Electron transmission through macroscopic metallic capillaries

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Synopsis We perform classical transport simulations to model the transmission of electrons through metallic capillaries. Excellent agreement between measured and simulated energy spectra of transmitted electrons is found.

We present trajectory simulations of the transmission of electrons with primary kinetic energies below 1 keV through macroscopic metallic capillaries. In contrast to insulating materials no local charge patches may build up to deflect subsequent projectiles. Electrons will therefore come in close contact with the capillary wall. A classical transport model with stochastic scattering events simulates such impact events.

The initial conditions for the CTMC simulation are chosen to match typical experimental conditions. Within the capillary electrons follow straight-line trajectories, interaction with its own image charge is only indirectly accounted for (deflection at vacuum-metal boundary). Within the material, projectiles are deflected due to elastic or inelastic scattering events and may, possibly after additional impacts on the capillary wall, eventually exit the capillary. If secondary electrons are generated along the trajectory of the primary we follow their trajectories as well with the position of the inelastic scattering event as their starting place. The initial momentum is given by the energy loss of the primary electron, the initial direction of motion is chosen randomly. Finally, the energy of all electrons (primaries and secondaries) reaching the exit opening of the capillary determines the total energy spectrum of our simulation which can be compared directly with experimental data (e.g. [1]).

Near the elastic peak the spectrum is dominated by trajectories with a small number of impacts on the inner surface of the capillary (see figure for 200 eV electron transmission through a platinum capillary [2]). Despite the small number of trajectories undergoing more than 2 impact events on the inner wall of the capillary (see figure) their contribution to the total spectrum has to be accurately accounted for in order to reach good agreement between experimental and simulated spectra (red solid line as opposed to black dashed line representing the energy spectrum for a single impact event). We also find that the electron-energy spectra are largely insensitive to the divergence of the incoming electron beam due to the broad exit angle distribution after impact on the surface.

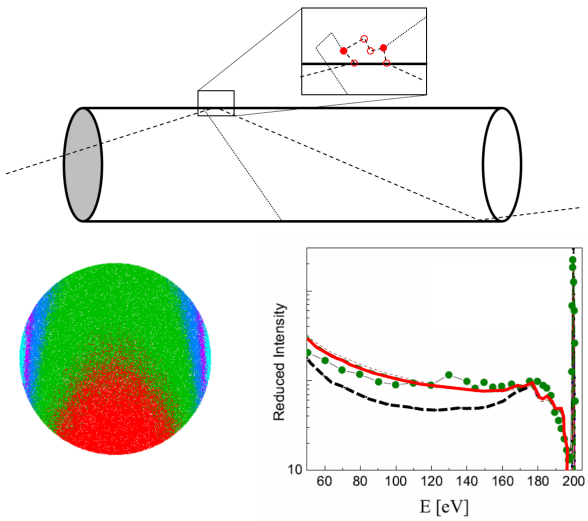

Figure 1. Schematic diagram of simulated system: an electron enters the capillary through the shaded entrance plane and will hit the capillary wall. There, elastic and inelastic scattering events (inset) may cause secondary electron emission and an eventual re-escape of the primary particle. If an electron exits the capillary its energy is recorded (bottom right, data from [1]). Depending on its entry point it will have suffered one (red area), two (green area), or more scattering events (other colors) along its trajectory (bottom left).

References

[1] A. R. Milosavljević *et al.* 2015 *Nucl. Instr. Meth. Phys. Res. B* **354** 86

[2] D. Borka *et al.* 2017 *Nucl. Instr. Meth. Phys. Res. B*, in print

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