CHARGE EXCHANGING PROCESSES IN SMALL IMPACT PARAMETER COLLISIONS BETWEEN S+q IONS AND RARE GASES

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Résumé. Pour des énergies de 32 à 48 MeV et avec des ions incidents S^{+5} à S^{+9}, les distributions de charge finale des ions de soufre produits par collision unique à faible parametre d'impact sur cible de gaz rares ont été mesurées à l'université de Pittsburgh. Les tendances observées sont les mêmes que celles d'expériences antérieures avec l'ion O^{+q}: la distribution de la charge finale est presque complètement indépendante de l'état de charge incident. Alors que le modèle de l'écran dynamique utilisé pour calculer la charge finale moyenne s'est avéré satisfaisant dans le cas de l'oxygène il a été ici nécessaire de tenir compte de l'effet de promotion des électrons des couches internes pour reproduire les résultats expérimentaux pour le cas S+Xe.

Abstract. The outgoing charge distributions of sulphur ions in the 32-48 MeV bombarding energy range, with initial charges S^{+5} to S^{+9} have been measured after small impact parameter collisions. Trends similar to those previously observed with oxygen projectiles were observed, namely an almost complete independence of the outgoing charge distributions on the incoming charge state. The dynamic screening model was used to calculate the average outgoing charge state and gave satisfactory agreements for the S+Ar and S+Kr cases. For the S+Xe case, promotion effects of the sulphur inner shell electrons had to be included to account for the experimental results.

Projectile charge state distributions after collisions with impact parameters much smaller than the K-shell radii of the colliding partner were studied by Rosner & Gur [1] for single collisions between oxygen and noble gases. It was found that for heavy targets the charge distributions of the scattered ions after such collisions were insensitive to the incoming projectile charge state as well as to the exact value of the impact parameter as reflected by the scattering angle. These results indicate that under the above stated conditions, equilibrium charge distribution is achieved in a single collision. Statistical calculations based on the dynamic screening of the projectile succeeded very well in reproducing the values of the average outgoing charge states [2].

In the experiment reported here, sulphur projectiles with initial charges +6 to +9 and energies of 32, 40 and 48 MeV obtained from the U. of Pittsburgh tandem accelerator were used. The outgoing charge state distributions after single collisions with Ar, Kr and Xe atoms at a scattering angle of 5° were determined by means of an experimental set-up similar to the one described in [1]. In figure 1 the results for 40 MeV bombarding energy are shown. Again the outgoing charge distributions are practically independent of the incoming charge state.

There is a reasonable agreement between the experimental average outgoing charge states and those calculated by the dynamic screening model for the Ar and Kr targets. However for the Xe target the experimental values exceed the theoretical prediction by about 0.7 charge units.

A possible explanation of this discrepancy is the presence of an electron-promotion mechanism superimposed on the statistical process. Figure 2 shows the molecular orbitals' diagrams for the three different systems. Since the electron velocity in the 3d shell of Xe is of the order of magnitude of the projectile velocity, electrons from this shell are easily excited [3] while the internuclear distance is still large. On further approach 1s electrons can be promoted to these vacancies by rotational coupling. An increase in the outgoing charge state is then further enhanced by Auger transitions.

In the S+Kr system the 1s sulphur orbital crosses only tightly bound levels and promotion is not possible. The S+Ar system is very interesting. For the S^{+6}+Ar as well as higher initial charge states the sulphur 2s and 2p orbitals are lower than the corresponding Ar levels [4] and the 1s sulphur level does not cross any Ar level. There is a possibility of "self promotion" of the 1s electrons to higher sulphur states and subsequent loss by Auger decay. However this small

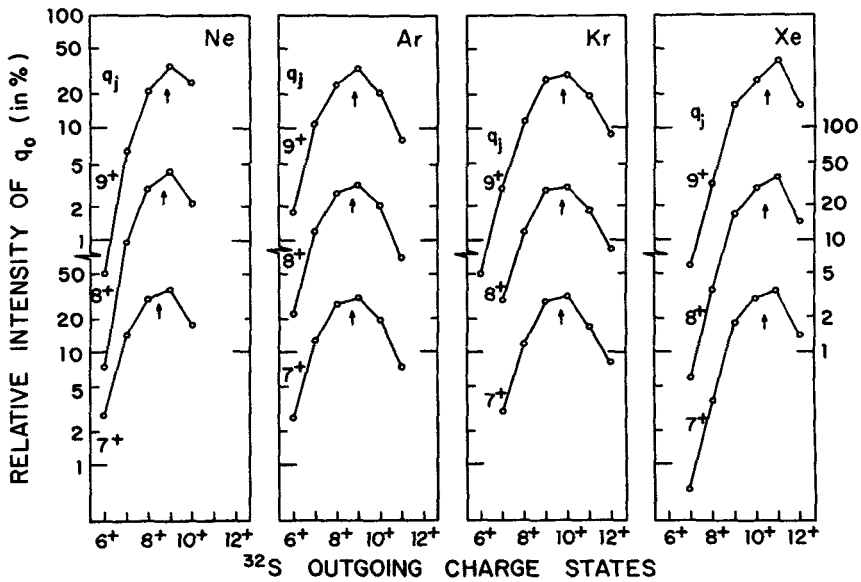

Fig. 1 - Charge-state distributions of outgoing 40 MeV sulphur ions as a function of their initial charge q_i, after scattering at $\theta = 5°$ by Ar, Kr and Xe atoms.

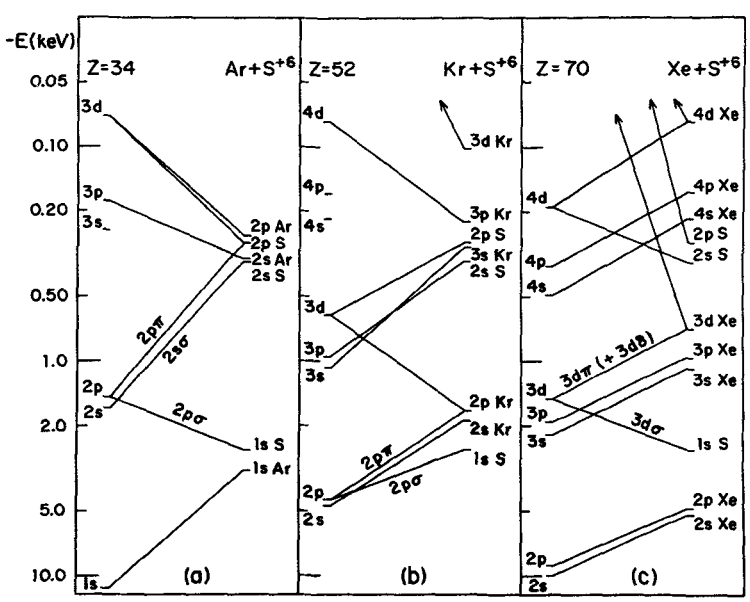

Fig. 2 - Adiabatic molecular-level correlation diagrams of S^{+6} with Ar, Kr and Xe targets.

effect would be largely neutralized by transfer of 1s Ar electrons to the 1s sulphur vacancies by radial coupling when the internuclear distance increases again.

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