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ANALYTICAL CROSS SECTION OF CHARGED PARTICLES SCATTERING UP TO RELATIVISTIC ENERGIES*

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We derived a simple analytically solvable model for calculation of the differential and total inelastic cross sections, mean free paths, and energy losses of charged particles in solids beyond atomic approximation [1]. It is applicable from small up to relativistic incident energies (from 30-50 eV up to GeV in a case of an electron).

Within the linear response theory, the scattering cross section is defined by the complex dielectric function. We approximate this function with a set of delta-functional oscillators. The parameters of the oscillators can be obtained from the Drude-like oscillators using only optical data as an input. No ad-hoc correction terms are required. The approach enables us to avoid further approximations (such as close and distant collisions etc.) and to obtain a closed solution for the cross section.

Being analytically solvable, the model allows for very fast yet precise calculations, and thus can be efficiently implemented in any simulation tools, such as Monte Carlo models [2]. It also avoids the Bragg additivity rule of the atomic cross sections, and is well suitable for compounds. Application of the derived formulae greatly saves computational time of evaluation of cross sections with respect to the numerical integration required by other models.

We demonstrate that the derived expressions are in a very good agreement with other more complex numerical models and experimental data within a wide range of energies and targets (metals, semiconductors, insulators). For electrons and positrons, the range of applicability is from ~50 eV up to ~GeV (within the precision ~20% at the energy of ~10 GeV, and ~1% at ~MeV energies). For protons it is from ~100 keV to ~50 GeV, while for heavy ions it is from ~100 MeV to ~TeV, which covers a typical energy range of modern ion accelerators.

REFERENCES

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