Iron K-shell radiative, Auger and photoionization processes in Debye-Hückel plasma environments

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Iron X-ray K-lines emitted by black hole accretion disks are very important lines for astrophysicists. Actually, they have observed widths and shifts that imply an origin very close to the central black hole [1]. Thus, they can be considered as natural probe of the regions very close to the compact object since the intensity and the shape of these lines can give information about the effects of special and general relativity in the emitting region. Moreover, some important properties of the black hole itself, such as its spin, can be inferred by modeling the distortion of the Fe K emission complex [2].

Plasma conditions in such accretion disks around black holes are thought to be characterized by electronic densities that can be as high as 10^{22} cm^{-3} [3]. Such high-density conditions may affect the atomic structure and processes corresponding to the ionic species present in the plasma. However, atomic data used in the standard programs to model astrophysical X-ray spectra are computed assuming an isolated ion approximation. Therefore, this shortcoming is thought to be the major reason for the inconsistencies observed in the results [4,5].

The main goal of the present work is to estimate the effects of high-density plasma environment on the atomic parameters involved in the K-line emissivities for cosmologically abundant ions, such as iron ions, within the astrophysical context of accretion disks around black holes. For this purpose, relativistic atomic structure calculations have been carried out using the multiconfiguration Dirac-Fock (MCDF) method, in which a time averaged Debye-Hückel potential has been considered for both the electron–nucleus and electron–electron interactions in order to model the plasma environment, using a combination of the GRASP2K [6] and of the RATIP [7] codes. In this contribution, we present a sample of results concerning the influence of plasma environment on the atomic structure, and on the K-shell radiative, Auger and photoionization processes in highly-charged iron ions.

[1] C.S. Reynolds and M.A. Nowak, Phys. Rep. **377**, 389 (2003).
[2] J. Garcia *et al.*, Astrophys. J. **782**, 76 (2014).
[3] J.D. Schnittman, J.H. Krolik and S.C. Noble, Astrophys. J. **769**, 156, (2013).
[4] J. Garcia *et al.*, Mon. Not. Roy. Astron. Soc. **462**, 751 (2016).
[5] J. Garcia *et al.*, Astron. Soc. Pacific Conf. Ser., **515**, 282 (2018).
[6] F.A. Parpia, C. Froese Fischer and I.P. Grant, Comput. Phys. Commun. **94**, 249 (1996).
[7] S. Fritzsche, Comput. Phys. Commun. **183**, 1523, (2012).