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Dynamic transmission of intermediate energy proton through polycarbonate nanocapillary

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Synopsis Dynamic transmission of 10~120keV proton through polycarbonate nanocapillary were observed. 10keV proton is guided along the capillary and the charge purity is about 80%. But protons with energies near 100keV show remarkable differences. The charge purity of them is also high, but the transmitted particles move along the direction of incident beam, while not along the capillary axis.

In this work, we measured the dynamic transmission of 10~120keV proton through polycarbonate nanocapillary. The data show that protons at 10keV are guided [1,2] through the capillary and with high charge purity. But the data near 100keV show significant differences. For 100keV proton, charge purity of the transmitted particles can reach to 80%, while they move along the direction near to the incident beam. This shows that the transmission of intermediate energy proton in capillary is different from that of low energy protons.

With further theoretical calculation, we found that the short range surface scattering force is important to 100keV proton. Guiding force can push the incident particles to leave the electron capture distance from surface, and then the charge exchange process is inhibited. But the transverse momentum of 100keV proton is rather large to let them to approach the range of surface scattering force. Thus, close collisions with surface atomic layers will make their trajectories look like quantum reflections. With another time quantum reflection near the exit, the transmitted particles will move along the direction of the incident beam.

In summary, guiding force and surface scattering force both play important role in transmission of hundreds keV protons through insulating capillaries. Guiding force makes the high charge purity and scattering force controls their trajectories. This finding is much helpful to the applications of micro-sized ion beams produced by capillary or trapped glass at hundreds keV energies.

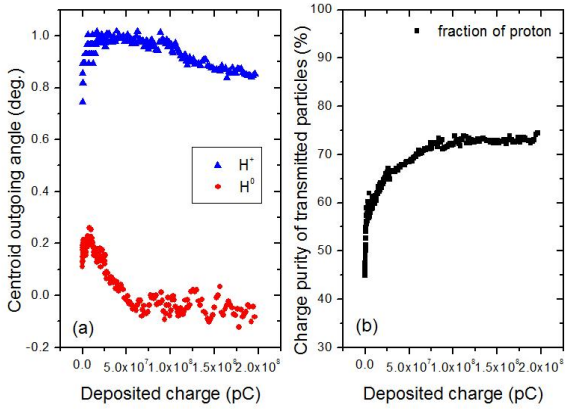

Figure 1. Time evolution of (a) centroid outgoing angle and (b) proton fraction, of the transmitted particles at energy of 10keV and title angle of +1 degree.

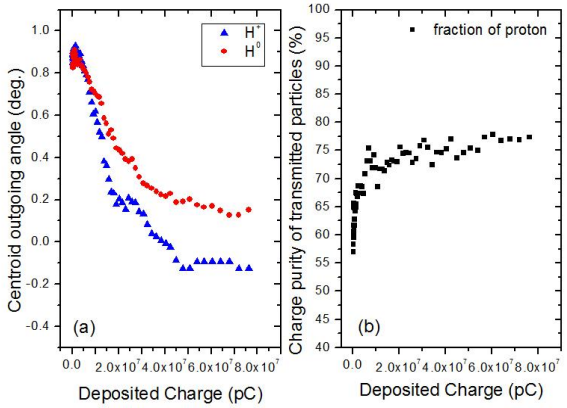

Figure 2. Time evolution of (a) centroid outgoing angle and (b) proton fraction, of the transmitted particles at 100keV energy and title angle of +1 degree.

References

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