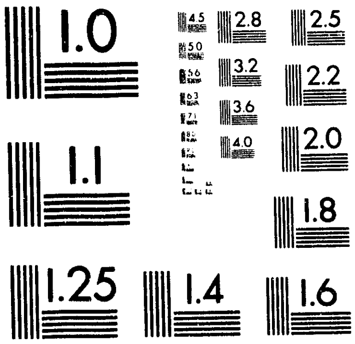
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ENERGY GAIN SPECTROSCOPIC STUDY OF Ar^{q+}-Ar COLLISIONS AT 40 qeV

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ABSTRACT

Energy gain spectra of $Ar^{q+}(8 \le q \le 16)$ on Ar at 40 qeV collision energy and 0.4 qeV energy resolution are presented. Capture into definite states of the projectile is observed which seems to exhibit a definite even-odd projectile charge state dependence.

INTRODUCTION

Thus far, there have been very few measurements of energy gain spectra in low energy, highly charged ion-atom collisions reported in the literature. Ohtani et al.[1] have measured the energy gain spectra of bare C and O projectiles that have captured one electron from helium, Nielsen et al.[2] have measured energy gain spectra of $Ar^{q+}(6 \le q \le 10)$ on Ne, Ar, and Xe, and Giese et at.[3] Ar^{q+} $(4 \le q \le 8)$ on Ar. The Nagoya group used highly charged ions produced by the electron beam ion source NICE-1, while the Aarhus and Kansas State groups used a recoil ion source. In both experiments, the energy resolution was such that capture into definite states of the projectile could be identified. In this paper we report on a measurement of energy gain spectra in Ar^{q+} - Ar $(8 \le q \le 16)$ collisions at 40 qeV.

EXPERIMENTAL METHOD

Figure 1 shows schematically the experimental arrangement used to measure energy gain spectra. Highly charged 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 were decelerated to 40 qeV by a combination einzel lens and decelerating lens system, and monochromatized by a pair of 180° spherical electrostatic analyzers connected in series. After passing through a gas cell, (typical pressures around 6.0×10^{-5} Torr), the direct

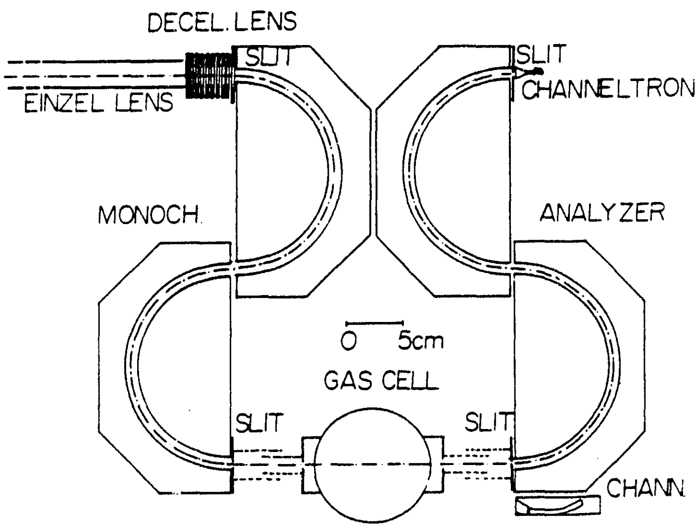

Figure 1.Experimental arrangement used to record energy gain spectra in Ar^{q+} on Ar collisions at 40 qeV.

beam was analyzed by a similar pair of analyzers. The mean radius of the analyzers is 8.9 cm, the separation between spherical surfaces is 1 cm, and for a 1 mm beam, $\Delta E/E = 0.005$.

To record the energy gain spectra, the energy profile of the incident ion beam was first measured by scanning the voltage applied to the pair of hemispherical analyzers used as a spectrometer. Once the projectile beam profile was obtained, gas was admitted into the 13 cm long gas cell, and the energy gain spectrum recorded.

RESULTS

Some of the 0^{o} energy gain spectra obtained are shown in figure 2, a through f. The primary beam, whose FWHM was typically around 0.5 qeV, is shown at the right in each spectrum. (The right hand scale represents counts per 2 sec, while the left hand scale is per 60 sec.)

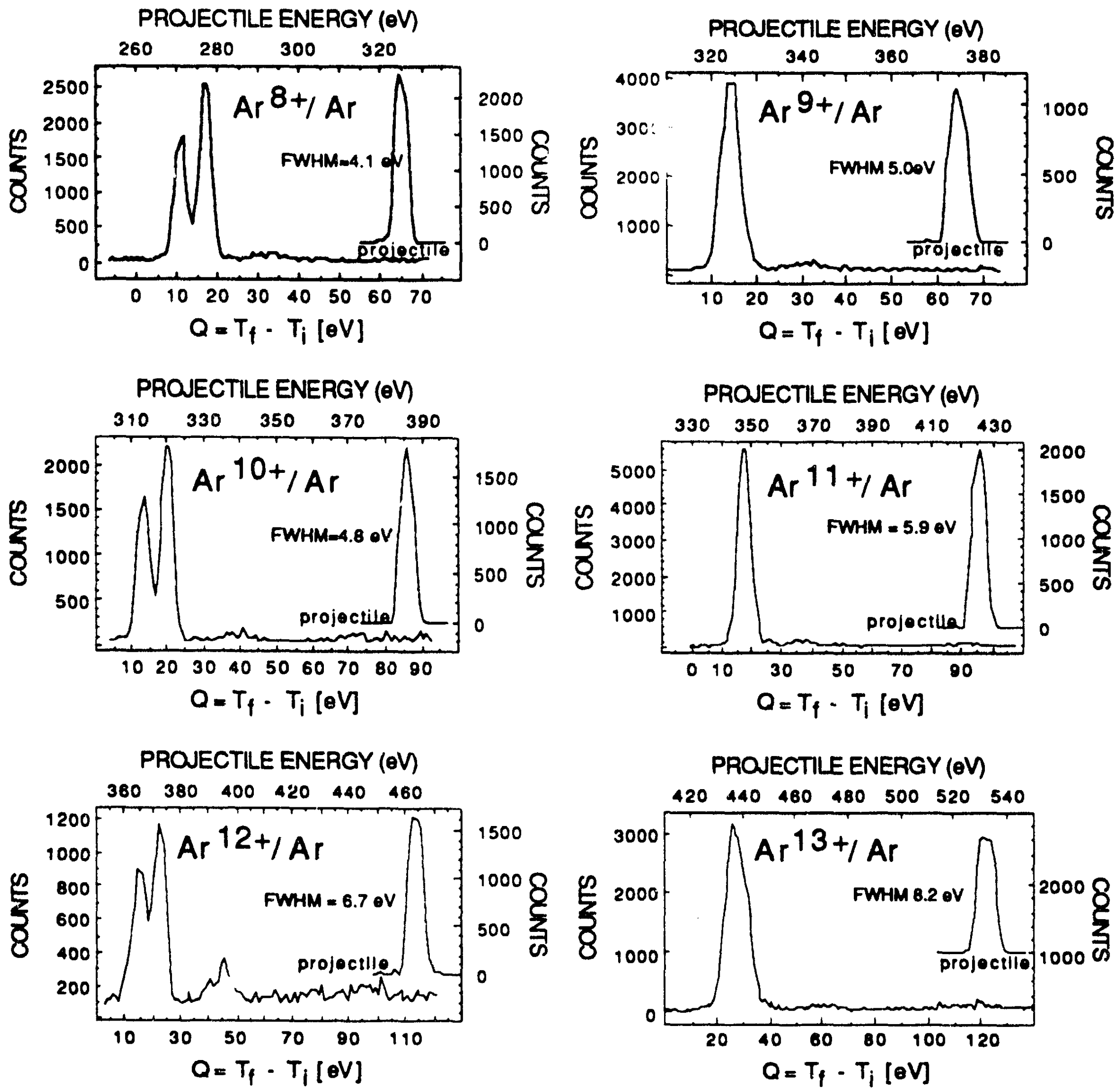

Figure 2. Translational energy spectra in Ar^{q+} - Ar collisions at 40 qeV.

DISCUSSION

For argon projectile charge states 8 through 10 on argon, Nielsen et al.[2] have measured energy gain spectra at 1.0 keV collision energy, and with an energy resolution of about 0.25 qeV. Our results for these charge states at about half the collision energy are similar to theirs, but there are some differences. For Ar^{9+} on Ar, Nielsen et al. observe a wider peak that does appear to consist of two peaks very close together, and which they attribute to 6dd' capture. In our case, if we look at the energy width of the incident projectile, the spectra seem to indicate an even-odd projectile charge state effect in which the even numbered charge states exhibit two distinct peaks while the odd numbered charge states show only one peak. (It is possibly that in the Ar^{9+}case there are two peaks, separated by less than 1 eV.) The reason for this effect is not understood at this time.

Q values for the reaction were calculated using Froese-Fischer's general Hartree-Fock computer code.[5] The values obtained differed from those quoted in reference 2 by about an eV. A one to one and a half volt uncertainty in our present analyzer energy scale prevents us from assigning specific nl values to the projectile capture state at this time.

The features at higher Q values, commonly attributed to transfer ionization, which appear to the right of the main peaks are not as pronounced in our spectra as in those observed in the Aarhus experiment. Whether or not this is due to our lower collision energy, or to the fact that our angular acceptance is on the order of a degree remains to be determined.

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