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The X-ray characteristic line in the framework of the Boltzmann transport equation

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The emission of characteristic lines after x-ray excitation is usually explained as the consequence of two independent and consecutive physical processes: the photoelectric ionization produced by the incoming photons and the successive spontaneous atomic relaxation. However, this is not the only mechanism for the formation of the characteristic lines. In first place, the photoelectric effect is not the only ionization mechanism driven by the incoming photons. As it has been recently shown, Compton ionization is another possible process which contributes not negligibly to the ionization of the shells L and M. In second place, secondary electrons from these two interactions, photoelectric and Compton, are also able to ionize the atom by means of the so called impact ionization. This contribution has been recently described showing that it can be more relevant at monochromatic energies which are specific of certain lines and elements. A third mechanism of line modification is the so called self-enhancement produced by absorption of the tail of the Lorentzian distribution of the characteristic line. These four effects concur to the formation of the characteristic line and must be considered to obtain a precise picture in terms of the shell and the element.
This article furnishes a review of these contributions and their formal theoretical descriptions. It is given a complete picture of the photon kernel describing the emission of characteristic x-rays comprising the major photoelectric contribution and the three effects of lower extent. The line formed with all these contributions can then be followed along successive photon interactions in deterministic or Monte Carlo photon codes to describe better the multiple scattering effects.

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