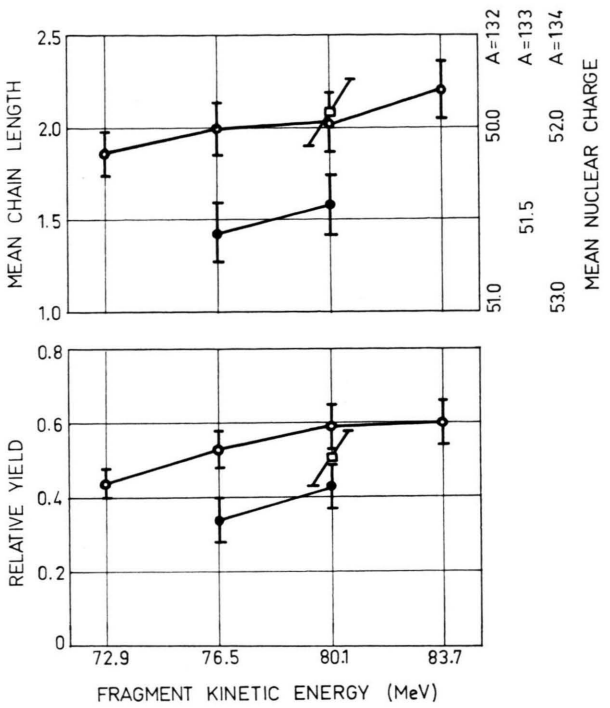

Fig. 2. *Top:* Mean chain lengths (left-hand scale) and mean nuclear charge (right-hand scales) for fission fragment masses $A=132$ (□), $A=133$ (●) and $A=134$ (○), as a function of fragment kinetic energy. *Bottom:* Fractional yields of the magic nuclei $^{132}_{50}Sn^{82}$ (□), $^{133}_{51}Sb^{82}$ (●), $^{134}_{52}Te^{82}$ (○) within the mass chains $A=132$, 133 and 134, respectively, as a function of fragment kinetic energy.

of each individual fission fragment track was determined. The simple relationship between the primary fragment nuclear charge, Z_p and n is $Z_p = Z_{st} - n$, where Z_{st} is the known charge of the stable end product of the mass chain under investigation.

Fig. 1 shows the charge distributions for masses $A=132$, 133 and 134; Fig. 2 shows the average charge, Z_p (top) and the relative contribution of the magic nuclei $^{132}_{50}Sn^{82}$, $^{133}_{51}Sb^{82}$ and $^{134}_{52}Te^{82}$ (bottom) as a function of fragment kinetic energy. With increasing kinetic energy the magic nuclei are formed with higher probability. Due to the relatively low intensity of particles with mass numbers 132 and 133 in connection with the separation principles of the mass spectrograph [4], the data in these cases were taken for only one and two energies, respectively.

The low value of Z_p for $A=132$ corresponds to a high yield of the doubly magic nucleus with $N=82$, $Z=50$.

The results are consistent with the average values of Z_p as given in ref. [1] but are in contradiction to the recent radiochemical measurements of Strom et al. [5] who obtain $Z_p=51.07$. The low value of Z_p for $A=132$ in the present measurement could be caused, in principle, by improperly including in the chain length determination a large number of conversion electrons which are indistinguishable from beta particles in the nuclear emulsion. However, preliminary results of a measurement by H. Rösler of this group, in which a 4π proportional counter is used to determine the chain lengths, indicate that the influence of conversion electrons is small.

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The Kinetic Energy of Autoionization of Helium

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A surprising difference between the kinetic energy distribution of He^+ ions and D_2^+ ions formed by electron impact above 60 eV has been observed. The experiments were performed on a MS-2 mass spectrometer of AEI-Manchester, and the kinetic energy distribution was measured by the deflection plate method. The apparatus and technique are described by Taubert and Fuchs [1]. The source makes use of a continuous electron beam with collimating magnetic field, and a continuous repeller field so that only nominal electron energies can be given. The cathode is a strip of tungsten. The ion extraction slit is parallel to the electron beam. In order to minimize instrumental effects the kinetic energy distribution of He^+ and D_2^+ were measured successively, with pressures adjusted to give equal ion currents at the multiplier. Experimental series were run with the repeller voltage, collimating magnetic field and pressure varied within the limits, $50-160$ V per cm, $90-320$ Gauss and $0.7-5\times10^{-6}$ torr. The fraction of the ions which undergo bimolecular collision before extraction from the source is negligible. The source temperature was measured by a thermocouple on the cage, and was found to be stable to better than ±1 degree over a run of several hours. The half width of the kinetic energy distribution curves were normalized to 450 °K.

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The kinetic energy distribution was obtained from measurement of the ion intensity I as a function of the voltage on the deflection plates U_d. In the deflection plate method [1], ions with a MAXWELLian velocity distribution give a linear plot of $\ln I$ vs. U_d^2. The constant of proportionality between U_d^2 and the ion kinetic energy $m v^2/2$ can be determined from the average kinetic energy $3kT/2$ of a gas at the measured source temperature.

For ions with a MAXWELLian velocity distribution, the average kinetic energy is $3/(2 \ln 2)$ times the kinetic energy measured at half width.

A series of measurements of the kinetic energy distribution of He^+ and D_2^+ as a function of electron energy were made. Over an extended period of time, the absolute values of the half widths varied by $1-2\%$ due to changes in the focusing conditions of the source. The ratio of the half width of He^+ divided by the half width of D_2^+ however, was reproducible to better than $\pm 0.5\%$. It was also insensitive to variations in the repeller field, pressure, and collimating magnetic field within the limits given. The average results of all the measurements are presented in Fig. 1 in terms of this ratio. The average kinetic energy of He^+ ions formed by electron impact between 60 and 300 eV is greater than the average kinetic energy of He^+ ions formed between 30 and 50 eV. There is an apparent threshold for this effect at about 60 eV. The average kinetic energy of D_2^+ ions formed between 30 and 300 eV is constant within experimental error, and equal to the average kinetic energy of He^+ ions formed between 30 and 50 eV. Using the calibration method given above, it is found that He^+ ions formed by electron impact at 80 eV have 2.7 ± 1.0 meV more average kinetic energy than those formed between 30 and 50 eV.

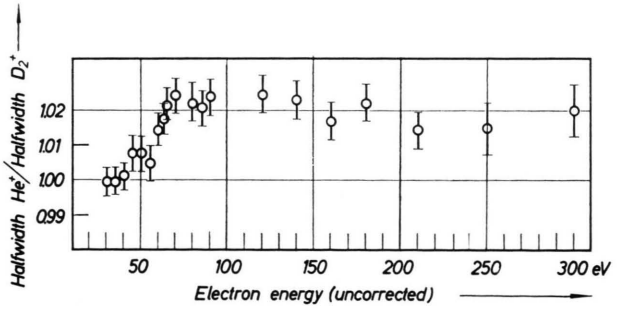

Fig. 1. The ratio of the (Half width of He)/(Half width of D_2^+) as a function of energy. The weighted averages of all the ratios are presented. The indicated uncertainties are average deviations $-\Sigma \mid \Delta v \mid / n-$ of the half widths.

It is known that there are a number of highly excited states of the He atoms in the range 58 to 64 eV [2], and it is assumed that the observed extra kinetic energy of He^+ ions formed above 60 eV is due to the excitation and the autoionization of He atoms in one or a number of these states. The lifetimes of these states are on the order of 10^{-13} sec [3], long compared to electron collision. Hence, the excitation process and the subsequent autoionization can be treated as separate two body processes. A crude qualitative model can be used to estimate the fraction of He^+ ions with extra kinetic energy needed to produce the observed broadening of the kinetic energy distribution curves.

By simple consideration of conservation of momentum, it is apparent that in a two body collision between an electron and a He atom, the transfer of 60 eV excitation energy to the He atom will also involve the transfer of 8 meV kinetic energy to the He atom in the direction of the electron beam. Because the He^+ and D_2^+ distributions are equivalent below 60 eV and the D_2^+ half width is independent of electron energy, it is assumed that other scattering phenomena can be ignored in the $He^+ - D_2^+$ comparison above 60 eV. When the highly excited He atom ionizes into He^+ and an electron, there is a nominal 35 eV excess energy to be shared between the 2 recoiling particles, as the first excited state of He^+ is at 65 eV. The electron would receive ≈ 35 eV kinetic energy, and the He^+ ion ≈ 4.2 meV. Thus, it is expected that He^+ ions formed by electron impact above 60 eV could be didived into 2 groups of ions. The first group, formed by direct ionization, would have a velocity distribution determined only by the source temperature. This would also describe the D_2^+ ions and the He^+ ions formed below 60 eV. The second group of He^+ ions would have a net velocity component in the direction of the electron flight of 6.4×10^4 cm/sec, as calculated from the 8 meV transfer of kinetic energy. This group would have a velocity distribution with a characteristic "temperature" 30 degrees higher than the source temperature because of the 4.2 meV extra kinetic energy imparted by the autoionization process. By use of this crude model, the observed broadening of the kinetic energy distribution curves can be reproduced by assuming that 5% to 15% of the He^+ ions formed in the range 60 to 300 eV have extra kinetic energy of autoionization, a surprisingly large fraction. The only theoretical calculations of the cross sections for electron impact excitation of the autoionizing states of He to our knowledge, are those given by MASSEY and MOHR [4]. At 200 eV, they find a cross section on the order of $10^{-3}\ \pi a_0^2$ for the states $(2s3p)\,^1P$, $(3s2p)\,^1P$ and $(2s2p)\,^1P$, as compared with the observed ionization cross section at 200 eV of $0.39\ \pi a_0^2$ [5].

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