Angular Distribution of Fragments from Fission of Au^{197} with Carbon Ions*

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The kinetic energy and angular distribution of fragments from fission of Au^{197} with 123- and 93-Mev carbon ions have been determined by observation of the fragments in gas scintillation and solid-state detectors. Between 20 deg and 160 deg in the center-of-mass system, both angular distributions lie slightly above a $1/\sin\theta$ curve, falling below it beyond those angles. The anisotropies $[\sigma(0°)/\sigma(90°)]$ are 4.7 and 3.8 for 123- and 93-Mev carbon ions, respectively. The most probable fragment kinetic energies in the center-of-mass system are 73±3 Mev and 71±3 Mev.

THE kinetic energy and angular distribution of fragments from fission of Au^{197} with 123- and 93-Mev C^{12} ions have been determined by observation of the fragments in gas scintillation and solid-state detectors.

The fragments entered the scintillation chamber through a $\frac{1}{4}$-in.-diam. window of 0.03-mil Ni foil supported against the vacuum by a 49%-transmission grid. The scintillating gas was argon which flowed through the chamber at 1 atmosphere. The chamber walls were coated with Tygon paint (reflector) and diphenyl stilbene (wavelength shifter). The face of the DuMont 6292 photomultiplier tube was also coated with diphenyl stilbene. Pulses from the photomultiplier tube were amplified before being analyzed by a Penco pulse-height analyzer.

The energy scale was calibrated with a Cf^{252} spontaneous-fission source. The values of the kinetic energies of the peaks of that spectrum were taken from the data of Fraser and Milton.[1] Corrections for energy loss of the fragments in passing through the window were made with the help of Fulmer's fragment range-energy data.[2]

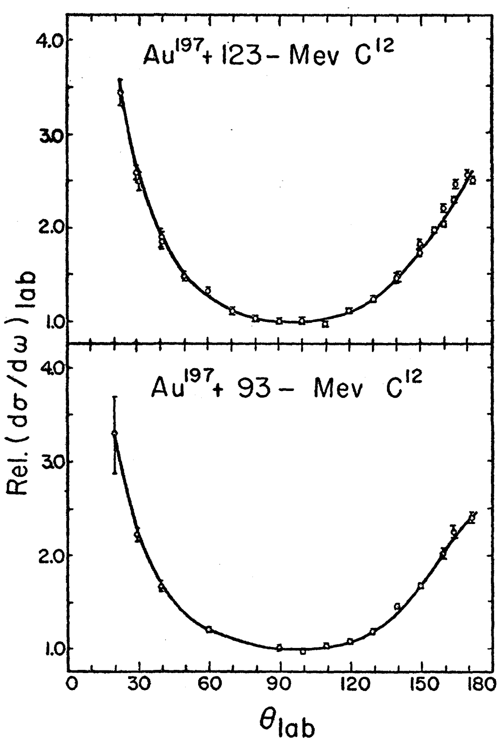

FIG. 1. Angular distribution of fission fragments in the laboratory system. Upper curve, Au^{197}+123-Mev C^{12}; lower curve, Au^{197}+93-Mev C^{12}.

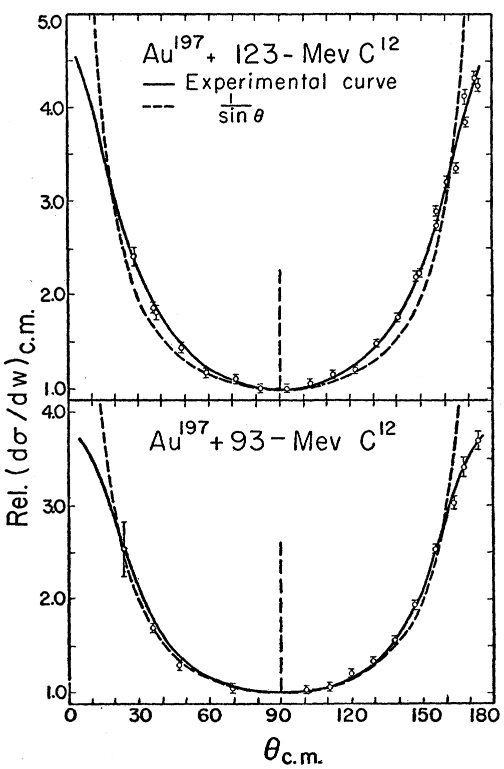

FIG. 2. Angular distribution of fission fragments in the center-of-mass system. Upper curve, Au^{197}+123-Mev C^{12}; lower curve. Au^{197}+93-Mev C^{12}.

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[1] J. S. Fraser and J. C. D. Milton, *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 1958* (United Nations, Geneva, 1958), Vol. 15, p. 216.

[2] Clyde Fulmer, Phys. Rev. **108**, 1113 (1957).

The targets were 100 to 200 $\mu g/cm^2$ of Au vaporized onto 0.1-mil Al backing foil. Corrections for energy loss in the target material were made empirically by bombarding a series of targets of various thicknesses and extrapolating the energy to zero thickness.

The solid-state detector consisted of a p-n junction produced by diffusion of n-type impurity into one face of a p-type Si wafer. Charged particles passing through the depletion layer create electrons and holes. These are collected and the pulses are amplified and recorded as described above. The junction was reverse-biased by a 9v potential. Under this condition, the edge of the depletion layer extended to $\sim 1.25\mu$ below the surface of the detector and had a total thickness of $\sim 30\mu$. The resolution and stability of the solid-state counter were much better than for the gas scintillation chamber. It should be possible to produce a solid-state detector in which the depletion layer extends to the surface.

The data were analyzed by assuming that the most probable kinetic energy represents the kinetic energy per fragment when symmetric division occurs. The plot of kinetic energy as a function of laboratory angle was fitted to calculated curves to obtain the values of the most probable kinetic energy per fragment in the center-of-mass system, and the ratio

$$\eta = v/V,$$

where v is the velocity of the compound nucleus in the direction of the beam, and V is the velocity of the fragment in the moving system.

The analysis yields η values of 0.223 ± 0.01 and 0.190 ± 0.01, and E_K(c.m.) values of 73 ± 3 Mev and 71 ± 3 Mev for 123- and 93-Mev bombardments, respectively. These η values were used to transform the laboratory angular distributions (Fig. 1) into the center-of-mass system (Fig. 2). Within experimental error, the η values represent full momentum transfer by the bombarding particle to the fissioning nucleus.

The following details of the results should be noted: (a) The center-of-mass angular distributions are symmetric about 90 deg, within experimental error. (b) Between 15 deg and 165 deg on the 123-Mev curve, the points lie somewhat above $1/\sin\theta$, in fair agreement with Griffin's predictions.[3] (c) The shape of the 93-Mev angular distribution near 0 deg and 180 deg is in better agreement with the predictions of Halpern and Strutinski[4] than with those of Griffin.

Preliminary results with 160-Mev O^{16} on Au^{197} confirm the results of Quinton, Britt, Knox, and Anderson.[5]

ACKNOWLEDGMENTS

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[3] James J. Griffin, Phys. Rev. **116**, 107 (1959).

[4] I. Halpern and V. Strutinski, *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, 1958* (United Nations, Geneva, 1958), Vol. 15, p. 408.

[5] A. R. Quinton, H. C. Britt, W. J. Knox, and C. E. Anderson, Bull. Am. Phys. Soc. **4**, 414 (1959).