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Rayleigh scattering of x–rays by many–electron ions

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Synopsis A theoretical investigation is presented for the elastic Rayleigh scattering of photons by many–electron ions. Special attention is paid to the question how the charge state and shell structure of the target ions affect the angular distribution and linear polarization of scattered light. Calculations are performed for helium–, neon– and argon–like heavy ions and for a wide range of the photon energies.

Investigations of the elastic Rayleigh scattering of photons by *bound* atomic electrons have a long tradition going back to 1930's. During the last decades a number of experimental and theoretical Rayleigh studies have dealt with high–energetic incident radiation and heavy atomic targets, see Ref. [1] for further details. The analysis of the elastic scattering in such a relativistic regime provides valuable information about the structure of many–electron systems as well as their coupling to the electromagnetic radiation in the presence of very strong nuclear fields.

In order to better understand the interplay between the many–body, relativistic and non–dipole effects in the $\gamma + A \to \gamma + A$ process, we have recently explored the elastic scattering of x–rays by multiply–charged heavy ions [2, 3]. In our study, we considered the set–up of a typical synchrotron experiments, where the incident radiation is (completely) linearly polarized. For this case, we employed the second–order perturbation theory and the independent–particle approximation (IPA) in which the photon is scattered by a single (active) electron at a time, while the remaining electrons were kept "frozen" [3].

By making use of the IPA, detailed calculations have been performed for the angular distribution and the linear polarization of the scattered light. In Fig. 1, for example, we display the results for the scattering of 175 keV x–rays by helium–, neon– and argon–like gold ions. As seen from the figure, the angle–differential Rayleigh cross sections can largely vary with the charge state of the ion. The most pronounced effect can be observed at forward scattering angles where the cross section is enhanced by almost two orders of magnitude in going from helium–like Au^{77+} to argon–like Au^{61+} as a target. In contrast to the angular distribution, the linear polarization of the scattered Rayleigh photons is virtually not affected by the ionic shell structure even though it can be sensitive to the nuclear charge Z of the target and to the energy of the incident radiation.

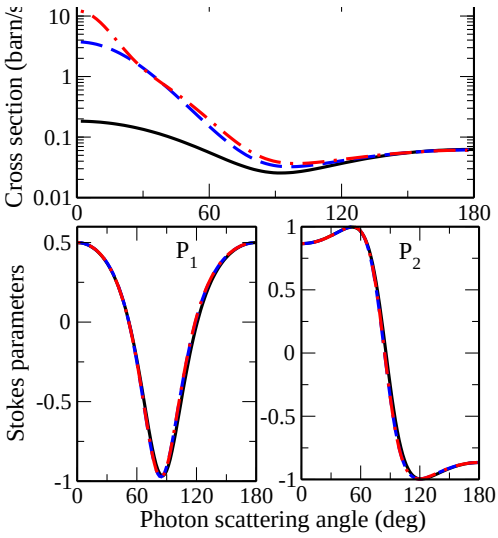

Figure 1. Angle–differential cross section (upper panel) and the linear–polarization Stokes parameters P_1 and P_2 (lower pannels) for the elastic Rayleigh scattering of linearly polarized x–rays by helium–like (solid line), neon–like (dashed line) and argon-like (dash-dotted line) gold ions in their ground state. Results are presented for the photon energy 175 keV and for the emission of the scattered light in the plane tilted by the angle $\phi = 30$ deg with respect to the polarization plane of the incident radiation.

References

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