A.1.7. Enhancement of Al-K and Molecular Orbital X-rays in Collisions of Low Energy Ne Ions with K-shell Vacancies—*Hiro Tawara, C. Fehrenbach, and Martin Stöckli*

In low energy collisions between heavy ions and heavy atoms where the quasi-molecular formation mechanisms are responsible for many features of the system, an inner-shell vacancy is usually generated through promotion of an inner-shell electron into a higher excited, unfilled level in the quasi-molecular atoms formed during collisions, leaving a vacancy in the inner-shell which decays after the collision is over.

In most of the experiments performed so far, the inner-shell vacancy is formed mainly in the lighter collision partner on the incoming path during collisions and then transferred to the heavier collision partner on the outgoing path. On the other hand, in the present experiment, such a vacancy is directly brought in at the very beginning of collisions by highly charged ions in well-controlled ways. Note that the ionization probabilities of the K-shell electron due to direct Coulomb ionization processes are very small at the collision energies studied in the present work.

In the present experiment, $^{22}Ne^{q+}$ (q=7, 8, 9 and 10) ions were obtained in the KSU EBIS and after extraction and charge/mass selection, accelerated up to 150 qkeV. They were then sent into a target chamber, which was evacuated down to 10^{-9} Torr. A polished Al solid target was inserted into the target chamber. X-rays produced by ion impact were observed with a Si(Li) detector.

Typical observed (not corrected for the Be window absorption) X-ray spectra from Ne^{9+} ion impact on a solid Al target are shown in Fig. 1 at different impact energies. Clearly three different X-ray energies are observable:

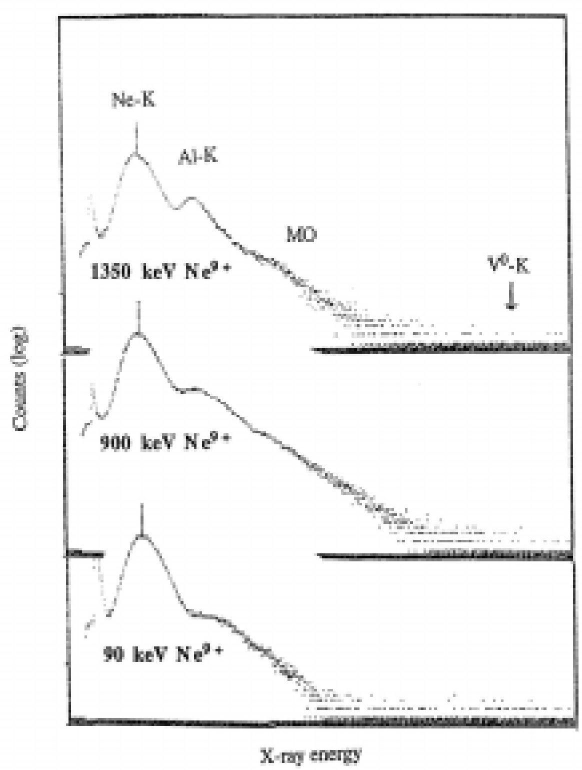

Figure 1. X-ray spectra from Ne^{9+} + Al collisions.

1) The most intense x-rays at ~ 0.89 keV are due to Ne K-X-rays which correspond to transitions of an electron captured at very high n-states into the K-shell vacancy of the projectile Ne^{9+} ions. (Where n is the principal quantum number and the most likely n is 15-20 in the present collisions.) The observed Ne K-X-ray spectrum is roughly four times broader than that expected from the calibration X-ray sources, indicating that a number of transitions originating from various n-states into the K-shell contribute to the observed X-rays.

2) Al K-X-rays having an energy of about 1.5 keV whose intensities are roughly an order of magnitude less than that of Ne K-X-rays. They are also broader than those excited by photons.

3) Continuous MO X-rays extending up to around 5 keV whose integrated intensities are less than 1% of Ne K-X-ray intensities.

Other features have also been observed as follows:

1) The peak energy of the observed Ne K-X-rays for Ne^{10+} ion impact is found to be shifted to higher energies corresponding to transitions involving electrons captured into higher excited states of Ne^{10+} ions, into one of the K-shell vacancies.

2) Very weak Ne and Al K-X-rays but almost no MO X-rays have been observed under Ne^{8+} and Ne^{7+} ion impact.

3) Intensities of Al K-X-rays and MO X-rays relative to Ne K-X-rays change as the collision energy increases.

Most of these features can easily be understood from the energy correlation diagram [1]. There we have to note that an electron in the 2p state of a highly ionized Ne ion is still more tightly bound than that in the 2p state of neutral Al (so-called level swapping) and thus, one of the K-shell electrons in a Ne ion can be promoted to its own vacant 2p state via $2p\sigma$-$2p\pi$ orbital coupling at close nuclear distances on the incoming path, forming a K-vacancy in the Ne ion. In turn, this K-vacancy of the Ne ion can be transferred into a K-vacancy of Al on the outgoing path through the Demkov-Meyerhof model with the double-passage [2].

References

1. M. Barat and W. Lichten, Phys. Rev. A 6, 211 (1972).
2. W.E. Meyerhof, Phys. Rev. Lett. 31, 1341 (1973).