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Sun : a laboratory source

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Abstract. We summarise here some of the recent advances in deriving molecular and atomic parameters using the high resolution spectra of the sun.

Key words: solar spectrum - log gf - oscillator strengths

1. Introduction

The solar photosphere at a temperature of about 5000 K provides an unique opportunity for observations of molecular and atomic lines. If we know the mechanisms and the conditions under which the lines are formed, one may derive or check such valuable information that are either not available from laboratory investigations or are known with less certainty. Alternatively any deficiencies in the solar values thus obtained may help refining our knowledge about solar models. In the present review, we essentially summarise the recent progress in the field. For detailed reviews on the subject we refer to Sinha (1991, 1993), Grevesse & Noels (1994, 1995) and Sauval (1996).

Thanks to the sustained efforts and close scrutiny, the HM solar model atmosphere (Holweger & Muller 1974) is today considered the best one particularly for the visible and the infrared regions of the sun. A high quality ATMOS spectra obtained from above the terrestrial atmosphere is available (Farmer & Norton 1989). In future studies, the weak and the strong lines of the CO molecules that span the deep and the high photospheric layers and that are considered sensitive probes, we hope, may further improve the HM model.

We dedicate this paper to the memory of the late Prof. Edith A. Muller.

2. Molecular lines

Some recent advances in the study of solar molecules may be summarised as below:

The molecule OH (*Melen et al. 1995*): Pure rotational lines as well as vibration – rotation lines not observed in any laboratory investigations were discovered in the solar IR spectra. It helped improve the molecular constants.

The molecule H_2O (*Wallace et al. 1995*): This provides first unambiguous proof of the presence of water molecules in the sunspot spectra.

The molecule TiO (*Ram et al. 1996*): Lines of the delta system were identified in laboratory and sunspot spectra to yield refined molecular constants.

The molecule SiH^+ (*Trivedi & Sinha 1996*): Finding some discrepancies in the solar and the laboratory values of the oscillator strengths, the whole problem was reinvestigated by us and the solar equivalent widths were suspected. Recently, we came to know that with the help of synthetic spectra, Grevesse & Sauval have revised the earlier reported oscillator strengths and the discrepancy has vanished !

3. Atomic lines

The solar spectrum is already known to be rich in atomic lines and the log gf values derived from them are gainfully employed in analysis of other stellar spectra. The method to derive log gf usually consists of iterations over trial values of the same quantity till there is at least a satisfactory match between the observed and the synthetic spectra. Equivalent widths too have been employed for the purpose (Johansson et al. 1994).

However, the recent success of a relatively less cumbersome and simple procedure of fitting the calculated central line depth with the corresponding observed quantity has resulted in compilation of solar log gf values for 1958 lines from 40 chemical elements (Gurtovenko & Kostik 1989). We utilized the technique first to effect a cheque upon the available log gf values in the spectral range 6209 - 6273 A (Stalin et al. 1996a). This was needed in a study of the star gamma Draconis. The success thus gained has prompted us to check the log gf values for about 292 lines in the infrared J and H bands. The various sources of uncertainty are discussed in a work that is nearing completion (Stalin et al. 1996b).

4. Conclusion

The sun successfully continues to provide valuable information on the various atomic and molecular parameters.

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