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A unified atomic description for high-Z impurities modelling in tokamak plasmas

Yves Peysson[1], **Axel Jardin[2]**, **Didier Mazon[3]**, **Dominik Dworak[2]**, **Jakub Bielecki[2]**, **Jedrzej Walkowiak[2]**, **Marek Scholz[2]**

[1] *CEA, France*
[2] *IFJ-PAN, France*
[3] *CEA Cadarache, France*

Most of the realistic kinetic calculations for tokamak plasmas require now to incorporate the effect of partially ionized high-Z elements, arising either from uncontrolled influxes of metallic impurities like tungsten in high input power regimes or from mitigation by massive gas injection of runaway electrons generated after plasma disruptions [1,2]. The usual electron-ion Fokker-Planck collision operator must be therefore modified, according to the atomic physics. as well as the cross-sections for some synthetic diagnostics, like bremsstrahlung, whose importance for characterizing the plasma state is considerable [3]. This represents a challenge, in order to perform fast but also accurate calculations, regardless the types of elements present in the plasma and their local level of ionization, while covering a wide range of electron energies in a consistent way, from thermal to highly relativistic limits. In this context, a unified modelling of the atomic physics has been developed, based on a multi-Yukawa potential representation calibrated against advanced quantum relativistic calculations [4]. Besides the possibility of an accurate description of inner and outer atomic shells, it is possible to derive analytical formulations for elastic and inelastic scattering which can be easily incorporated in kinetic codes [3,5-7]. The impact of the number of exponentials in the description of the atomic potential is discussed, and compared with the Thomas-Fermi or Thomas-Fermi-like atomic models.

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Presenting Author Email Address: *yves.peysson@cea.fr*