Quantum approach to atomic populations and radiative properties in fusion and laser produced plasmas

The applied and fundamental aspects of nuclear fusion are closely intertwined [1]. On the one hand, the drive for achieving the Lawson criterion, necessary for self-sustained fusion reaction (the applied aspect), requires reaching even higher plasma parameters (plasma temperature, density, energy confinement time), and thus advancing further into previously unexplored scientific territory (the fundamental aspect). There are no direct ways for measuring these parameters and the development of methods for studying hot plasmas has evolved into an independent branch of plasma science called high-temperature plasma diagnostics and plasma spectroscopy [2]. Studying the emission of hydrogen, deuterium, tritium and helium is of particular interest for the analysis, control and optimization in the DT-fusion reaction [2-5] and the so-called standard collisional-radiative theory [2] has been developed to describe the radiative properties of hot plasmas. However, the basic conception to determine the atomic populations is based on a classical and rather heuristic approach while the first principle approach to atomic populations and related radiative emission requires the quantum mechanical density matrix theory [6,7]. This theory provides not only fundamental insight but also allows studying the various approximations of the standard collisional-radiative model that can hardly be evaluated otherwise.

In the framework of the present M2 internship the student will study one and two electron systems and determine the atomic populations in the framework of the atomic density matrix. Particular attention will be paid to applications such as the H-alpha emission of H-like atoms/ions for fusion relevant conditions and to the X-ray emission of He-like ions in dense laser produced plasmas to identify the quantum and classical effects in the atomic populations.

The successful applicant has a very good knowledge in programming, basic knowledge in atomic physics and quantum mechanics and can communicate in English to take part in the international collaborations of the PAPD research group at LULI.

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M2 Internship at LULI (Laboratoire pour l’Utilisation des Lasers Intenses)

Supervisor: Frank ROSMEJ, frank.rosmej@sorbonne-universite.fr