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X-RAY FREE ELECTRON LASER DRIVEN RESONANCE PUMPING OF SPECTRAL LINES OF HIGHLY CHARGED IONS IN DENSE PLASMAS

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Atomic populations and line shapes belong to the fundamental quantities characterizing the spectral emission from plasma systems, thus being important for various disciplines in science and applications like radiation transport, astrophysics, fusion science, High-Energy-Density-Physics, diagnostics. E.g., radiation transport controls the energy balance and temperature profile in stars while opacity represents a key parameter to understand the evolution of various astrophysical objects [1,2]. In standard transport theory the opacity τ_ω is linked to the spectral distribution I_ω via the local source function S_ω that is the ratio between the local emission coefficient ϵ_ω and the absorption coefficient $S_\omega = \epsilon_\omega / \kappa_\omega$ while ϵ_ω and κ_ω themselves are the sum of the bound-bound, bound-free and free-free contributions, i.e. $\epsilon_\omega = {\epsilon_\omega}^{bb} + {\epsilon_\omega}^{bf} + {\epsilon_\omega}^{ff}$ and $\kappa_\omega = {\kappa_\omega}^{bb} + {\kappa_\omega}^{bf} + {\kappa_\omega}^{ff}$ [1,3]. Therefore, the emission and absorption line profiles impact not only to the bound state properties but to the continuum ones too.

The calculation of X-ray line shapes in dense plasmas is a discussion up to present days [e.g. 4-7, and references therein] and suffered from a lack of suitable experiments. The situation has changed with the development of X-ray Free Electron Lasers (XFEL's) providing intense and tunable photon sources with narrow bandwidths allowing resonance pumping of spectral lines up to 20 keV. Moreover, current installations [8-10] provide more that 10 orders higher photon flux compared to the most brilliant synchrotron sources. This allows to induce observable changes in the X-ray spectral emission because photon induced rates are competitive with other collisional-radiative processes even in dense plasmas [11].

The XFEL provides high near monochromatic photon flux that is not met in nature. However, it is this property that enables to produce fluorescence emission data capable to challenge dedicated parts in the theory. The present talk will outline the possibilities of current dense plasma experiments at XFEL installations and report the results of the first high-resolution X-ray spectroscopic experiments [12,13] where the intense XFEL beam was brought to interaction with a dense plasma that had been produced by the irradiation of a powerful auxiliary optical laser system.

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