CHARGE STATE AND SCATTERING ANGLE MEASUREMENTS OF 800eV/q Xe^{q+} IONS TRANSMITTED THROUGH Ni-MICROCAPILLARIES FOR MULTIPLE ELECTRON TRANSFER STUDY

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We have been studying the charge state distribution of ions after interaction of highly charged ions with a metallic surface, where a micro capillary foil is used as the target, which provides important information on multiple electron capture processes of highly charged ions.

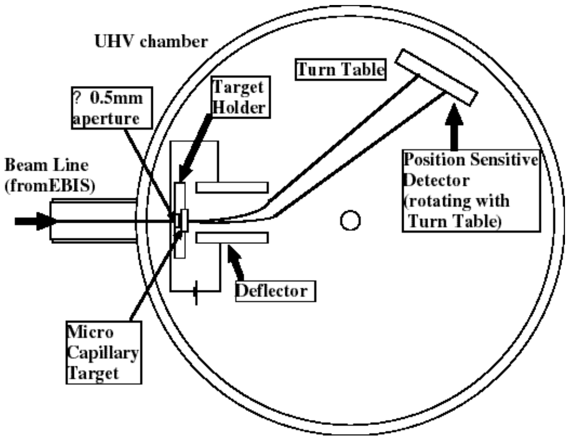

Fig.1: Experimental set up for charge state analysis

When a slow highly charged ion approaches a metallic surface, target electrons are transferred to the ion when the ions are still far above the surface. Electrons are transferred into highly excited states keeping its inner shells empty. Such a transient atomic state with many electrons in highly excited states and many innershell vacancies is called a “Hollow Atom” above the surface. Various experiments have been done and proven that a Classical over Barrier model (COBm) reproduces various aspects of the observations. However, it was very difficult to study the behavior or nature of hollow atom because it hits the surface violently immediately after its. S. Ninomiya et al. have suggested that a micro capillary target can make it possible to extract hollow atoms above the surface into the vacuum [1].

Figure.1 shows the experimental setup. Ions were extracted from an Electron Beam Ion Source (EBIS) at University of Tokyo. Through the ϕ0.5mm aperture, ions were injected into a Ni micro capillary target with its angular divergence of ~0.1degree. The pore diameter and thickness of the capillary target were ~100nm and 700nm, respectively. The vacuum chamber was evacuated up to $\sim 10^{-9}$ Torr. Ions were deflected with a charge state analyser, and then detected by a 2D position sensitive detector (PSD) at 300mm downstream from the target. The 2D PSD consists of a micro channel plate and a wedge-meander-strip type anode.

Figure.2 shows the final charge state distribution, which shows a U-shaped for all the incident charge states measured. On the other hand, COBm tells that critical distance d_c

where electron transfer occurs between ion and metallic surface is given by $\sim \sqrt{2q}/W$, where q is the charge state of ions before the electron transfer takes place and W is the work function of the target metal. From this distance d_c, we can roughly calculate the final charge state distribution, which is noted by solid line in Fig.2. It is seen that the general behavior for low charge states are similar but that for high charge states are quite different, which may be explained with Auger electron emission processes. A Monte Carlo simulation taking into account Auger processes has been made for N^{6+} ions by Tokesi et al. [2], the results of which is shown by the dotted line in Fig.2. It is seen that the agreement with our measurements is quite satisfactory.

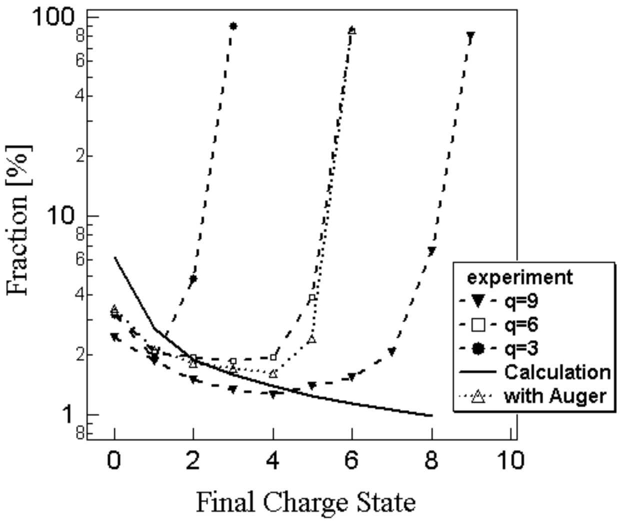

Fig.2: Final charge state distribution for Xe^{3+}, Xe^{6+}, Xe^{9+} incident.

The angular distributions for each exiting ions are shown in Fig.3. It is seen that ions with higher exiting final charge states are more deflected than those with lower final charge states, which is not consistent with a qualitative expectations. Actually, Tokesi et al. calculated the angular distribution of 2.1 keV/u N^{6+} transmitted through Ni micro capillary target with COBm[2] and showed the qualitative expectations are reproduced. In order to study this puzzling but interesting discrepancies, a new measurement employing other targets with much straight capillaries are under preparation.

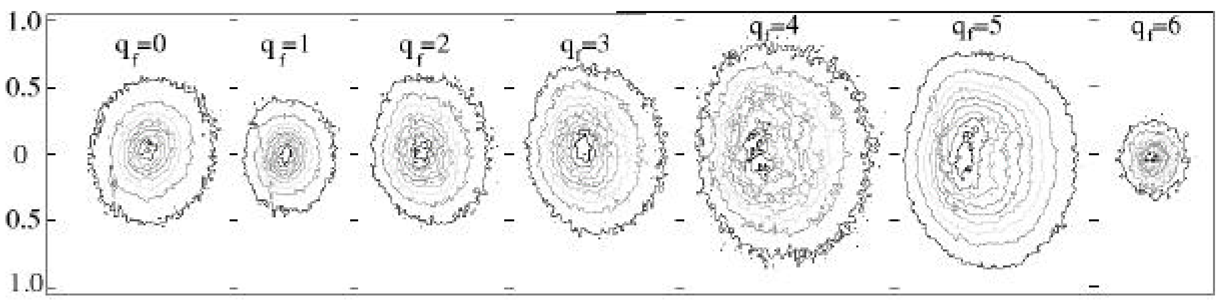

Fig.3 2-D contour plot for Xe^{6+} incident

References

[1] S. Ninomiya et al., Phys. Rev. Lett. **78**, 4557 (1997)

[2] K. Tokesi et. Al., Phys. Rev. **A61**, 020901(R) (2000)