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# The electrofission of $^{238}U$

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**Abstract.** A measurement using surface barrier layer detectors of the kinetic energy of fission fragments from $^{238}U$ bombarded by 70 MeV electrons was used to find the relative yield and the total kinetic energy released as a function of the ratio of the fragment masses.

## 1. Introduction

An experimental study of fission phenomena initiated by electron bombardment yields useful information about the fission process for two reasons. Firstly the interaction between electrons and nuclei is well known; secondly this interaction can easily excite collective states of the target nuclei through which fission could proceed. To date, electrofission studies have been undertaken by relatively few groups, most of these investigations concentrating on measuring fission cross sections as a function of incident electron energy. However, for a clear picture of the fission mechanism to emerge from the data, it is necessary to measure not only cross sections but also the mass and energy of the fission fragments and the total energy released by the reaction.

There are only two reported attempts to measure the kinetic energy of fission fragments produced by electrofission. In the first case Bowman *et al* (1968) used a surface barrier detector to measure fragment energies; they reported that the energy spectrum was distorted due to background radiation. In the second case Maly (1971) attempted to determine fragment kinetic energies by measuring fragment ranges in plastic foils.

The purpose of this paper is to report some preliminary measurements of the energy and mass distributions for fission fragments and total energy released from the reaction $^{238}U(e, e')f$ induced by electrons of energy 70 MeV.

## 2. Experimental procedure

The accelerator used in this study was the Linac at the Kelvin Laboratory of the University of Glasgow. The energies of fragments emitted from the reaction have been measured with surface barrier detectors to an accuracy of 1 MeV notwithstanding the radiation background. This has been made possible by careful consideration of the radiation background and the development of special configuration detectors. These detectors can be successfully used 10 cm away from a target bombarded by an electron beam of 10 mA peak current in pulses of 0·5 μs duration. Some of the fission spectra for a $^{238}U$ target recorded by these detectors for an electron beam energy of 70 MeV are given below. Figure 1 schematically illustrates the beam-handling system. The final 90°

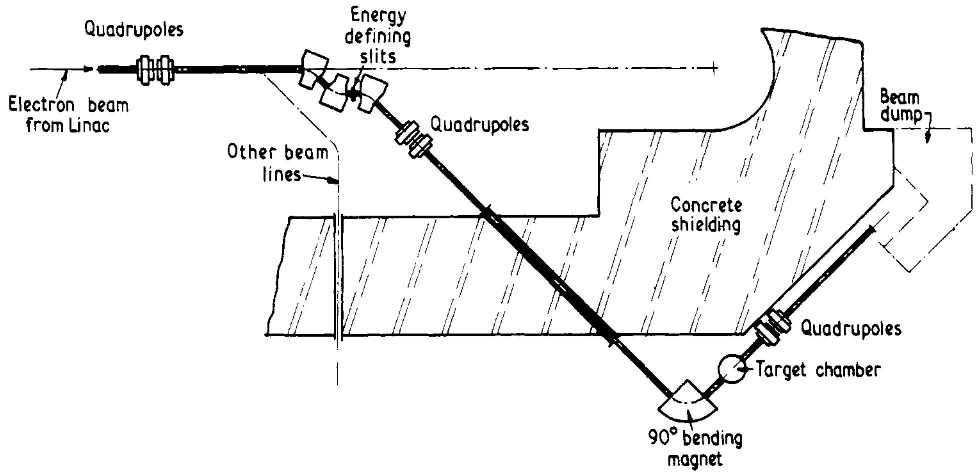


**Figure 1.** Layout of the experimental beam line.

deflection magnet before the target ensures that the electron beam is free from $\gamma$ rays. Since neutrons generated by the electron beam can give rise to fission events which would be difficult to separate from the electron-induced events being studied, the neutron flux near the target had to be determined. This was done by using uranium foils sandwiched between plastic foils. The low number of fission tracks in these foils led to the conclusion that the fission fragments recorded by the detectors were almost entirely due to electron bombardment of the target. The target consisting of 100 μg depleted $^{238}U$ deposit on 250 μg Ag backing was situated in an experimental target chamber containing two detectors each at 90° to the beam direction and on opposite sides of the target. Pulses from the counters that were in coincidence were fed into a PDP-8 computer operating in a two-dimensional mode. The detectors were calibrated by the procedure prescribed by Schmitt *et al* (1965).

## 3. Discussion

An energy spectrum of fission fragments from the uranium target is shown in figure 2. The information stored by the computer is in the form of a matrix $N(E_1, E_2)$, $E$ representing the energy of a fragment. This matrix is transformed to a form $N(E_T, M_R)$ after correcting for energy loss in the target backing. The total kinetic energy of the two fragments is $E_T$, $M_R$ is the fragment mass ratio. From this last matrix, mass and kinetic energy distributions may easily be obtained. Figure 3 shows the mass ratio histogram; figure 4 shows the total kinetic energy released as a function of mass ratio. From the data of figure 4, the average total energy released is calculated to be 161 MeV. This value is in reasonable agreement with the value calculated from the empirical relationship determined by Viola (1966). The lowering of the experimental total kinetic energy near symmetric mass division has also been observed by Wheatstone (1963) but as yet there is no fundamental explanation of the magnitude of this effect.

The mass histogram of the fission fragments in figure 3 has a maximum for a mass ratio $1{\cdot}35 \pm 0{\cdot}03$. This figure for the mass asymmetry may be compared with the value of 1·42 for fission of $^{238}U$ induced by fast neutrons, or 1·46 for fission of $^{235}U$ by thermal neutrons; in these two cases, however, the intermediate nucleus is of course different.

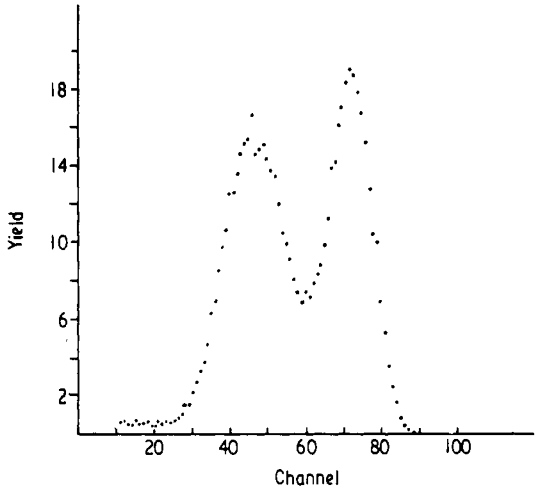


**Figure 2.** Fission spectra, recorded by one detector, from $^{238}U$ bombarded by 70 MeV electrons.

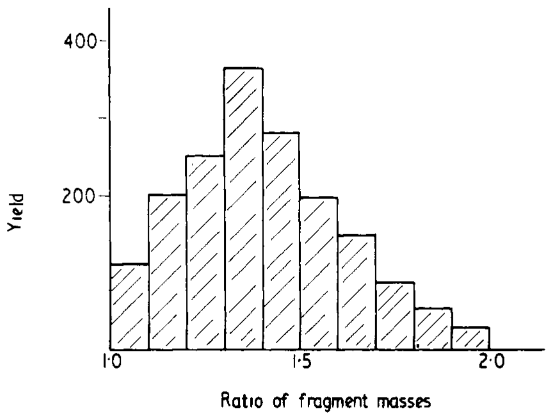


**Figure 3.** Fission mass division.

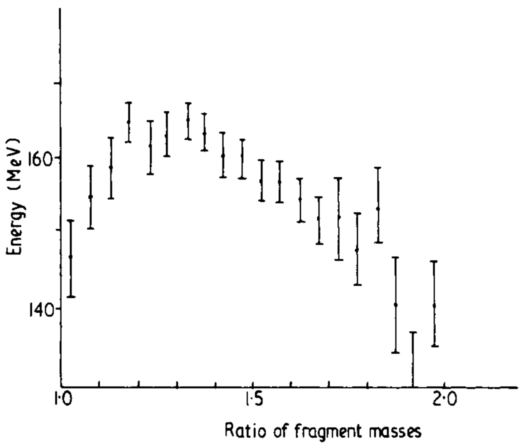


**Figure 4.** Total fragment kinetic energy released as a function of mass ratio.

The yield ratio between events for $M_R$ = 1·0 to peak value 1·35 is 0·3. The limited data near the symmetric region could introduce large errors so the actual ratio might be considerably smaller than 0·3. Figure 5 shows the mass distribution of fission fragments for fission events within a total kinetic energy window. It can be clearly seen from this figure that the fission events for symmetric division have a lower kinetic energy than those for asymmetric division.

The data we present in this paper are of sufficient quality to enable extraction of kinematic parameters associated with the fission process, which up to now has not been possible. A future experimental study of the change in these parameters with electron energy should yield information against which fission models can be tested.

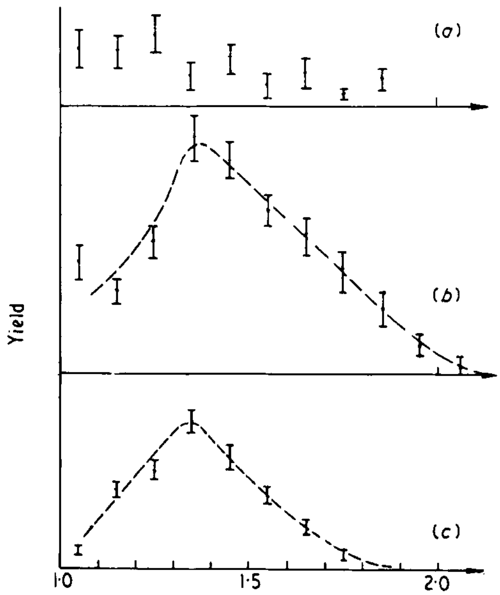


**Figure 5.** Distribution of fragment mass ratios for different total energy windows. (*a*) 120–40 MeV ; (*b*) 140–60 MeV ; (*c*) 160–80 MeV.

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