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THE INFLUENCE OF COLLISIONS WITH CHARGED PARTICLES ON STELLAR LINE SPECTRA

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Abstract. The astrophysical importance of the line broadening due to the interaction between emitter(absorber) and charged particles (Stark broadening) is discussed. A review of semiclassical calculations of Stark broadening parameters and comparison of different semiclassical procedures is presented too, as well as the comparison with critically selected experimental data and more sophisticated, close coupling calculations. Approximate methods for the calculation of Stark broadening parameters, useful especially in such astrophysical problems where large scale calculations and analyses must be performed and where a good average accuracy is expected, have also been discussed.

Among the various pressure broadening mechanisms, broadening due to interaction between emitter and charged particles (Stark broadening) is dominant in several cases. For $T_{\text{eff}} > 10^4$K, hydrogen, the main constituent of a stellar atmosphere is mainly ionized, and the main collisional broadening mechanism for spectral lines is the Stark effect. This is the case for white dwarfs and hot stars of O, B and A0 type. Even in cooler star atmospheres as e.g. Solar one, Stark broadening may be important. For example, the influence of Stark broadening within a spectral series increases with the increase of the principal quantum number of the upper level and consequently,Stark broadening contribution may become significant even in the Solar spectrum.

An important problem where we need reliable Stark broadening data is also the determination of chemical abundances of elements from equivalent widths of absorption lines. Stark broadening data are also required for the estimation of the radiative transfer through the stellar plasmas, especially in subphotospheric layers and for opacity calculations. In such a case data for especially large numbers of lines are needed. An illustrative example might be the article on the calculation of opacities for classical cepheid models (Iglesias *et al.* 1990), where 11,996,532 spectral lines have been taken into account, and where Stark broadening is important.

Stellar spectroscopy depends on very extensive list of elements and line transitions with their atomic and line broadening parameters. It is difficult to state in general terms which are the relevant transitions since the atmospheric composition of a star is not known a priori, and many interesting groups of stars exist with very peculiar abundances as compared to the Sun.

The interest for a very extensive list of line broadening data is additionally stimulated by spectroscopy from space. In such a manner an extensive amount of spectroscopic information over large spectral regions of all kind of celestial objects has been and will be collected, stimulating the spectral–line–shape research.

The most sophisticated theoretical method for the calculation of a Stark broadened line profile is of course the quantum mechanical strong coupling approach. However, due to its complexity and numerical difficulties, only a small number of such calculations exist. In a lot of cases such as e.g. complex spectra, heavy elements or transitions between more excited energy levels, the more sophisticated quantum mechanical approach is very difficult or even practically impossible to use and, in such cases, the semiclassical approach remains the most efficient method for Stark broadening calculations.

Here is presented a review of semiclassical calculations of Stark broadening parameters and comparison of different semiclassical procedures is discussed, as well as the agreement with critically selected experimental data and more sophisticated, close coupling calculations. Approximate methods for the calculation of Stark broadening parameters, useful especially in such astrophysical problems where large scale calculations and analyses must be performed and where a good average accuracy is expected, have also been discussed.

References

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