L and M-shell ionization of very heavy targets

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L and M-shell ionization of very heavy targets

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Synopsis We present a theoretical study on the inner-shell ionization of Au, Pb, and Bi. A collective response model, the shellwise local plasma approximation (SLPA), is employed, which works within the dielectric formalism. The wave functions and binding energies were obtained in fully-relativistic way by solving numerically the Dirac equation. The theoretical results describe nicely the experimental data for M-shell ionization of Au and Bi above 2MeV/amu, and for L-shell ionization of Au and Pb above 10 MeV/amu. The SLPA tends to underestimate the data for energies below the range of validity of the model and approach to them for higher energies.

Ionization of different shells has attracted great attention over the decades especially for the interest in the characteristic radiation from inner-shells. Reliable ionization cross sections are sensitive and critical inputs for particle-induced x-ray emission (PIXE) analysis. One of the most employed theories is the well known ECPSSR by Brandt and Lapicki [1], of probed efficacy in an extended energy range, and the usual input in the PIXE codes[2].

The goal of this work is to present fully theoretical calculations (no parameters included) for ionization of deep shells of very heavy targets (Z=79, 82, and 83), by employing the shellwise local plasma approximation (SLPA) [3].

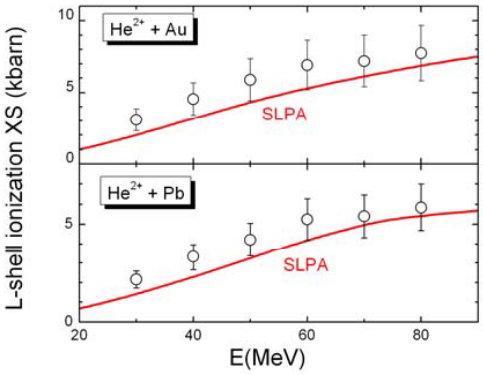

Figure 1. L-shell ionization cross section of Au and Pb by He^{+2} ions. Experimental data by Hardt et al [5]. Curves: SLPA results.

The SLPA works within the dielectric formalism (not independent electron model or hydrogenic potentials). Instead, each sub-shell is described as a whole including screening and correlation among electrons

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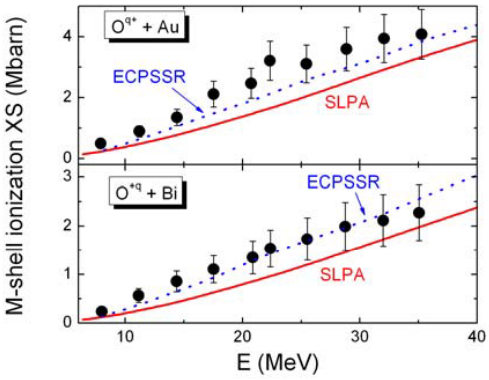

Figure 2. M-shell ionization cross section of Au and Bi by O ions. Experimental data by Czarnota et al [6]. Curves: SLPA, solid line; ECPSSR, dotted line.

The comparison with he experimental data available and the ECPSSR shows that the SLPA results are good for L-shell ionization above 10 MeV/amu, and for M-shell above 2 MeV/amu, with a tendency to underestimate the data.

The SLPA is an alternative and quite simple calculation that only requires the density and binding energies of target electrons. In the present case the atomic wave functions were calculated in fully relativistic way, by solving numerically the Dirac equation employing the GRASP code [4].

References

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