ENERGY LOSS OF CHARGED PROJECTILES INTERACTING WITH METALLIC NANOPARTICLES

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We present a theoretical study on the interaction of moving charged particles with metal clusters and nanoshells. First, we make use of time-dependent density functional theory (TDDFT) to calculate the energy lost by antiprotons colliding through the center of spherical jellium clusters of different size and electronic density parameter, r_s. The results allow us to define an effective stopping power S as the energy loss per unit path length inside the cluster. Analysing the dependence of S on the projectile velocity, we obtain results which are unexpectedly close to the ones corresponding to the free electron gas, even for very small clusters (e.g. clusters with as few as 18 electrons, corresponding to a radius of ~5 atomic units for $r_s = 2$) and low velocities (down to ~0.1a.u.). We thus conclude that the collision process is quite local, and that the discreteness of electronic states in the cluster does not play an important role in the screening process. Moreover, the stopping powers obtained from our calculations using nanostructures of a few nanometeres in size are comparable to experimental values for macroscopic materials, both for protons and antiprotons [1]. This reassures us that the dynamic screening within the cluster is essentially that of a homogeneous system in the velocity range considered. For completion of the study, we also show the velocity dependence of the S in collision processes with off-center projectile trajectories, as well as the case of the interaction of antiprotons with nanoshells of different electronic density parameters and size.

References:

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