Dynamics of guiding of Ne^{7+} and Ar^{7+} ions through nano- and microcapillary arrays

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Transmission of highly charged ions through tilted nano- and microcapillaries attracted considerable interest in recent years. The guiding effect is due to the electrostatic charging up of the capillary wall by the incident ions, which deflects other ions to the capillary exit. The transmission develops in a self-organizing manner [1,2]. In this work we present cases when the dynamics of the development exhibits unusual transient behaviour compared to earlier studies. The first case is the observation of irregular phase shifts in the first angular oscillations of ion guiding at a polyethylene terephthalate (PET) sample bombarded by 3 keV Ne^{7+} ions. The second studied case is the development of guiding of 21 keV Ar^{7+} ions through a glass microcapillary array.

The experiments were performed at the ECR ion source of Atomki. Two-dimensional distributions of the transmitted particles (ions and neutrals) were measured by a position sensitive detector. A long set of snapshots have been recorded to record the full transient period of the time development. In the first experiment we studied a rather high density ($10^8/cm^2$) PET sample with a pore diameter of 200 nm and a thickness of 10 μm. Here we found that the starting phase of the mean angle of ion transmission can be both negative and positive. It is likely to be due to a density effect. The analysis is in progress, and will be shown at the Conference.

In the second experiment, we used a piece of not fully manufactured multichannel plate (MCP) as target, which was not covered with electron emission layer. The length of the capillaries was 1 mm and their diameter was 5 μm with an opening of ~50%. In order to avoid macroscopic charge up, both sides of the sample were covered with thin gold layer. The typically 700 pA beam current was collimated to a diameter of 0.5 mm. Images were acquired for 9 seconds with 1 second breaks. Ions and neutrals were electrostatically separated in front of the detector. The neutrals immediately appeared on the detector as the beam was switched on. After a short delay ions also appeared, but in a very irregular pattern. The distribution of ions changed very dynamically. Multiple patches were popped up and completely changed almost on a picture to picture basis. Examples will be demonstrated at the Conference. After a while these patches merged and the transmission became regular.

The total integrated intensity continuously increased. This measurement has a preliminary character, since the detector got overloaded, when the intensity was not yet saturated. We plan to repeat the measurement with a combined detection technique.

The reason of the stochastic transmission is still a puzzle. Earlier, similar behaviour was observed for single glass capillary too [3], but not for tapered glass capillaries [4]. This work was supported by the Hungarian National Science Foundation (OTKA, Grant No. K83886), and by the TÁMOP-4.2.2/B-10/1-2010-0024 project, which is co-financed by the European Union and the European Social Fund.

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