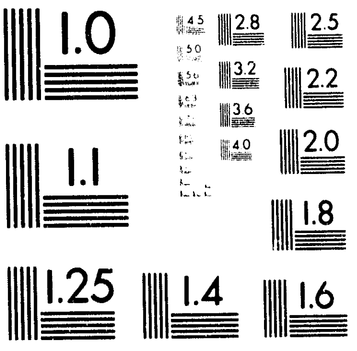
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ELECTRON EMISSIONS IN LOW ENERGY Ar^{q+}-Ar COLLISIONS

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ABSTRACT

The spectra of electrons emitted in Ar^{q+}on Ar ($8 \leq q \leq 16$) collisions at 2.3 qkeV were measured in the 30 to 400 eV energy range. With the exception of Ar^{8+} on Ar, the overall appearance of the electron spectra is quite similar, suggesting that the same mechanism is responsible for the observed features. One possible mechanism is the delocalization of the 3p and 3s target electrons during the collision. The resulting molecular state either deexcites by Auger transitions during the collision, or strands two or more electrons on the projectile in an excited state. This state in turn deexcites by Auger transitions.

INTRODUCTION

In collisions of low energy, highly charged argon ions with argon atoms, most of the Ar^{q+} projectiles undergo collisions in which the charge state q decreases by one unit only. Collisions involving projectile charge state changes by two units are less frequent, and by more than two units are quite rare. [1] At the same time, the recoil target ion charge state distribution contains ions whose charge ranges from one to eight.[2] Since singly charged recoil ions account only for about one half of the ions observed, a significant fraction of the collisions is accompanied by electron emissions.

By looking at the number and energy distribution of the electrons emitted, one might expect to learn something about collisions between low energy, highly charged ions and a multi-electron target atom. The presence of a large number of electrons, six and two in the 3p and 3s subshells of argon, complicates the interpretation of the observed ejected electron spectra. There are at least two ways of approaching this problem of interpretation. Recently Posthumus and Morgenstern[3] have measured the spectra of electrons emitted in 108 keV Ar^{9+} on Ar collisions in coincidence with target argon ions. In this way, they have been able to associate certain features of the observed electron spectra with different recoil ion charge states. This allowed them to identify possible excited states of the projectile formed in the collision by the transfer of a known number of electrons from the target. In this paper we report on a somewhat different method of attack on the problem of interpretation of observed electron spectra emitted in such collisions. The method is based on a systematic study of electron spectra emitted in Ar^{q+} on Ar ($8 \leq q \leq 16$) collisions at 2.3 qkeV.

EXPERIMENTAL METHOD

Ar^{q+} ions were produced by the Cornell superconducting solenoid, cryogenic electron beam ion source CEBIS,[4] and extracted at 2.3 kV. Magnetically selected charge states passed through a gas cell containing argon at a pressure of 7.5×10^{-4} Torr. The electrons emitted in Ar^{q+}-Ar collisions were analyzed at 90^{o} to the incident beam direction by a $\pi/\sqrt{2}$ cylindrical electrostatic analyzer. The analyzer outer and inner radii were 6.03 and 5.02 cm

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respectively. The analyzer was made from aluminum and then copper and gold plated. The experimental arrangement is shown in figure 1. After passing through the gas cell, the ion beam could be charge state analyzed by another electrostatic analyzer if desired.

The gas cell was located near the focus of a 90^o bending magnet. At this position, the measured beam size is 1.5 mm. The beam size, together with a 1.0 mm wide analyzer entrance slit, analyzer dimensions and a 10 mm diameter channeltron detector placed directly behind the exit slit set the energy resolution $\Delta E/E$ at 0.024.

To record electron spectra, the analyzer was set to transmit 45 eV electrons, and the spectrum recorded by slowing down the electrons entering the analyzer.

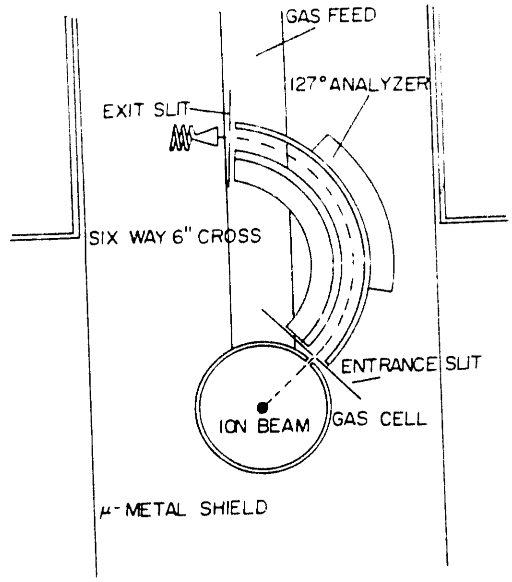
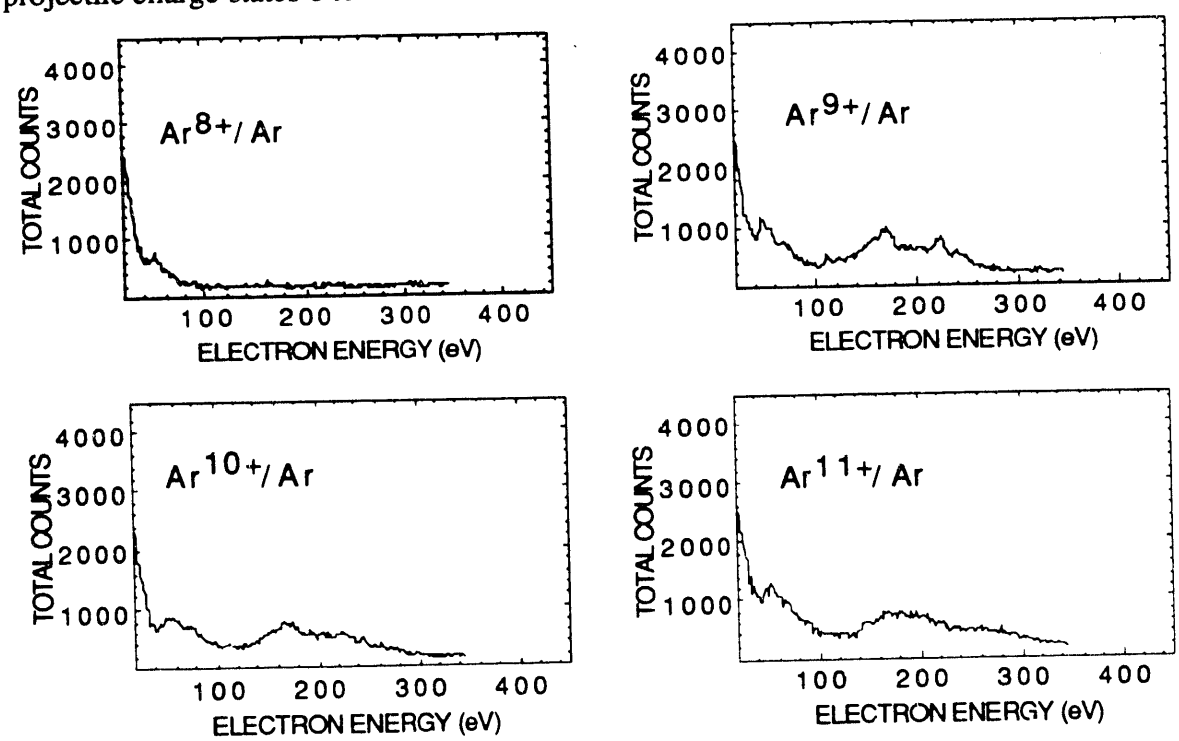


Figure 1. Experimental arrangement used to record electron spectra.

RESULTS

Electrons emitted in Ar^{q+}-Ar collisions in the 30-400 eV energy range were recorded for projectile charge states 8 to 16 inclusive. The results are shown below in figure 2.



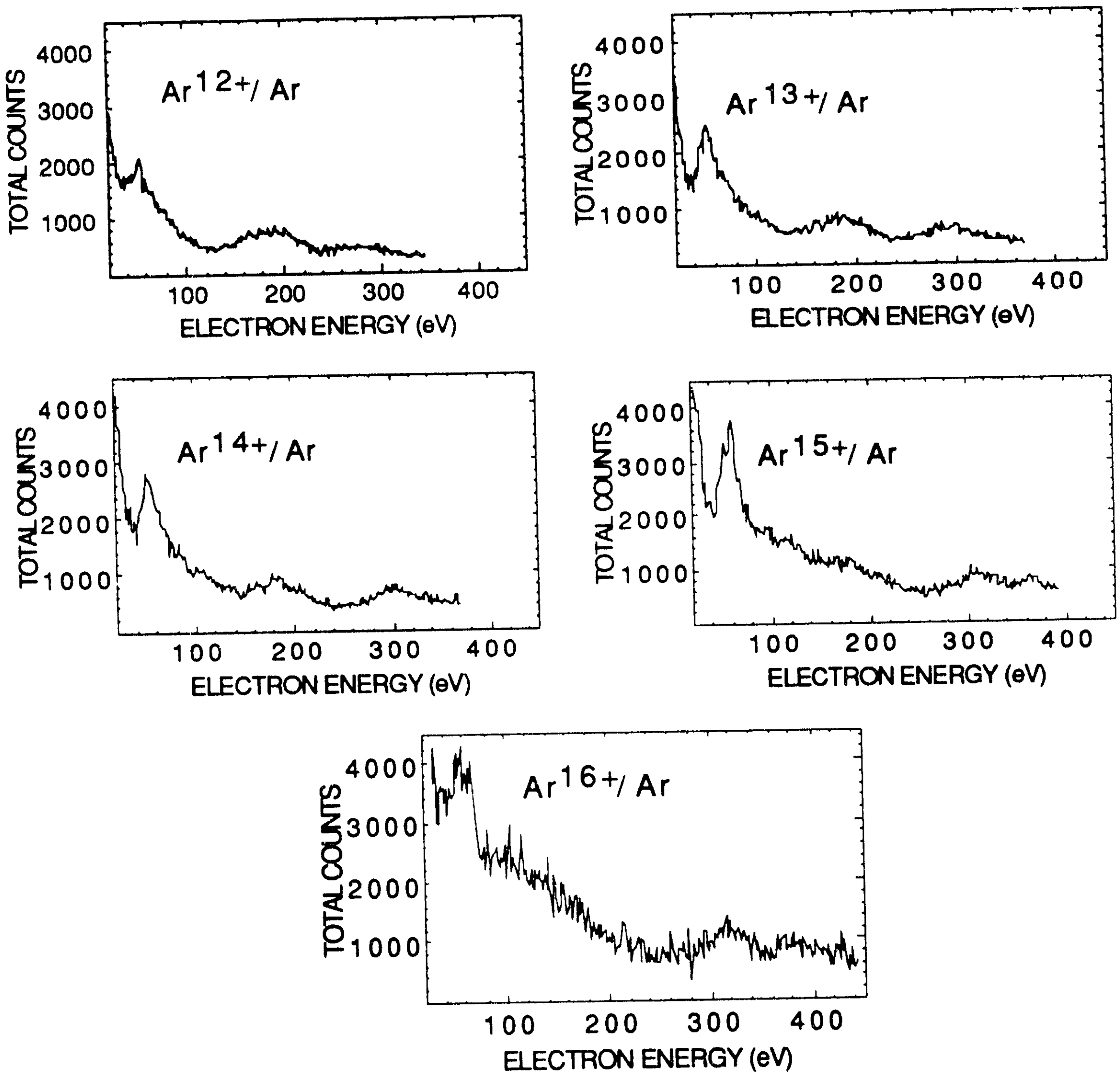


Figure 2, a through i. Electron spectra emitted in Ar^{q+} on Ar collisions at 2.3 qkeV.

In the above figure , the electron spectra were normalized to the same beam intensity in order to give an idea how the electron intensity increases with the projectile charge state. For each electron spectrum, the ion beam transmitted through the cell was charge state analyzed, to ensure that the transmitted beam contained mostly one and two electron tranfer peaks.

DISCUSSION

With the exception of Ar^{8+} on Ar, the overall appearance of the electron spectra is quite similar, suggesting that the same mechanism is responsible for the observed features. One possible mechanism is the delocalization of the 3p and 3s target electrons during the collision. Figure 3 shows the sum of two Thomas-Fermi potentials, one for a neutral argon atom and the other for an Ar^{10+} ion along the z-axis in spheroidal prolate coordinates. The 10.66 a.u. internuclear separation corresponds to the measured Ar^{10+}-Ar total cross section. The Thomas -Fermi potential for the neutral atom is calculated in the Tietz approximation,[5] while that for the ion by the method of Stewart and Rotenberg[6]. The dashed lines indicate the position of calculated single particle states[7] in the separated atom and ion respectively. The 2s and 2p states in the atom and ion are at -9.57 and -12.32, and -18.3 and -15.6 a.u. respectively, and from figure 3, one can see that these states should remain on their respective nuclei.

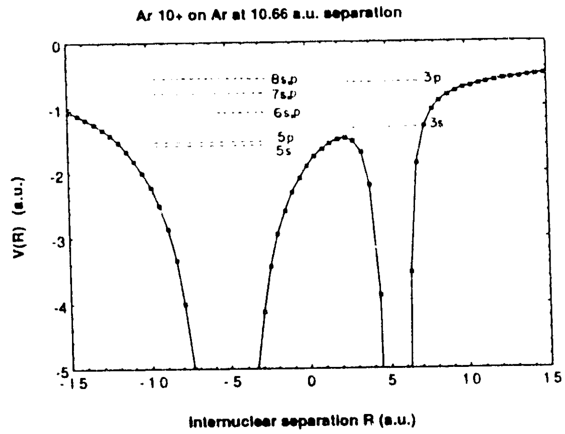


Figure 3. Position of separated atom -ion single particle states shown in the sum of -Thomas-Fermi potentials for an atom and ion at 10.66 a.u internuclear separation.

Accordingly, one might expect that the molecular state, formed from the 3p and 3s target argon electrons and the available unoccupied Ar^{q+} states, is responsible for the observed electron spectra. This state may decay during the collision by Auger transitions, emitting several of the original target atom electrons, or it may leave two or more electrons stranded on the projectile ion in excited states that in turn deexcite by Auger emission.

ACKNOWLEDGMENTS

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