Time-evolution of the screening charge around a suddenly created point charge at a metal surface

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The space-time evolution of the dynamical screening charge density caused by a suddenly created point charge at the Cu(111) surface is investigated in the linear response approximation. Considering a finite-thickness slab as a model for the Cu(111) surface we investigate the confinement effects on dynamical screening as well. The results have been obtained on base of self-consistent evaluation of the energy-momentum dependent response function taking into account the realistic surface band structure of Cu(111).

At the initial stage, we observe fast long range charge density oscillations due to excitation of the surface plasmon modes. Then we observe the propagation of the shock wave of the electron-hole excitations along the slab with velocity determined by the Fermi velocity of bulk Cu. At longer times, we have identified the propagation along the two slab surfaces of much slower (with velocity ~0.3 a.u., close to the Fermi velocity of the Cu(111) surface state) charge disturbance due to acoustic surface plasmon. A role of the energy band gap in the direction perpendicular to the surface on the establishing of the screening is also addressed.