Can the ions be guided with MeV/amu energies? The case of the 1 MeV proton microbeam

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Can the ions be guided with MeV/amu energies? The case of the 1 MeV proton microbeam.

K. Tőkési[a1], I. Rajta[a], G.U.L. Nagy[a], and R.J. Bereczky[a]

[a]Institute for Nuclear Research, Hungarian Academy of Sciences (Atomki), Debrecen, Hungary, EU

Synopsis The transmission of 1MeV proton microbeam through aTeflon microcapillary was studied. Using the suitable combination of the capillary temperature and beam intensity we identified three different regions in the transmission as a function of time. In the third region stable guided transmission was obtained where the dominant contribution of the transmitted protons did not suffer energy loss.

Since its discovery, the study of the ion guiding in insulator capillaries has attracted strong interest. According to our recent knowledge, the transmission of charged particles through insulating capillaries under incident angles larger than the geometrical limitation is based on the self-organized formation of charge patches on the inner surface of the sample, producing a guiding electric field. Guiding sets in when these charge patches reach a dynamical equilibrium (i.e. the arriving and leaving ions result in a constant amount of charge on the wall). Arriving ions come from the incident beam, while the charge decreases by transport into the bulk of the wall material, or along the surface towards the capillary exit. The transmitted ions keep to a high extent their initial charge-state.

Most of the experiments and simulations focus on the transmission of slow highly charged ions (HCIs) through randomly distributed or ordered arrays of nanocapillaries. Systematic measurements of collisions between slow HCIs and a macroscopic glass capillary with large aspect ratio and with cylindrical shape has also been performed. The results prove that the guiding effect known from nanocapillaries is also valid up to a few hundreds of μm diameter.

In this work, instead of HCI, the combination of MeV proton microbeam and Teflon microcapillary has been used. For the measurements, a new experimental setup had to be constructed [1]. The intensity of the transmitted beam was measured by a Faraday-cup placed behind the sample. The energy distribution of the particles could also be determined by a particle detector. For the measurement of the beam deflection we used a fluorescent screen that emits visible light where the beam hits it. A parallel plate deflector connected to a high voltage power supply was used to identify whether the transmitted beam consisted of charged or neutral particles.

During the experiments the beam spot size was 1 μm, and the angle of the beam divergence was between 0.01° and 0.3°. The axis of the capillary, at the beginning of the measurement, was aligned to the direction of the proton microbeam. Then we tilted the sample relative to the beam axis and concluded that the guiding phenomenon took place. The intensity of the transmitted beam increased gradually up to over 90 percent relative to the incident beam.

We analyzed the energy distributions of the transmitted protons at different stages of the charge-up process. We identified three completely different regions in the transmission as a function of time. At first, at the beginning of the creation of the charge patch on the inner wall of the capillary, the energy spectra of the transmitted protons contained only inelastic contributions. This is due to Coulomb scattering on the inner wall atoms. Later the elastic peak also appears and becomes more and more significant. Finally, in the third region, after the amount of deposited charge on the wall reached a dynamical equilibrium, stable guided transmission was obtained.

Acknowledgements
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References

[1] G.U.L. Nagy, I. Rajta, R.J. Bereczky, K. Tőkési, 22nd International Conference on the Application of Accelerators in Research and Industry. Fort Worth, Texas, USA, 5-10 Aug., 2012. Proceedings. New York, AIP (AIP Conference Proceedings) in press.

E-mail: tokesi@atomki.mta.hu