ON THE CHROMOSPHERIC BEHAVIOUR OF PHOTOSPHERIC Mn 539.47 nm SPECTRAL LINE

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1. Introduction

The measured equivalent width of the Mn 539.47 nm line irradiance shows a cycle variability of about 2% (Livingston, 1992). In this paper we analyse the unusually large variation of this line.

2. Observations, Data Analysis and Hypotheses

Reduced equivalent widths (EW) and central depths (r_c) of Fe (539.32, 539.52 nm) and Mn (539.47 nm) lines obtained on Kitt Peak Observatory (1979-1996; KP data) and used for this analysis with kind permission of Livingston(1997). From 1987 on, these lines have also been observed at Belgrade Astronomical Observatory (BAO data).

The BAO data were divided into two samples: the high activity sample (HAS; 1989-1992) and the low activity sample (LAS; 1987, 1995, 1996). The relative changes of EW and r_c of the Mn line between HAS and LAS are found by dividing these parameters by the corresponding parameters of the comparison Fe 539.32 nm line (this line has no cycle response (Livingston (1992))). A comparison of the HAS and LAS parameters gives the following results (HAS/LAS): $(\frac{\Delta EW}{W})_{rel} = 1.2\% \pm 4\%$; $(\frac{\Delta r_c}{r_c})_{rel} = 2.6\% \pm 2\%$. Both the EW and r_c increase with activity. The same procedure of reduction was applied to the KP data yielding the following results: $-1.6\% \pm 0.2\%$ for EW and $-1.2\% \pm 0.1\%$ for r_c. The EW and r_c decrease with activity. This discrepancy between KP and BAO data is probably due to systematic errors in BAO data (e.g., water vapour blends or an instrumental change in 1994). Because of that our further discussions will be based on KP data, and a special care will be taken in future for elimination of systematic errors in BAO data. The Fourier spectrum of the KP data shows a significant peak at frequency $3.0 \times 10^{-4} day^{-1}$ with a relative variation of 1.12% for EW and with 1.05% for r_c.

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The observed relative changes EW of about 1% can be explained by a temperature gradient variation of about 5 K or by a temperature change of about 3 K (Erkapić and Vince, 1995). According to Gray and Livingston (1996) the amplitude of temperature variation (derived from CI 538.03 nm line) during a solar cycle is only 1.5 K.

Using the VAL models (Vernazza *et al.*, 1981) and a plage model (Kučera and Baranovsky, 1992) we calculate the EW and r_c of Mn line for different bright network elements (BNE), and for plages. To explain the observed variations of EW and r_c during the cycle we need to assume filling factors changes that are too large in comparison to the observed values.

Strong chromospheric emission spectral lines could influence the electron population of Mn atom energy levels, but we did not find any important Mn bound-bound transitions that could be influenced by those lines.

There is also a possibility that a chromospheric component of the Mn 539.47 nm line causes the observed variations. Our synthetic profile calculations, truncating step by step the upper layers of the VALC model, show that layers over 450 km contribute to EW about -3% and to r_c about -6%. Consequently, the variation of the chromospheric Mn emission component from 20% to 50 % could explain the observed behaviour of the Mn line. We plan to check the existence of the Mn emission component by observing the transition of the photospheric into the chromospheric spectrum during the 1999 solar eclipse.

Since photons with $\lambda \leq 166.8$ nm can ionize the MnI atoms, and one of the largest transparency jumps of the solar atmosphere occurs at this wavelength region (such that chromospheric photons could penetrate to MnI line formation layers), we assume that photoionization is the main source of the MnI 539.47 nm line variability. Unfortunately, we have not relevant data at our disposal to check this assumption yet.

References

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