Thesis subject

Name of the laboratory: Physique des Interactions Ioniques et Moléculaires

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Subject's title: Characterization of white dwarf atmospheres by spectroscopic means

Subject description:

The theory of stellar structure knows three final states for a star: black holes, neutron stars and white dwarfs. According to observations and current models, the vast majority (of the order of 90%) of all stars, including our sun, will evolve towards the third final state, that of white dwarf [1,2]. These stars no longer burn nuclear fuel; instead, they are slowly cooling as they radiate away their residual energy. It is known today that white dwarfs support themselves against gravity by the pressure of degenerate electrons. They are referred to as compact objects because of their high density (up to 10^6 g/cm^3). The characteristic cooling time of a white dwarf is closely related to the structure of its atmosphere, in particular its opacity to the radiation coming from the core. Studies have shown that the majority of white dwarfs have an atmosphere of pure hydrogen as a result of gravitational setting, which removes helium and heavier elements from the atmosphere and moves them towards inner layers [3,4]. These atmospheres can be considered as hydrogen plasmas, which are similar to some created in laboratory. Such white dwarfs are classified as of DA type due to the strong hydrogen absorption lines they present. The electron density in a white dwarf atmosphere is high enough (up to 10^{17} cm^{-3}, and higher) so that the line shapes are dominated by Stark broadening and, hence, can serve as a probe for the electron density N_e.

The goal of the PhD thesis is to improve the accuracy of the line shape models involved in white dwarf atmosphere diagnostics. Specific issues, such as the description of ion dynamics effects in Stark broadening [5], must be addressed. The observation of Zeeman pattern on several white dwarf spectra [6,7] has prompted a specific interest in the design of models accounting for the simultaneous action of electric and magnetic fields on the structure of atomic energy levels. Investigations must be done. The problem, which is similar to the modeling of spectra in magnetic fusion experiments, will possibly be tackled using models and codes previously developed in this framework and available at the laboratory. A part of the work will be devoted to the calculation of synthetic spectra and will involve the modeling of the stellar atmosphere structure.

Bibliography:

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