MW-Gaia STSM

Stark broadening of Ga II spectral lines

Milan S. Dimitrijević from Astronomical Observatory (Belgrade, Serbia) spent two weeks (03-22/05/2023) to collaborate with D. Christova from Technical University Sofia, Bulgaria.

We first made the corresponding model of Ga II ion and completed the literature about experimental and theoretical investigations of Stark broadening of Ga II spectral lines, about its presence in stellar spectra and about its significance in astronomy. Then we prepared and calculated the input data: atomic energy levels, oscillator strengths, line factors, multiplet factors and dipole matrix elements. With these data we performed the corresponding calculations using the semiclassical perturbation theory (see Ref. 1 and references therein). We calculated Stark widths and shifts, determining line profile, for 20 multiplets containing 37 spectral lines of Ga II broadened by collisions with the most important charged constituents of stellar atmospheres, electrons, protons and He II ions. Calculations have been performed for a grid of temperatures and perturber densities. Then, using the obtained results, we compared line widths broadened by collisions with electrons and protons, with thermal Doppler widths as a function of Rosseland optical depth, for several atmospheric models of hot sars and white dwarfs. We also compared the influence of collisions with charged particles (electrons and protons) for spectral lines in UV, optical and infrared part of the spectrum. Also, we prepared the obtained data in VO (Virtual Observatory) and XSAMS (XML Schema for Atomic, Molecular and Solid Data) format for the implementation of results in the international, on-line database STARK-B, a part of VAMDC (Virtual Atomic and Molecular Data Center), after the publication of article. We also discussed, the obtained results and start to write the corresponding article, with the objective to publish it before the end of the action.

1. Sahal-Bréchot S., Dimitrijević M. S., Ben Nessib, N., 2014, Widths and shifts of isolated lines of neutral and ionized atoms perturbed by collisions with electrons and ions: An Outline of the Semiclassical Perturbation (SCP) Method and of the Approximations Used for the Calculations, Atoms 2, 225

Description of the STSM main achievements and planned follow-up activities

As the main result, we obtained Stark broadening parameters, FWHM (full widths at half intensity maximum) and shifts, for electron-impact, proton-impact and ionized helium-impact broadening, for spectral lines of around 37 spectral lines in 20 multiplets of ionized gallium, using semiclassical perturbation theory. Calculations have been performed for a grid of temperatures and densities of perturbing particles. Also we used the obtained results for the analysis of the influence of Stark broadening in comparison with thermal Doppler broadening in CP stars of A and late B type with the overabundance of gallium, and in particular, in white dwarfs.

The results obtained during this STSM will be presented in at least two articles and on a couple of Conferences, all with an acknowledgement to the GAIA cost action. After the publication of the main article, they will be also implemented in the STARK-B database, dedicated, first of all, for modelling of stellar atmospheres, and which is a part of VAMDC - Virtual Atomic and molecular data center.
Since one of the best known and well-studied anomalies in Hg-Mn stars is the strong overabundance of the gallium, and because in Hg-Mn and other CP stars Stark broadening is often important, Stark broadening data for Ga II, obtained in this study will be of interest. They are also needed for research of stars and their characteristics in general, and particularly for white dwarfs and A and late B type stars. Stark broadening data are needed for analysis and synthesis of spectral lines, stellar atmosphere modelling, abundance determination, radiative transfer calculation and stellar plasma diagnostics. They enter also in the calculations of absorption coefficient, radiative acceleration and consequently, they are of interest for equation of state, and other topics in stellar physics.
The obtained results contribute to the following working groups and tasks of **CA18104: WG1: WGT1b**: Stark broadening data for upcoming spectroscopic surveys to be combined with GAIA data. Namely Ga II Stark broadening data are useful for interpretation, analysis and synthesis of stellar spectra obtained in the surveys. **WGT1c**: Gaia Challenge, including development of detailed MW (chemo) dynamical models. Namely Ga II Stark broadening data are useful for abundance determination which may be used for monitoring of chemical evolution of stars and of nuclear processes in their interiors. **WG2: WGT2a**: Stellar atmospheres and spectroscopy. Stark broadening of Ga II spectral lines is useful for stellar atmosphere modelling, especially in the case of white dwarfs but also for A and late B type stars, for analysis and synthesis of Ga II spectral lines in stellar spectra, for gallium abundance determination, stratification of gallium in stellar atmospheres, radiative transfer calculations and stellar opacity determination. **WGT2b**: modelling microscopic processes in stars. Ga II Stark broadening data enter in the determination of line absorption coefficient so that they are of interest for all microscopic processes where this coefficient enters as for example for investigation of diffusion and radiative acceleration in stellar atmospheres.

We will continue our collaboration trying to provide the missing data for line profiles broadened by collisions with charged particles, needed for a number of problems stellar physics.

We will continue the collaboration, with the aim to provide data for electron-impact, proton-impact and He II impact broadening (main charged perturbers in stellar atmospheres) of spectral lines for various atoms and ions of interest for analysis and synthesis of stellar spectra, abundance determination, opacity and radiative transfer calculation, modelling of stellar atmospheres, absorption coefficient calculations and other topics in stellar physics.

A couple of papers will be additionally submitted.