Charge Changing Collisions between Multiply Charged Xe and Pb Ions

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Charge changing collisions between multiply charged ions in homonuclear collision systems are not only of basic interest as an ideal testing ground for theory [1]. As the beam intensities in modern accelerator and storage rings increase, intensity losses due to charge changing intrabeam collisions may become significant for lower charge states [2, 3]. Resulting mainly from betatron oscillations, the center-of-mass energies for these collisions are typically in the keV region for beam energies up to 1 GeV/u. A theoretical treatment of the charge changing processes in this low energy region is difficult, because perturbation theory usually cannot be applied. As the collision velocity is much smaller than the classical Bohr velocity of the active electrons, a treatment in the molecular orbital model would be the preferred choice. However, the many electrons still present in the heavy ions make such calculations nearly impossible. Thus experimental investigations are currently the only way to obtain the cross sections for charge changing collisions between heavy ions.

The Giessen ion-ion experiment is ideally suited to study the charge transfer between two ions with charge states between 2+ and 4+. The respective data for Ar and Kr ions has already been presented in [4]. Here we present the same systematic study for the collision systems

$$Xe^{q+} + Xe^{q+} \rightarrow Xe^{(q-1)+} + Xe^{(q+1)+} \quad (1)$$

$$Pb^{q+} + Pb^{q+} \rightarrow Pb^{(q-1)+} + Pb^{(q+1)+} \quad (2)$$

with $q = 2, 3, 4$. The absolute cross sections are shown in Fig. 1 and Fig. 2.

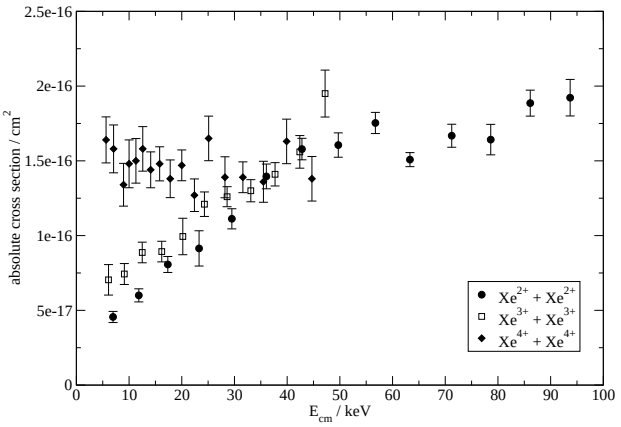

Figure 1: Absolute cross sections for charge transfer in the collision system Xe^{q+} + Xe^{q+} with $q = 2$ (circles), $q = 3$ (squares) and $q = 4$ (diamonds, [5]).

For Xe^{2+} and Xe^{3+} ions we see the expected increase of the cross section with the center-of-mass energy, which is typical for non-resonant collision systems at this low energies. This is not the case for Xe^{4+} and all Pb ions, where essentially no dependence is seen. Such a behaviour is more typical for resonant or near resonant collision systems. As the table shows, this is not the case provided the ions are in the ground state. However, electron impact ionization studies have revealed a significant amount of metastable ions of 29% in the Xe^{4+} beam. We thus attribute the cross section dependence for these and the Pb ions to a large metastable fraction leading to Q-values near 0 eV and thus near resonant conditions.

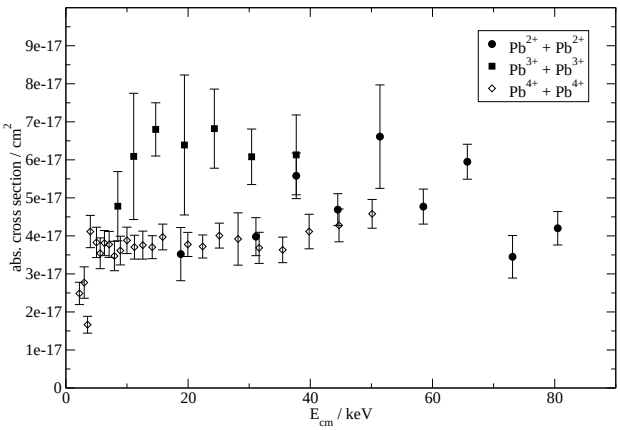

Figure 2: Absolute cross sections for charge transfer in the collision system Pb^{q+} + Pb^{q+} with $q = 2$ (circles), $q = 3$ (squares) and $q = 4$ (diamonds, [6]).

	2+	3+	4+
Xe	-9.7 eV	-12.1 eV	-12.2 eV
Pb	-15.6 eV	-10.7 eV	-27.1 eV

Table 1: *Q-values for the charge transfer reactions* X^{q+} + $X^{q+} \rightarrow X^{(q-1)+}$ + $X^{(q+1)+}$ + Q. *The Q-values have been calculated using the computer code GRASP [7].*

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