Letters to the Editor

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The Yield of Nuclei Formed by Fission

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THE recently published yield curve[1] for the nuclei formed in fission emphasizes the lack of any explanation for this striking feature of the fission phenomenon. Calculations of the potential energy associated with deformations of the liquid-drop model of the nucleus[2, 3] have met with difficulties in attempting to predict any of the details of the fission process. The purpose of this note is to point out that a physical condition is imposed on the fission process by the consideration that, since the pair of fission products are structures of known energy content, they must be formed with a definite potential energy. This condition is automatically satisfied in the liquid-drop model of the nucleus, at least to the extent that this model accounts for the masses of the nuclei, but its formulation as a quantitative physical condition independent of any theoretical interpretation of mass defects is of interest as it suggests a reason why some types of fission are more probable than others.

The curve marked E in Fig. 1 is the kinetic energy acquired by the different pairs of fission products, whose masses are plotted as abscissae. It is computed from the mass changes between uranium and the fission nuclei, using the packing-fraction curve[4] given by the writer in 1938, and allowing 22 Mev for the energy of excitation,[5] and the equivalent energy of eight extra electrons that are in the fission products when formed. E is also the potential energy at the instant of separation of the two fission nuclei. The most probable type of fission gives the masses 95 and 139, indicated by the arrows, and not two equal masses, even though this latter process would release a greater amount of energy. The curve d is the computed distance between the centers of the fission products, supposed spherical, at which the potential energy, $Z(92-Z)e^2/d$, due to Coulomb repulsion, is equal to E. The value of d comes out to be larger than the sum of the radii R_1+R_2 given by the liquid-drop theory of atomic nuclei, using the formula:[6] $R=r_0A^{\frac{1}{3}}$, with $r_0=1.48\times10^{-13}$ cm. Even smaller values for r_0 have been proposed.[7] The sum of the radii of the two fission products, calculated from this formula, is given by the broken line at the bottom of Fig. 1. There appears to be a difficulty, analogous to the paradox met with in alpha-ray emission, in that the fission particles must have no kinetic energy at a distance between centers (d), greater than the sum of their radii. It may, however, be possible to increase the theoretical values of the radii enough to make the lower curve cut across the curve d.

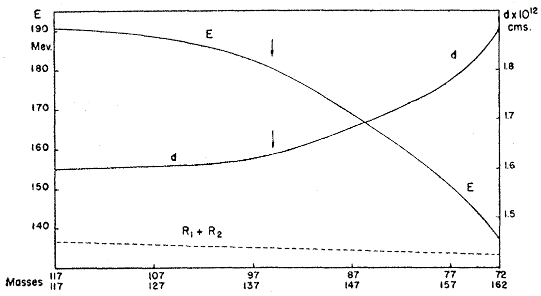

FIG. 1. Curve E gives the kinetic energy of fission products, or the potential energy at separation. Curve d gives the separation of centers of spherical fission products that would account for E. R_1+R_2 gives the theoretical sum of the radii of the fission products.

The curves, however, suggest possible reasons for the different fission yields. For the case of large differences in the masses, d must be large and E small, and only an unusual manner of separation would give the small potential energy permitted. With the fission masses 95 and 139, a normal separation can be considered as leaving the products with the required potential energy. In the case of even division, on the other hand, only unusual separation processes would be able to provide the large potential energy in the fission products required by the curve E.

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[1] The Plutonium Project, Rev. Mod. Phys. **18**, 539 (1946).
[2] R. D. Present, F. Reines, and J. K. Knipp, Phys. Rev. **70**, 557 (1946).
[3] N. Bohr and J. A. Wheeler, Phys. Rev. **56**, 426 (1939).
[4] A. J. Dempster, Phys. Rev. **53**, 870 (1938).
[5] K. Way and E. Wigner, Phys. Rev. **70**, 116 (1946).
[6] H. A. Bethe and R. F. Bacher, Rev. Mod. Phys. **8**, 97 (1936).
[7] E. Feenberg, Phys. Rev. **55**, 504 (1937).

Geiger-Mueller Counter Detection of Light Radiation from the Paths of High Energy Particles

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DETECTION of Čerenkov radiation has been attempted by use of photographic methods[1] and photomultipliers.[2] Furry[3] recently pointed out the possible value of Geiger-Mueller counter tubes of high light sensitivity to cosmic-ray studies.

An experiment was designed in an attempt to detect Čerenkov radiation accompanying the passage of cosmic-ray particles and of radiation from a natural radioactive source by means of light-sensitive Geiger-Mueller counters.

The counters used had been developed in connection with other work[4] and had their spectral response in the ultraviolet, between 2000A and 3000A. They consisted of a cathode cylinder of wire screen of 50 percent coverage, covered with a 0.005-in. thick layer of electroplated gold, and contained in a Corning 9741 glass envelope capable of