have abundances close to solar in the secondary
component. The best fit with the profiles of the chromospherically active com-
ponent can be obtained with solar abundances of Fe, but the abundance of Ca
must be reduced by 0.5 dex. The remaining discrepancy between the observed and
theoretical profiles may be connected with the inaccuracy of atmospheric parame-
ters, atomic data for the spectral lines and with the existence of spotted areas on
the surface of the star. In the present report we use the standard method for the
rotational broadening of the lines (e.g. Gray, 1976, p. 394), without a calculation
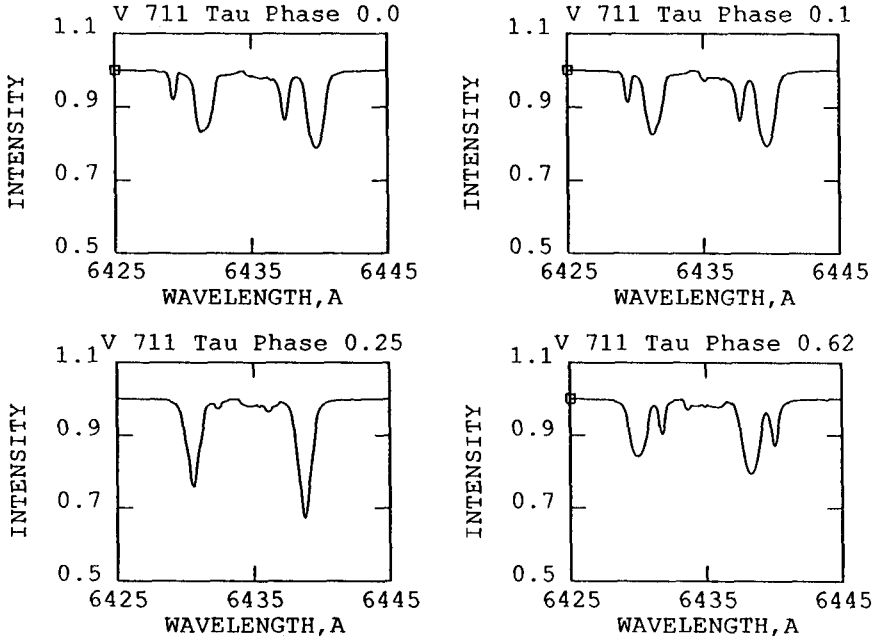of the local line profile explicitly on the visible disc for different distances from

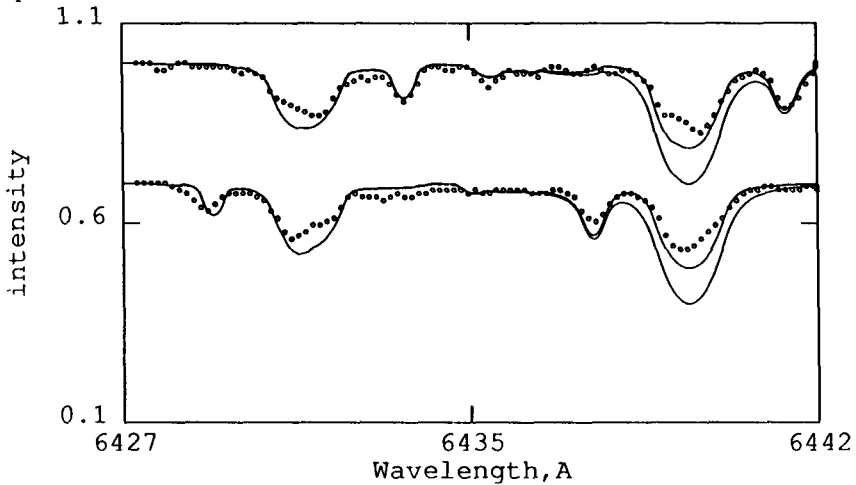**Fig. 1.** Examples of the theoretical composite spectra of the HR 1099 system for four orbital phases.

Fig. 2. Comparison between the observed (Fekel, 1983) and calculated spectrum for two phases: 0.565 (top) and 0.919 (bottom). Synthetical spectra are produced for two abundances of Ca in the atmosphere of the primary: log A(Ca) = 5.90 (upper curve) and log A(Ca) = 6.40 (lower curve). Solar abundances are assumed for other elements in the atmospheres of both components.

the disc centre. This approximation, which should be avoided in the mapping procedures of surface inhomogeneities (see e.g. Piskunov, and Hackman *et al.*, these Proceedings), influences the form of the line profile in the line centre.

Figure 3 provides the possibility of estimating the influence of microturbulent velocity ξ_t and changes in damping constant γ on the Ca I and Fe I lines. The total damping constant in our calculations is assumed to be the sum of radiative, Stark and van der Waals broadening (e.g. Gray, 1976, p. 250), the last used with a scaling factor of 1.5. The behaviour of the line profiles is different because of the different strengths of the lines and stronger saturation of Ca I line. While damping changes the whole profile, the microturbulent velocity does not influence the wings. For both Ca I and Fe I lines, the best fit can be obtained with the classical values of damping and $\xi_t = 1.0$ km/s. It can also be concluded that changes in the parameters γ and ξ_t can have similar effects to the changes in abundances.
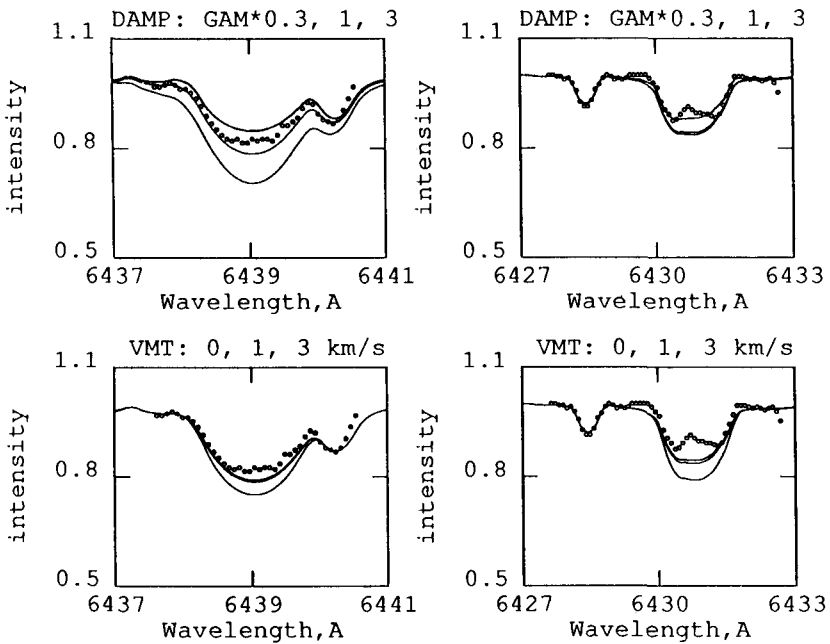

Fig. 3. Comparison between the observed (Vogt, 1983) and synthetic spectrum for Fe I (left) and Ca I (right) lines. Theoretical spectra are calculated with three values of the total damping constant – the "classical" value and this value multiplied by 0.3 and 3 (upper part of the figure). The lower part represents the synthetic spectrum with three values of microturbulent velocity, 0, 1 and 3 km/s.

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