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On the solar abundance of iron

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Abstract. Utilizing the MACKKL photospheric model and the latest oscillator strengths, solar abundance of iron close to the meteoritic value N(Fe) = 7.51 ± 0.01 is obtained. It helps to remove the discrepancy between photospheric and meteoritic abundances of iron.

Key words : iron abundances—photospheric models

1. Introduction

Based on new measurements of oscillator strengths of iron lines, Blackwell *et al.* (1984, BBP) analysed the solar lines and derived an iron abundance N(Fe) = 7.67 ± 0.03 which is 0.16 dex higher than the corresponding meteoritic value (Anders & Grevesse 1989). The problem was recently studied by Holweger *et al.* (1990, HHK), Holweger *et al.* (1991, HBKK) and Biemont *et al.* (1991, BBKPP). These authors, independently analysed the solar lines due to singly ionised and unionised iron and after due consideration of the values of oscillator strengths, damping constants and non-LTE effects, they show that the result due to BBP is high. HBKK used photospheric model due to Holweger & Müller (1974, HM) and while assessing the role of model atmospheres on such studies, they indicate that the choice of a model due to Vernazza *et al.* (1976, VAL) may lead to iron abundances lower by 0.127 dex. We wish to show here that the VAL model may not be a good choice and models such as HM and MACKKL (Maltby *et al.* 1986) should be used for such studies. Another purpose for this study was to study and use some computer programmes written and provided to us by Dr Y. Chmielewski.

2. The computer programmes

The programmes aimed at analysis of spectra of late F to K stars consist of three parts. Programme ADRSL computes synthetic stellar spectra under LTE. It is derived from a computer programme originally written by Baschek *et al.* (1966). Besides its better flexibility, the most significant difference of the present version with the original is the possibility of handling molecular lines either individually or in blends with other atomic or molecular lines. Besides some other work, this programme is also used for a series of calculations of single lines with iteration on the abundances. The programme iterates on the abundance of the desired element until the calculated equivalent width matches the measured value. The first correction to the abundance is estimated by use of an universal curve of growth. For the next iteration $\triangle N$ is just interpolated in table $[N_j, W_j]$, where j is the iteration index. The total number of iteration is limited to 5. It is difficult to comment upon the basis and the accuracy of this method, from the computer programme we have. The success of this method in reproducing the results due to HHK, HBKK and BBKAP is clearly demonstrated in section 3.

For a model atmosphere described by a given temperature and optical depth relation, the programme ATM calculates the density and pressure by integration of the hydrostatic equilibrium equation. It then calculates at each depth the monochromatic continuous opacity for a given set of wavelengths. It also prepares a complete model atmosphere in the structure required for use with the spectrum synthesis programme ADRSL.

The programme TCONV performs the necessary successive convolutions on the synthetic spectra computed by the programme ADRSL for comparison with observations. Some commonly used types of broadening profiles are built in the programme : a basic rotational broadening profile and the gaussian, exponential or radial — tangential models for macroturbulence. Other profiles defined numerically, like, *e.g.* a measured instrumental profile can be input separately.

3. Results and discussions

For a critical review on oscillator strengths used by us, we refer to the papers by HHK, HBKK and BBKAP. The solar abundance of iron was obtained as 7.48 ± 0.09 by HHK, as 7.50 ± 0.07 by HBKK and 7.54 ± 0.03 by BBKAP for the HM model atmosphere. Utilizing the same inputs as given by these authors, the calculations were repeated and we obtained in excellent agreement the abundances as 7.51 ± 0.09, 7.50 ± 0.08 and 7.55 ± 0.08 respectively. It may be noted here that BBKAP quote the uncertainity in abundance determination as twice the standard deviation of the mean whereas HHK, HBKK and we give them as the standard deviations. Having thus gained in confidence in our effort we then proceed to check the above calculations for the MACKKL model. For the Fe II lines used by HHK, N(Fe) = 7.46 ± 0.09, for the Fe I lines used by HBKK, N(Fe) = 7.44 ± 0.08 and for the Fe II lines used by BBKAP, N(Fe) = 7.50 ± 0.10 were obtained. Thus the introduction of the model MACKKL leads to only a slight lowering of the mean abundances within the error bars. The above results on iron abundances get further confirmed by a recent analysis by Johansson *et al.* (1992). A detailed analysis of very high excitation lines (4f – 5g) of Fe I present in the spectral region 2545–2585 cm^{-1} in high resolution spectra both in the laboratory and in the ATMOS solar spectra obtained from space lead these authors to derive a solar abundance of iron in agreement with the meteoritic value.

Biemont *et al.* (1981) discussed the weakness of the VAL model. Further arguments in favour of HM model can be found in Grevesse (1984) and in references cited therein. We found lower than observed rotational temperatures from the VAL model for the molecules

C_2 (Sinha 1984) whereas similar results based on HM and MACKKL models are consistent with observations (Sinha & Tripathi 1990).

4. Conclusions

We feel inclined to believe that the solar abundance of iron is close to the meteoritic value.

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References

Anders E., Grevesse N., 1989, Geochim. Cosmochim. Acta, 53, 197.

Baschek B., Holweger H., Traving G., 1966, Abhand. Hamburger Sternwarte, VIII, 26.

Biemont E., Grevesse N., Hannaford P., Lowe R. M., 1991, ApJ, 248, 867.

Biemont E., Bandoulex M., Kurucz R. L., Ansbacher W. & Pinnington E. H., 1991, A & A, 249, 539. (BBKAP).

Blackwell D. E., Booth A. J., Petford A. D., 1984, A & A 132, 236. (BBP).

Grevesse N. 1984 Physica Scripta, T 8, 49.

Holweger H., Müller E. A., 1974, Solar. Phys., 39, 19 (HM).

Holweger H., Heise C., Kock M., 1990, A & A, 232, 510 (HHK).

Holweger H., Band A., Kock A., Kock M., 1991, A & A, 249, 545 (HBKK).

Johansson S., Nave G., Geller M., Sauval A. J., Grevesse N., 1992, in : Infrared Solar Physics, Proc. IAU Symp., 154, Kluwer Academic Publishers (in press).

Maltby P., Avrett E. H., Carlsson M., Kjeldseth-Moe O., Kurucz R. L., Loeser R., 1986, Ap J, 306, 284 (MACKKL).

Sinha K., 1984, BASI, 12, 172.

Sinha K., Tripathi, B. M., 1990, PASJ, 42, 737.

Vernazza J. E., Avrett E. H. Loesesr R., 1976, ApJS, 30, 1 (VAL).

Note added in Proof : Utilizing HM model and new data on gf values Hannaford *et al.* (1992, A & A, 259, 301) obtained N [Fe] = 7.48 ± 0.04 in agreement to the present analysis.