Study of plasma environment effects on radiative and non-radiative atomic processes involving the K inner-shell in ions of astrophysical interest

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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. Thus, they can be considered as natural probes 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.

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}. Such high-density conditions may affect the atomic structure and processes corresponding to the ionic species present in the plasma. However, the 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 inconsistencies observed in the results.

The main goal of my PhD thesis work is to estimate the effects of high-density plasma environment on the atomic parameters involved in the K-line emissivities for ions of astrophysical interests (iron, oxygen), within the context of accretion disks around black holes. In 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 and of the RATIP codes.

It turned out that the ionization potentials and the K-shell thresholds of all the oxygen and iron ions were the most affected atomic parameters, as a significative lowering of these latter was obtained. This may affect the ionization balance of the astrophysical plasma and the K-line emissitivies, which would thus bring about modifications in the astrophysical X-ray spectra.