COMPLEX ATOM PHYSICS AND RADIATION FROM OUT OF EQUILIBRIUM PLASMAS

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Atomic physics is involved in the plasma context for a proper evaluation of various quantities such as charge state distribution, radiative properties (i.e. emissivity or opacity), etc…These derived quantities are in turn used for the calculation of transport properties, spectroscopic diagnostics, etc…

The calculation of these derived quantities requires a prior calculation of the population distribution over the numerous atomic or ionic energy levels. Whether in natural or laboratory plasmas, this distribution is rarely given by the Thermodynamical Equilibrium laws. Also, the enumeration and the calculation of these energy levels is a formidable task, not to mention all the possible transitions between them.

The difficulty is that one faces situations of different complexities, from simple nearly closed-shell configurations to open-shell many-electron configurations. This is the field of complex-atom physics in which Jacques Bauche made many important contributions concerning the emerging properties from large ensemble of levels. These contributions concern the existence of *statistical laws* for
- ensembles of levels,
- ensembles of spectral lines,
- the transition rates between ensembles of levels.

These ensembles can be configurations, superconfigurations or compound configurations (mixed by CI)

After a discussion of the description of out-of-equilibrium states in relation to the description of thermodynamical equilibrium, this talk will review some of these *statistical laws* and their consequences concerning applications such as the charge state distribution in plasmas, the radiative properties or the emergence of effective temperatures.
We will discuss also a few experimental results where an application of these methods has proven to be necessary and efficient.