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Guiding of highly charged ions through capillaries in insulating materials: Milestones in experiments and simulations

After the first observation that keV ions are guided through insulating nano¬capillaries, the topic has received consid¬erable attention during the past decade. These capillaries are nanotubes with a diameter of about 100 nm and a length of about 10 μm. The essential property of the capillary guiding is a self-organizing process, which governs the charge deposition inside the capillaries. With increasing deposition of the ions, the charge patch increases until the electrostatic field is large enough to deflect the ions. At equilibrium, the ions are guided maintaining their incident charge state. Milestones of the field concerning experiments and simulations are presented in accordance with a recent review over the field of capillary guiding. Experiments are described giving emphasis to the guiding of highly charged ions in the keV energy range. Recent experiments with a single straight macrocapillary are treated allowing for the control of conductivity by changing the temperature of the material. Single tapered capillaries are discussed involving an enhancement of the beam density and the production of a microbeam for biological applications. These studies have motivated several groups devoting efforts to the production of a beam with diameter of the submicron scale. Apart from the experimental studies, theoretical concepts of the capillary guiding are discussed. Calculations using a drift model for trajectories and charge distributions for 4.5-keV Ar^{7+} incident under 0° and 1° into a conical microcapillary were shown in Figure-1. The simulations show that the density of the transmitted ions is enhanced by a factor as large as 4. These results are of importance for the biological applications mentioned. Altogether, it is elucidated that capillary guiding involves several novel phenomena whose understanding has made essential progress.

Recent Publications

1. N Stolterfoht and Y Yamazaki (2016) Guiding of charged particles through capillaries in insulating materials. *Physics Reports;* 629: 1-107.

2. N Stolterfoht, et al. (2015) Experiments and simulations of 4.5 keV Ar^{7+} ion guiding through a conical glass macrocapillary, *Phys. Rev. A*; 91: 32709.

References

1. K Schiessl, et al. (2005) Simulation of guiding of multiply charged projectiles through insulating capillaries. *Phys. Rev. A;* 72: 062902.

Biography

Nikolaus Stolterfoht started his career in the 70's at the Hahn-Meitner Institute in Berlin, which is one of the national laboratories of Germany. He was the Head of a research group working in the field of atomic collisions with gaseous atoms and solids. He was the Professor at the University of Caen, France. Later, he re-joined to the Helmholtz-Zentrum Berlin.

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