Publ. Astron. Obs. Belgrade No. 99 (2020), 283 - 286 *Contributed Paper*

IMPACT OF STARK BROADENING ON Co II SPECTRAL LINE MODELLING IN HOT STARS

ABEER ALMODLEJ[1], ZLATKO MAJLINGER[2], NABIL BEN NESSIB[1,3],
MILAN S. DIMITRIJEVIĆ[2,4] and VLADIMIR A. SREĆKOVIĆ[5]

[1]*Department of Physics and Astronomy, College of Sciences, King Saud University, Saudi Arabia*

E-mail amodlej@ksu.edu.sa
[2]*Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia*
E-mail zlatko.majlinger@gmail.com, mdimitrijevic@aob.rs

[3]*GRePAA, INSAT, Centre Urbain Nord, University of Carthage, Tunis, Tunisia*
E-mail nbennessib@ksu.edu.sa

[4]*Sorbonne Université, Observatoire de Paris, Université PSL, CNRS, LERMA,*

F-92190 Meudon, France
[5]*Institute of physics, University of Belgrade, P.O. Box 57, 11001, Belgrade, Serbia*
E-mail vlada@ipb.ac.rs

Abstract. The ignorance of Stark broadening during the modelling of a spectral line profile in hot star spectra can cause significant errors in abundance determination. We choose several Co II, spectral lines observed in stellar spectra to show how Stark broadening influence on their profiles and we calculated Stark widths which can help to determine the abundance of this element in stellar atmosphere more accurate. Using calculated Stark widths, line profiles are synthesized and compared with isolated lines from existing observed stellar spectra. Comparisons of synthetic lines with and without taking of Stark broadening into consideration confirm previous findings that exist cases when synthetic lines with inclusion of Stark widths better fit in the observed spectral lines, especially in the line wings.

1. INTRODUCTION

Stark broadening data are useful for a number of applications as e.g. laboratory plasma diagnostics (Konjević, 1999), the research and modelling of different technological plasmas (Hoffman et al., 2005, Dimitrijević and Sahal-Bréchot, 2014) as well as for inertial fusion (Griem, 1992) and lasers and laser-produced plasmas investigation (Csillag and Dimitrijević, 2004, Dimitrijević and Sahal-Bréchot, 2014). They are particularly useful in astrophysics for a number of problems like for example stellar plasma modelling, abundance determination, and stellar spectra analysis and synthesis (see e.g. Dimitrijević and Sahal-Bréchot, 2014, Majlinger et al. 2020).

In stellar astronomy, Stark broadening data are of particular importance for white dwarfs of DA (Majlinger et al., 2017), DB (e.g. Simić et al., 2013) and DO (e.g. Popović et al., 2001) type, where Stark broadening is the dominant collisional line broadening mechanism. Such data are also of interest for interpretation, analysis and synthesis of A and B type star spectra (see e.g. Lanz et al., 1988; Popović et al., 2001, Dimitrijević et al., 2007). In particular thanks to large space observatories like Hubble, Chandra, Spitzer, Lyman, and to large, ground-based telescopes, spectra of different celestial objects with very high resolution could be obtained from X to radio wavelength ranges. So the spectral lines of earlier unsignificant trace atoms and ions, like Co II, become important as well as and data for them.

2. RESULTS AND DISCUSSION

Co II spectral lines are observed in stellar spectra (see e.g. Adelman et al., 1993) and recently Stark broadening parameters for lines of 46 Co II multiplets have been calculated (Majlinger et al., 2018, 2020) by using the modified semiempirical method (Dimitrijević and Konjević, 1980).

The aim of this research is to investigate the importance of Stark broadening of Co II lines in the conditions of stellar atmospheres and to synthesize line profile of a Co II line including Doppler and Stark broadening. The --> synthesized profile, obtained using previously calculated data for Stark broadening of Co II lines (Majlinger et al., 2018, 2020) will be compared with the profile observed in stellar spectrum.

As an example of our work we present here the behaviour of Doppler and Stark full line widths at half intensity maximum, as a function of optical depth expressed as the logarithm of Rosseland opacity, for an A type stellar atmosphere using Kurucz (1979) model with log g = 4.5 and T_{eff} = 10000 K (Kurucz, 1979). The analysis has been performed for Co II $(^4P)4sb\ ^3P - (^4P)4py\ ^3D^o$ 2533.2 Å; Co II $(^4F)4pz\ ^3G^o - (^4F)5se\ ^3F$ 2709.0 Å and Co II $(^4F)5se\ ^3F - (^4F)5p\ ^3G^o$ 2533.2 Å multiplets and the results are presented in Fig. 1. As we can see, for the multiplet λ9519 the influence of Stark broadening is the highest among the three considered multiplets and for deepest layers it becomes more influencing than the Doppler broadening.

We can also see in Fig. 1 that the influence of Stark broadening on Co II lines increases with the increase of wavelength. This is the consequence of the fact that

Stark width is proportional to λ^2 and the Doppler width to λ, so that the influence of Stark broadening will increase towards the infrared part of the spectrum.

In the continuation of our work we will synthesize a part of χ Lupi spectrum where Co II lines were observed and compare the results of our calculations with the observed spectrum of this star. We will pay particular attention to the line wings, where the largest influence of Stark broadening is expected due to characteristics of the Stark (Lorentzian) and Doppler (Gaussian) line profiles.

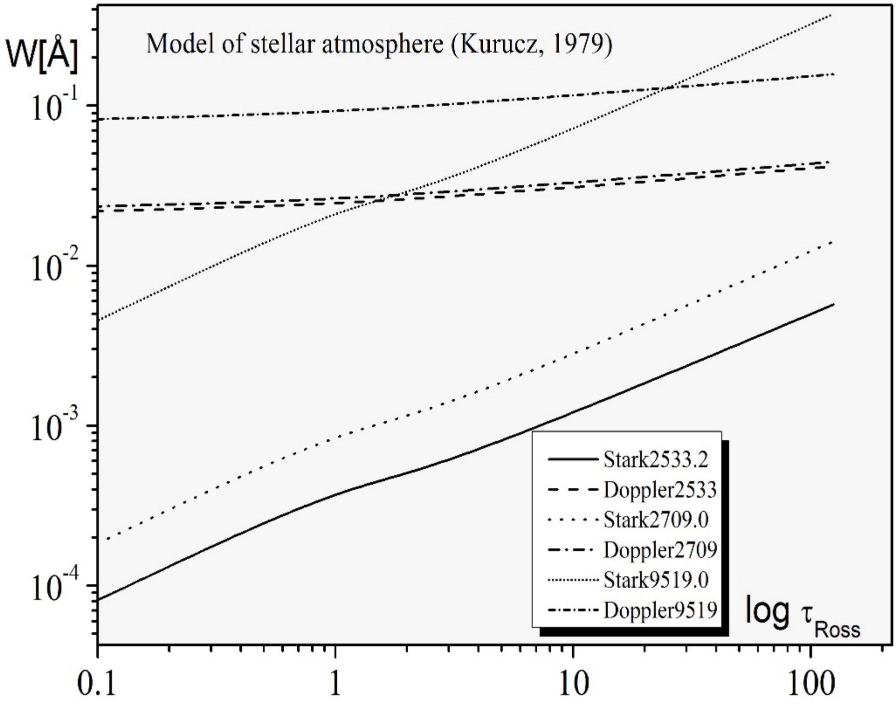

Figure 1: Stark and Doppler broadening for Co II spectral lines λ2533.2, λ2709 and λ9519 as a function of optical depth (log τ_{Ross}) for the model atmosphere (Kurucz, 1979) of A-type star with model parameters log g = 4.5 and Teff = 10000 K.

Acknowledgements

This work was supported by the Astronomical Observatory Belgrade and Institute of Physics Belgrade, through the grant by the Ministry of Education, Science, and Technological Development of the Republic of Serbia.

References

Adelman, S. J., Cowley, C. R., Leckrone, D. S., Roby, S. W.,Wahlgren, G. M.: 1993, *Astrophys. J.*, **419**, 276.

Csillag, L., Dimitrijević, M. S.: 2004, *Appl. Phys. B,* **78**, 221.

Dimitrijević, M. S. and Konjević, N.: 1980, *J. Quant. Spectrosc. Radiat. Transfer*, **24**, 454.

Dimitrijević, M. S. and Sahal-Bréchot, S.: 2014, *Atoms*, **2**, 357.

Dimitrijević, M. S., Ryabchikova, T., Simić, Z., Popović, L. Č. and Dačić, M.: 2007, *A&A,* **469**, 681.

Griem, H. R., 1992, *Phys. Fluids B*, **4**, 2346.

Hamdi, R., Ben Nessib, N., Milovanović, N., Popović, L. Č., Dimitrijević, M. S. and Sahal-Bréchot, S.: 2008, *MNRAS*, **387**, 871.

Hoffman, J., Szymański, Z. and Azharonok, V.: 2006, *AIP Conf. Proc*., **812**, 469.

Konjević, N.: 1999, *Phys. Rep*. **316**, 339.

Kurucz, R. L.: 1979, *Astrophys. J. Suppl*., **40**, 1.

Lanz, T., Dimitrijević, M. S. and Artru, M.-C.: 1988, *A&A*, **192**, 249.

Majlinger, Z., Simić, Z. and Dimitrijević, M. S.: 2017, *MNRAS*, **470**, 1911.

Majlinger, Z., Dimitrijević, M. S., Simić, Z.: 2018, *Astron. Astrophys. Trans*., **30(3)**, 323.

Majlinger, Z., Dimitrijević, M. S. and Srećković, V. A.: 2020, *MNRAS*, **496**, 5584.

Popović, L. Č., Simić, S., Milovanović, N. and Dimitrijević, M. S.: 2001, *ApJS,* **135**, 109.

Simić, Z., Dimitrijević, M. S. and Sahal-Bréchot, S.: 2013, *MNRAS*, **432**, 2247.