X-ray emission from highly-ionized iron ions embedded in high-density astrophysical plasmas

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The main goal of this work is to estimate the plasma environment effects on the atomic parameters involved in X-ray K-line emission by highly-charged iron ions embedded in high-density astrophysical plasmas such as black hole accretion disks. In that purpose, relativistic atomic structure calculations have been carried out by considering a time averaged Debye-Hückel potential for both the electron-nucleus and electron-electron interactions. A sample of results showing plasma effects on various atomic parameters for highly-charged iron ions will be presented in this talk.

X-ray emission from high-density black hole accretion disks

Emission lines in the X-ray spectral region from accreting black holes have observed widths and shifts that imply an origin very close to the compact object [1]. The intensity of these lines can provide insight into the effects of special and general relativity in the emitting region as well as insight into some properties of the compact object itself, such as its spin [2]. Recent studies seem to reveal that the plasma electronic density of such an accretion disk can reach values up to 10^{22} cm^{-3} [3]. Such a high-density 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. This shortcoming is thought to be the major reason for the inconsistencies with the observed data [4].

Atomic computations

The purely relativistic Multiconfiguration Dirac-Fock (MCDF) method, as implemented in the GRASP92 code [5], has been used to model the atomic structure of the iron ions considered in this work. Plasma effects on the various atomic parameters has been estimated by means of a time-averaged Debye-Hückel potential for both the electron-nucleus and electron-electron interactions, by using the RATIP code [6].

Results

In this talk, a sample of results concerning plasma effects on the atomic structure and several atomic parameters involved in K-line emission for highly-charged iron ions, namely radiative and Auger rates, transition wavelengths and photoabsorption (photoexcitation and photoionization) cross sections, will be presented.

References

[1] C.S. Reynolds and M.A. Nowak, "Fluorescent iron lines as a probe of astrophysical black hole systems", *Phys. Rep.* **377**, 389, 2003.

[2] J. Miller, "Relativistic X-ray lines from the inner accretion disks around black holes", *Annu. Rev. Astron. Astrophys.* **45**, 441, 2007.

[3] J. Schnittman, J. Krolik and S. Noble, "X-ray spectra from magnetohydrodynamics simulations of accreting black holes", *Astrophys. J.* **769**, 156, 2013.

[4] J. Garcia, T.R. Kallman, M.A. Bautista, C. Mendoza, J. Deprince, P. Palmeri, and P. Quinet, "The problem of the high iron abundance in accretion disks around black holes", *Astron. Soc. Pacific Conf. Ser.* **515**, 282, 2018.

[5] F.A. Parpia, C. Froese Fischer and I.P. Grant, "GRASP92: A package for large-scale relativistic atomic structure calculations", *Comput. Phys. Commun.* **94**, 249, 1996.

[6] S. Fritzsche, "The RATIP program for relativistic calculations of atomic transition, ionization and recombination properties", *Comput. Phys. Commun.* **183**, 1523, 2012.