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Si 6142 AND 6155 Å LINES IN STELLAR ATMOSPHERES: STARK BROADENING EFFECT

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Abstract. We study the influence of Stark broadening effect on Si I lines in the ro Ap 10 Aql star, where the lines are asymmetrical and shifted. First we have calculated Stark broadening parameters using by the semi-clasical method for two Si I lines: 6142.48 Å and 6155.13 Å. We have adopted SYNTH code to include into account both Stark width and shift for these lines. From comparison of our calculation data with observations we found that Stark broadening plus stratification effect can explain the width and the asymmetry of the Si I lines in the atmosphere of ro Ap 10 Aql star.

1. Introduction

The Stark broadening mechanism is very important for A and B type of stellar atmospheres, and one has to take into account this effect for investigations, analysis and modeling of such stellar atmospheres. In one of our previous work (Popović et al. 2001) we obtained that by neglecting this mechanism, we introduced an error between 10% and 45% in the equivalent width determination, and corresponding errors in the abundance determination. On the other hand, in A and B stars some of the lines have blue or red asymmetry. Especially this is the case for Cp stars, where e.g. Si I 6155.134 Å line has red asymmetry, which is not the case in the Solar as well as in other non-Cp star spectra. Moreover, in spectra of Ap 10 Aql star the lines of Si I 6142.483 Å and 6155.134 Å are shifted to the blue side with respect to the other Si I lines.

The aims of the paper are: a) to calculate the Stark broadening for Si I lines (6142.483 Å and 6155.134 Å); b) to test the contribution of Stark and stratification effect to asymmetry and shift of Si I 6142.483Å and 6155.134 Å.

2. The Stark broadening parameters calculation

Calculations have been performed within the semi-classical perturbation formalism, developed and discussed in detail in Sahal-Bréchot (1969ab). This formalism, as

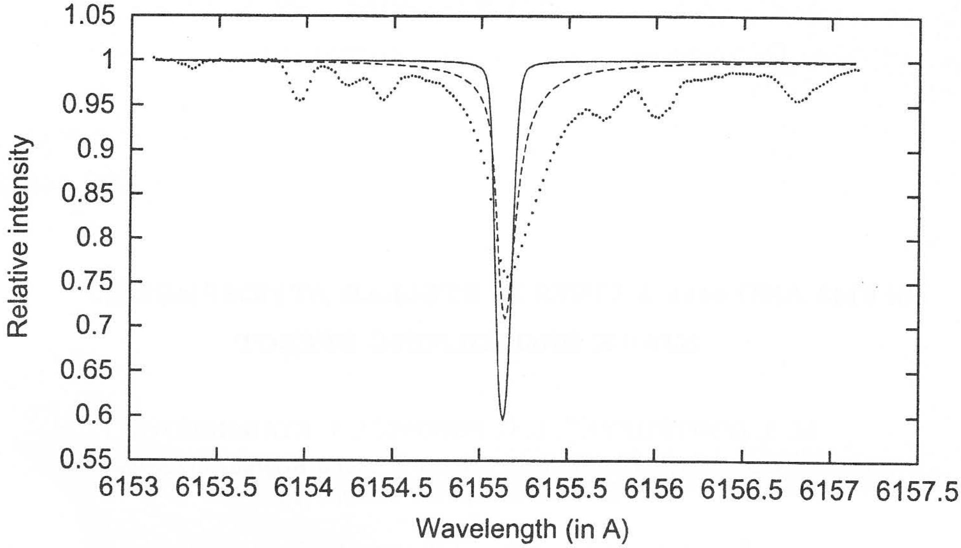

Fig. 1: The observed profile (dots) compared with the modeled one whereby we included calculated Stark parameters (dashed line). The solid line is the profile whereby Stark parameters are approximatively given in the code.

well as the corresponding computer code, have been optimized and updated (Sahal-Bréchot, 1974; Dimitrijević and Sahal- Bréchot, 1984a, Dimitrijević, 1996).

The atomic energy levels needed for calculations were taken from Martin and Zalubas (1983), but LS determination of $6s^1P^o$ and $7s^1P^o$ terms has been adopted according to Moore (1971). Oscillator strengths have been calculated by using the method of Bates and Damgaard (1949) and tables of Oertel and Shomo (1968). For higher levels, the method described in van Regemorter, Binh Dy and Prud'homme (1979) has been used. Our results for electron-, proton-, and ionized helium-impact line widths and shifts for three Si I spectral lines, for perturber density of 10^{14} cm^{-3} and temperatures T = 2,500 – 50,000 K, are shown in Table I. For perturber densities lower than those tabulated here, Stark broadening parameters vary linearly with perturber density. Nonlinear behavior of Stark broadening parameters at higher densities is the consequence of the influence of Debye shielding and has been analyzed in detail in Dimitrijević and Sahal- Bréchot (1984b).

3. Results

The results of our Stark broadening calculation are given in Table I. The calculated Stark broadening data were used to explain the asymmetry of Si I 6142.483 Å and 6155.134 Å. We have modeled the Si I 6142.48 Å and 6155.13 Å lines including calculated Stark broadening parameters. The corresponding parameters were included in each layers of stellar atmosphere. In Fig. 1 one can see the line profile without

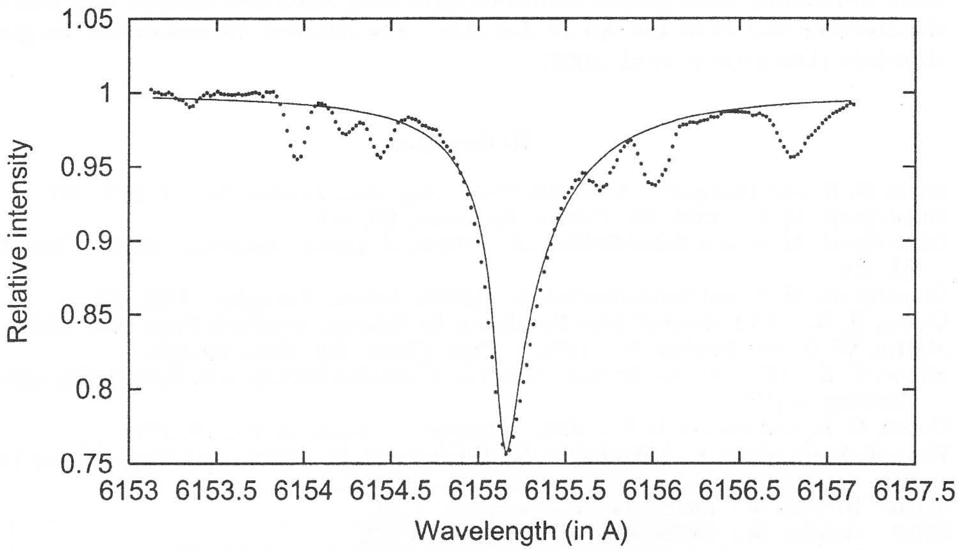

Fig. 2: The observed profile (dots) compared with the modeled one, whereby we have included Stark broadening and stratification.

Table 1: Stark Broadening Parameters for Si I Spectral Lines. This Table shows electron-, proton-, and ionized helium-impact broadening parameters for Si I for perturber density of 10^{14} cm^{-3} and temperatures from 2,500 to 50,000 K. The quantity C (given in Å cm^{-3}), when divided by the corresponding full width at half maximum, gives an estimate for the maximum perturber density for which tabulated data may be used. For higher densities, the isolated line approximation used in calculations breaks down. WIDTH(A) denotes Full line width at half maximum in Å, while SHIFT denotes Line Shift in Å. A positive shift is toward red.

		ELECTRONS		PROTONS		HELIUM IONS	
TRANSITION	T(K)	FWHM(A)	SHIFT(A)	FWHM(A)	SHIFT(A)	FWHM(A)	SHIFT(A)
SiI 4S - 5P	2500.	0.509E-02	0.333E-02	0.160E-02	0.701E-03		
2.0 1.0	5000.	0.581E-02	0.409E-02	0.172E-02	0.898E-03		
5950.2 A	10000.	0.652E-02	0.381E-02	0.183E-02	0.109E-02	0.167E-02	0.851E-03
C= 0.36E+19	20000.	0.740E-02	0.328E-02	0.194E-02	0.127E-02	0.175E-02	0.101E-02
	30000.	0.811E-02	0.271E-02	0.202E-02	0.139E-02	0.181E-02	0.111E-02
	50000.	0.903E-02	0.212E-02	0.213E-02	0.153E-02	0.188E-02	0.123E-02
SiI 3p3-5f	2500.	0.971E-01	-0.585E-01	0.176E-01	-0.145E-01	*0.145E-01	-0.115E-01
3D3-3D3	5000.	0.109	-0.624E-01	0.196E-01	-0.168E-01	0.161E-01	-0.134E-01
6142.48A	10000.	0.120	-0.597E-01	0.220E-01	-0.193E-01	0.178E-01	-0.155E-01
	20000.	0.132	-0.447E-01	0.248E-01	-0.219E-01	0.198E-01	-0.176E-01
	30000.	0.140	-0.368E-01	0.267E-01	-0.236E-01	0.211E-01	-0.190E-01
	50000.	0.146	-0.286E-01	0.295E-01	-0.258E-01	0.229E-01	-0.208E-01
SiI 3p3-5f	2500.	0.831E-01	-0.591E-01	0.176E-01	-0.146E-01	0.146E-01	-0.115E-01
3D3-3G4	5000.	0.916E-01	-0.644E-01	0.196E-01	-0.169E-01	0.161E-01	-0.135E-01
6155.13A	10000.	0.102	-0.616E-01	0.219E-01	-0.194E-01	0.179E-01	-0.155E-01
	20000.	0.110	-0.446E-01	0.245E-01	-0.220E-01	0.199E-01	-0.177E-01
	30000.	0.118	-0.360E-01	0.261E-01	-0.237E-01	0.212E-01	-0.191E-01
	50000.	0.125	-0.281E-01	0.285E-01	-0.260E-01	0.230E-01	-0.209E-01

Stark broadening (solid line) and with Stark broadening (dashed) line in comparison with observations (dots)

As one can see from Fig. 1, Stark broadening effect alone cannot explain the line shape. Next step was to take into account the stratification effect which is characteristic for atmospheres of Ap stars. As one can see in Fig. 2, the modeled line whereby

Stark broadening effect plus stratification have been taken into account very well fits the observed line from the Ap 10 Aql star. The detailed discussion will be given elsewhere (Dimitrijević et al. 2002)

References

Bates, D. R. and Damgaard, A. : 1949, *Trans. Roy. Soc. London, Ser. A*, **242**, 101.
Dimitrijević, M. S. : 1996, *Zh. Priklad. Spektrosk.*, **63**, 810.
Dimitrijević, M. S. and Sahal-Bréchot, S. : 1984a, *J. Quant. Spectrosc. Radiat. Transfer*, **31**, 301.
Dimitrijević, M. S. and Sahal-Bréchot, S. : 1984b, *Astron. Astrophys.*, **136**, 289.
Griem, H. R. : 1974, *Spectral Line Broadening by Plasmas*, Academic Press, New York.
Martin, W. C. and Zalubas, R. : 1983, *J. Phys. Chem. Ref. Data*, **12**, 323.
Moore, C. E. : 1971, *Atomic Energy Levels Vol. I*, NSRDS-NBS 35, U.S. Govt. Print. Office, Washington (1971).
Oertel, G. K. and Shomo, L. P. : 1968, *Astrophys. J. Suppl. Series*, **16**, 175.
Popović, L. Č., Simić, S., Milovanović, N., Dimitrijević, M. : 2001, *ApJ Suppl. Series*, **135**, 109.
Sahal – Bréchot, S. : 1969a, *Astron. Astrophys.*, **1**, 91.
Sahal – Bréchot, S. : 1969b, *Astron. Astrophys.*, **2**, 322.
Sahal – Bréchot, S. : 1974, *Astron. Astrophys.*, **35**, 321.
van Regemorter, H., Hoang Binh Dy and Prud'homme, M. : 1979, *J. Phys. B*, **12**, 1073.