Identification and analysis of uv emission lines observed near 1550 Å in the spectrum of α Tau obtained with the GHRS.

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1. Introduction

Carpenter, Robinson & Judge (1994) recently detected broad C IV emission lines at around 1550Å in the spectrum of α Tau observed with the Goddard High Resolution Spectrograph (GHRS) on the Hubble Space Telescope (HST). They also discovered a number of sharp emission lines, and they identified some of these as transitions in Fe II, excited by the H Lyman α line, as discussed by Johansson and Jordan (1984). We have now identified other lines as transitions in Ca II, H2 and Fe II, also excited by H Lyman α, and have made calculations of the line fluxes.

2. Identifications

The 5f→3d transitions in Ca II have been identified for the first time in a star other than the Sun, where the nf-3d and other series are observed in sunspot spectra (Sandlin et al. 1986). These are recombination lines following photoionization by H Lyman α out of the metastable 3d levels (Linsky & Avrett 1970, Rowe 1992).

Lines of H2, excited by H Lyman α, and previously observed in solar sunspot spectra (Jordan et al. 1977), have been identified for the first time in a giant star. The upper level ($B^1\Sigma_u^+ v' = 1, J = 4$), is excited from the $X^1\Sigma_g^+ v'' = 2, J = 5$ level, and the decays occur in the R(3) and P(5) branches. The transitions observed are $v' = 1, J = 4$ to $v'' = 8, J = 3, 5$ at 1547.3 and 1562.4Å.

The lines of Fe II identified are transitions to the (3G) 4s a^4G term from (5D) 5p levels. These upper levels are pumped from the (5D) 4s a^4D term by H Lyman α.

3. Analysis

The analyses carried out so far use the model of the chromosphere of α Tau by Kelch et al. (1979). The H Lyman α intensity throughout the chromosphere and upper photosphere is calculated by solving the radiative transfer and hydrostatic equilibrium equations using the MULTI code (Carlsson 1986). The results should
be reliable above the temperature minumum, but in the upper photosphere and the region of the temperature minumum, they will be less reliable owing to the limitations of the opacity package.

3.1. Calcium

The chromospheric model by Kelch et al. (1979) and Rowe’s 40 level Ca II atomic model have been used with MULTI to compute the predicted line fluxes, which agree with those observed to within a factor of two.

3.2. Molecular Hydrogen

We assume that the $X 1\Sigma^+_g$ levels have Boltzmann populations, that only H Lyman $\alpha$ pumping excites the upper level, and that all emitted photons in the decays back to the lower levels escape from the atmosphere. The $H_2$ number density is calculated in the hydrostatic equilibrium code in MULTI. At present the calculated fluxes exceed those observed because of the high abundance of $H_2$ in the photosphere. The analysis will be improved by the inclusion of collisional effects.

These fluorescent lines are potentially important in testing the presence of cooler than average components of the chromosphere and the concept of thermal bifurcation in the low chromosphere (Wiedemann et al. 1992).

3.3. Iron

The analysis is carried in the same way as for $H_2$. It is assumed that iron is all singly ionized in the part of the chromosphere of interest. On average the calculated fluxes are lower than those observed by about a factor of two. The oscillator strengths (Kurucz 1990) for the transitions involving the pumps and decays are quite small ($\approx 3 \times 10^{-3}$) so these will be uncertain to some degree.

References

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