by neutrons diffracted into the detector by the scatterers; its greatest value is about 3 percent. The results are given in Table I.

If these cross sections are expressed in terms of a collision radius R, were $\sigma=2\pi R^2$, and plotted against $A^{\frac{1}{3}}$ as done by Sherr,[3] it is seen that the values from Li to U lie on a nearly smooth curve, and are all below Sherr's line $[R=(1.7+1.22A^{\frac{1}{3}})\times10^{-13}$ cm$]$ for 25-Mev neutrons. The difference becomes less for the heavier nuclei, as if the values are tending to approach a line near his. One possible interpretation is to say that the lighter nuclei are partially transparent, and approach opacity with increasing A. Dr. Serber has shown[4] that such an interpretation is well justified. An empirical formula that fits the data from Li to U very well is: $R=(0.5+1.37A^{\frac{1}{3}})[1-\exp(-0.49A^{\frac{1}{3}})]\times10^{-13}$ cm. This formula is not intended to have any theoretical significance, but may be useful for purposes of interpolation. From Li to O, the cross sections are nearly proportional to A. A complete account of this work will be published later.

This paper is based on work performed under Contract No. W-7405-eng-48, with the Atomic Energy Commission in connection with the Radiation Laboratory, University of California, Berkeley, California.

[1] A. C. Helmholz, E. M. McMillan, and D. C. Sewell, Phys. Rev. **72**, 1003 (1947).
[2] R. Serber, Phys. Rev. **72**, 1007 (1947).
[3] R. Sherr, Phys. Rev. **68**, 240 (1945).
[4] R. Serber, Phys. Rev. **72**, 1114 (1947).

The Uncertainty Principle and the Yield of Nuclei Formed in Fission

P. F. Gast
The General Electric Company, Hanford Engineer Works, Richland, Washington
September 29, 1947

A RECENT letter by Dempster[1] discussed the yield curve[2] for the nuclei formed in fission from the standpoint of the liquid-drop model. As an alternative, the hypothesis is here advanced that the yield curve is related to the Heisenberg uncertainty principle in much the same ways as the line breadth of atomic spectra.[3]

Just before the moment of separation of the two fragment nuclei, produced by the fission process, nucleons may be pictured as passing through the area of contact caused by the "thermal" agitation of the particles forming the nucleus. The quantum-mechanical waves associated with these particles have an extent comparable with that of the nuclei themselves, and thus the time for a wave to pass the contact surface will be Bethe's[4] "characteristic nuclear time," 3×10^{-22} sec. The uncertainty in the time of final break between the fragments must be of a comparable magnitude.

From the width of the yield curve at half-maximum and Dempster's curve connecting the masses of the fragments with the energy a value, $\Delta E\approx18$ Mev, is obtained for the uncertainty in the energy. The use of the relation

$$\Delta E\Delta t\approx h/2\pi$$

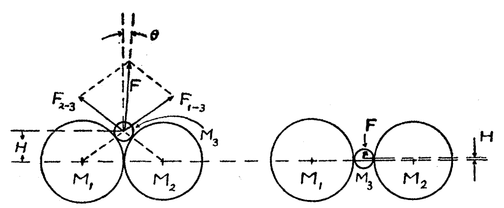

FIG. 1. Curve A gives the experimentally observed fission yields on a logarithmic scale. Curve B is calculated assuming cores of 60- and 16-mass units for the heavy and light fragments, respectively. Curve C gives the calculated yields when all nucleons have equal probability of being in either fragment.

then gives $\Delta t\approx3.6\times10^{-22}$ sec., in reasonably good agreement with the value postulated above.

This suggests the possibility that some of the nucleons, at least, have wave functions giving them an appreciable probability of being in either fragment at the time of fission, and that the yield curve is the net result of the various probabilities for the nucleons involved. The yield curve itself gives a clue as to the number of nucleons involved. Since the difference between the two maxima of the curve is 44 mass units, we assume "cores" for the two fragments differing by that amount, taking for the heavy fragment a core of mass number 60 (the nucleus having the largest known negative packing fraction[5]) and for the light fragment mass number 16. The remaining 158 nucleons are assumed to have equal probability of being in either fragment. Figure 1 shows a curve calculated from the well-known theory of combinations and based on the above assumptions along with the observed curve. The calculated curve gives a value of 6.3 percent at the maxima and underestimates the yield near the maxima while overestimating it in more remote regions. This may arise because neutrons and protons are not distinguished in the calculation. The curve which would be obtained when all nucleons have equal probability of being in either fragment is also shown for comparison.

[1] A. J. Dempster, Phys. Rev. **72**, 431 (1947).
[2] The Plutonium Project, Rev. Mod. Phys. **18**, 539 (1946).
[3] W. Heitler, *The Quantum Theory of Radiation* (Clarendon Press, Oxford, 1936), p. 113.
[4] H. A. Bethe, Rev. Mod. Phys. **9**, 72 (1937).
[5] J. Mattauch, *Nuclear Physics Tables* (Interscience Publishers, Inc., New York, 1946), p. 113.

Microwave Spectrum Frequency Markers*

Robert L. Carter and William V. Smith
Department of Physics, Duke University, Durham, North Carolina
November 8, 1947

MEASUREMENT of the separation of the satellites of NH_3 microwave spectrum lines exhibiting quadrupole splitting has been reported by Strandberg and others,[1] and subsequently by Watts and Williams.[2] In their experiments the microwave oscillator was frequency modulated by the application of a variable intermediate frequency component of known frequency to the reflector voltage. This caused the microwave oscillator simul-