Atomic models of dense plasmas, applications and current challenges

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Modelling plasmas in terms of atoms or ions is theoretically appealing for several reasons. When it is relevant, the notion of atom or ion in a plasma provides us with an interpretation scheme of the plasma's internal functioning. From the standpoint of quantitative estimation of plasma properties, atomic models of plasma allow to extend many theoretical tools of atomic physics to plasmas. This notably includes the statistical approaches to the detailed accounting for excited states, or the collisional-radiative modelling of non-equilibrium plasmas, which is based on the notion of atomic processes. In this paper, we focus on the challenges raised by the atomic modelling of dense, non-ideal plasmas.

First we make a brief, non-exhaustive review of atomic models of plasmas, from ideal plasmas to strongly-coupled and pressure-ionized plasmas. We discuss the limitations of these models and pinpoint some open problems in the field of atomic modelling of plasmas.

We then address the peculiarities of atomic processes in dense plasmas and point out some specific issues relative to the calculation of their cross-sections. In particular, we discuss the modelling of fluctuations, the accounting for channel mixing and collective phenomena in the photoabsorption, or the impact of pressure ionization on collisional processes.