On the MgH Oscillator Strengths

K. Sinha *Uttar Pradesh State Observatory, Manora Peak, Naini Tal 263129*

Abstract. The theoretical estimates of the oscillator strengths by Kirby, Saxon and Liu (1979) for the $A\,\Pi^2 - X\Sigma^2$ system of the MgH molecule are compared with the solar photospheric results. It is found that the two results are in reasonable agreement.

Key words: oscillator strengths—photospheric spectrum—MgH molecules

1. Introduction

Due to an increase in laboratory data and the availability of refined solar photospheric models, studies are being undertaken to have reliable estimates of elemental abundances for the solar atmosphere (Tsuji 1977; Lambert 1978; Lambert and Luck 1978). However, reliable laboratory estimates of the MgH oscillator strengths are still lacking and hence Lambert and Luck (1978) could not use the A–X transition of this molecule observed in the photospheric spectrum for a similar analysis. They used Mg I and Mg II lines to derive the solar magnesium abundance.

Recently, Kirby, Saxon and Liu (1979) have presented a set of theoretical estimates of oscillator strengths for the MgH transition under consideration. Naturally, one would like to use them in order to interpret the MgH line intensities.

In the present paper, the results of Kirby, Saxon and Liu (1979) are compared with our solar photospheric results obtained using the latest magnesium abundance. The KPNO Atlas (Brault and Testerman 1972) and Liege Solar Atlas (Delbouille, Roland and Neven 1973) were used in this analysis.

2. Calculations

Four photospheric models were used to compute the ratio of the equivalent width (W) to the oscillator strength of the 0–0 band (f_{0-0}) for a fairly large number of MgH lines. Dividing the corresponding observed photospheric equivalent width by this ratio yields an average value of f_{0-0}. The results presented by Sinha (1981) for

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unblended MgH lines of good quality present in the KPNO Atlas (Brault and Testerman 1972), were used to determine the observed equivalent widths. The Liege tracings due to Delbouille, Roland and Neven (1973) were used as a check.

For the model calculations of W/f_{0-0} the standard procedure for equivalent width calculations of weak lines (Sotirovski 1971) was used under the assumption of LTE. The lines were assumed to be unsaturated and Doppler broadened. The photospheric models considered were HSRA-71 (Gingerich et al. 1971), AC-72 (Altrock and Cannon 1972), HM-74 (Holweger and Müller 1974) and VAL-76 (Vernazza, Avrett and Loeser 1976). The reason for selecting these models is given in a paper by Sinha, Shukla and Tripathi (1979). The magnesium abundance was taken to be 7·62 (Lambert and Luck 1978) for each photospheric model. The dissociation constants due to Tripathi and Gaur (1979) were used to evaluate the partial pressure of magnesium. The calculations are based on D_0^0 (MgH) $= 1·27$ eV (Balfour and

Table 1. (0–0) band of the MgH $(A—X)$ system in the photospheric spectrum.

Wavelength (Å)	Branch (N'')		Equivalent width (mÅ)		Present analysis		Ratio $\dfrac{\text{Liege}}{\text{KPNO}}$
		MMH	S	LMP	KPNO	Liege	
5209·567	P_1 (19)	1		1·4	3·6	4·8	1·3
5207·625	P_1 (21)	4·5	3		5·7	8·2	1·4
5207·29	P_2 (10)	2	2	1·5	3·1	4·2	1·4
5207·073	P_2 (21)	1·5		1·7	3·6	5·0	1·4
5203·477	P_1 (7)	3·5			3·7	4·6	1·2
5202·985	P_1 (24)	2·5	3	1·9	2·1	3·2	1·5
5200·822	P_2 (6)	3	1·5	1·8	3·7	3·7	1·0
5198·326	P_2 (26)	2	2	1·5	2·4	3·9	1·6
5193·865	P_1 (28)	2	2	3·8	3·7	5·4	1·5
5193·358	P_2 (28)	3	2·5	2·2	3·7	7·9	2·1
5190·561	P_2 (29)	7	2	1·0	3·2	3·2	1·0
5178·464	Q_2 (8)	5·5	4·6		8·3	12·1	1·5
5159·790	Q_2 (16)	4	6	4·1	7·7	6·8	0·9
5157·006	Q_1 (17)	7		4·5	5·9	7·7	1·3
5124·367	R_2 (13)	3·5			3·5	5·0	1·4
5121·237	Q_1 (26)				3·2	4·5	1·4
5118·311	R_2 (14)				4·3	3·4	0·8
5106·848	R_2 (16)	4·5	3·5	3·7	5·1	5·3	1·0
5106·206	Q_2 (29)				4·3	4·8	1·1
5096·151	Q_1 (31)	3	3		5·3	7·5	1·4
5090·367	Q_2 (32)	2·5	3·5		2·1	3·2	1·5
5088·724	R_2 (19)	3	3		3·7	4·5	1·2
5085·178	Q_1 (33)		3·5		4·2	8·7	2·1
5063·519	R_1 (23)	2·5	3		1·8	3·7	2·1
5061·536	Q_2 (37)	3·5	2·5	2·9	3·7	4·8	1·3
5055·405	Q_2 (38)	1·5	1·5	1·0	1·6	2·6	1·6

Code:
MMH : Moore, Minnaert and Houtgast (1966).
S : Schadee (1964).
LMP : Lambert, Mallia and Petford (1971).
KPNO : Brault and Testerman (1972).
Liege : Delbouille, Roland and Neven (1973).

Lindgren 1978). The opacity sources listed by Tsuji (1966) were included in the opacity calculations.

3. Results and discussion

The MgH-line intensities as measured from the KPNO and the Liege tracings are given in Table 1. Similar results by Moore, Minnaert and Houtgast (1966), Schadee (1964) and Lambert, Mallia and Petford (1971) are also presented for the sake of comparison. In the present analysis, the wings of each line were traced to the near by true continuum marked in the atlas and the area under the curve was evaluated by counting the square millimetres on a transparent graph paper placed above the tracing (Moore, Minnaert and Houtgast 1966). Due to a higher placement of continuum, the Liege equivalent widths are higher by 40 per cent on an average.

Table 2 summarises the results of our oscillator strength calculations. The Liege results are again higher than the KPNO result, but agree within the standard deviations.

The mean result for the HSRA-71, AC-72 and VAL-76 is about the same. This is so because these models vary only slightly from one another. Model HM-74 differs substantially in structure and hence the result based on it is different. A higher value of oscillator strength for HM-74 is an indicator of the fact that this model needs a higher magnesium abundance, because a hotter model leads to lesser molecule formation. To keep the HM-74 result close to the VAL-76 result, the magnesium abundance may have to be increased by about 0·16 dex.

The result $f_{0-0} = 0·161 \pm ·03$ obtained by Kirby, Saxon and Liu (1979) is in perfect agreement with the KPNO result. Hennekar and Popkie (1971) found $f_{0-0} = 0·250$. The dissociation energy used by them is not known to us. Lambert, Mallia and Petford (1971), Grevesse and Sauval (1973) and Balfour and Cartwright (1976) give f_{0-0} as 0·055, 0·035 and 0·257 respectively. These results appear to differ from our results presented in Table 2, because a different elemental abundance and/or a different dissociation energy was used in their evaluation.

For the photospheric MgH molecules, Hinkle and Lambert (1975) remarked that there is practically no difference in the results obtained for scattering and for pure absorption hypotheses. So the assumption of pure absorption used here is probably satisfactory.

Table 2. Oscillator strength for the A–X system of MgH deduced from the solar spectrum.

Model	Oscillator strength for the (0–0) band	
	KPNO	Liege
HSRA-71	0·19 ± 0·08	0·25 ± 0·11
AC-72	0·21 ± 0·09	0·28 ± 0·12
HM-74	0·28 ± 0·13	0·37 ± 0·16
VAL-76	0·19 ± 0·08	0·26 ± 0·11

Code:

KPNO: Brault and Testerman (1972).
Liege: Delbouille, Roland and Neven (1973).

In conclusion it may be remarked that the results of oscillator strength calculations due to Kirby, Saxon and Liu (1979) are in agreement with the solar result. They may serve as the lower limit on MgH oscillator strengths; the only experimental result (f_{0-0} <0·002) due to Main, Carlson and DuPuis (1967) is too low.

References

Altrock, R. C., Cannon, C. J. 1972, *Solar Phys.*, **26**, 21.
Balfour, W. J., Cartwright, H. M. 1976, *Astr. Astrophys. Suppl. Ser.*, **26**, 389.
Balfour, W. J., Lindgren, B. 1978, *Can. J. Phys.*, **56**, 767.
Brault, J. W., Testerman, L. A. 1972, *Preliminary Edition of Kitt Peak Solar Atlas*, Arizona.
Delbouille, L., Roland, G., Neven, L. 1973, *Photometric Atlas of the Solar Spectrum from λ3000 to λ10000*, Institut d'Astrophysique de l'Université de Liège, Belgium.
Gingerich, O., Noyes, R. W., Kalkofen, W., Cuny, Y. 1971, *Solar Phys.*, **18**, 347.
Grevesse, N., Sauval, A. J. 1973, *Astr. Astrophys.*, **27**, 29.
Hennekar, W. H., Popkie, H. E. 1971, *J. chem. Phys.*, **54**, 1963.
Hinkle, K. H., Lambert, D. L. 1975, *Mon. Not. R. astr. Soc.*, **170**, 447.
Holweger, H., Müller, E. A. 1974, *Solar Phys.*, **39**, 19.
Kirby, K., Saxon, R. P., Liu, B. 1979, Astrophys. J., **231**, 637.
Lambert, D. L. 1978, *Mon. Not. R. astr. Soc.*, **182**, 249.
Lambert, D. L., Luck, R. E. 1978, *Mon. Not. R. astr. Soc.*, **183**, 79.
Lambert, D. L., Mallia, E. A., Petford, A. D. 1971, *Mon. Not. R. astr. Soc.*, **154**, 265.
Main, R. P., Carlson, D. J., DuPuis, R. A. 1967, *J. quantit. Spectrosc. radiat. Transfer*, **7**, 805.
Moore, C. E., Minnaert, M. G. J., Houtgast, J. 1966, *The Solar Spectrum 2935Å to 8770Å: Second Revision of Rowland's Preliminary Table of Wavelengths*, NBS, Washington.
Schadee, A. 1964, *Bull. astr. Inst. Netherl.*, **17**, 311.
Sinha, K. 1981, *In preparation*.
Sinha, K., Shukla, D. S., Tripathi, B. M. 1979, *Bull astr. Soc. India*, **7**, 38.
Sotirovski, P. 1971, *Astr. Astrophys.*, **14**, 319.
Tripathi, B. M., Gaur, V. P. 1979, *J. quantit. Spectrosc. radiat. Transfer*, **22**, 407.
Tsuji, T. 1966, *Publ. astr. Soc. Japan*, **18**, 127.
Tsuji, T. 1977, *Publ. astr. Soc. Japan*, **29**, 497.
Vernazza, J. E., Avrett, E. H., Loeser, R. 1976, *Astrophys. J. Suppl. Ser.*, **30**, 1.