January 16, 1944

Remarks on Nuclear Fission

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1. General character of fission yield curves derived from formula:

\[ \sigma_F = \sigma_0 \left[ \frac{\Gamma_F}{(\Gamma_R + \Gamma_N + \Gamma_F)} \right] \]

Characteristic dependence of \( \Gamma_R, \Gamma_N \) and \( \Gamma_F \) indicated in Figure 1.

Assuming a simple course of curve for \( \sigma_F \) as indicated in Figure 2 one obtains curves for \( \sigma_F \) of the types illustrated on same figure.

Curve \( \sigma_F^{(1)} \) would correspond to neutron fission of \( \text{25} \). Whether peculiar dip in \( \sigma_F^{(25)} \) is primarily due to competition between neutron escape and fission or whether it may be partly due to some marked minimum of \( \sigma_F \) in this region can of course not be decided apriori; but it is interesting that a curve for \( \sigma_F \) of the type assumed in a qualitative way explains not only the experimental curve for \( \sigma_F^{(25)} \) but also for \( \sigma_F^{(49)} \). In the latter case the observation that \( \sigma_F \) in the region (0.1 Mev < \( E_N < 0.5 \) Mev) is closely proportional to \( 1/v \) might in fact be the combined result of the gradual decrease of the \( \sigma_F \) curve and the competition between \( \Gamma_F \) and \( \Gamma_N \) which in this region is rapidly increasing. The observed flat part of the \( \sigma_F^{(25)} \) curve for high energies should thus correspond to the later more parallel course of the curves for \( \Gamma_F \) and \( \Gamma_N \).

While \( \sigma_F^{(28)} \) qualitatively corresponds to \( \sigma_F^{(28)} \) it is obviously necessary to discuss the curves for \( \Gamma_F \) and \( \Gamma_N \) in somewhat more detail in order to explain the observed peculiar differences between \( \sigma_F^{(25)} \) and \( \sigma_F^{(28)} \) indicated by the dotted lines in Figure 3. It is here assumed that the \( \Gamma_N \)
curve has some characteristic irregularities due to the successive appearance of levels for inelastic scattering. The \( \Gamma_F^{28} \) and \( \Gamma_F^{02} \) are assumed apart from a displacement of 0.2 Mev to be essentially similar since the short lifetime of the transition state will have the effect almost entirely to efface any specific level structure.

2. **Estimate of critical fission energy** \( F \) and neutron binding energy \( W \).

On the assumption that

\[
F = f(Z^2/A)
\]

we may in the comparatively small region of \( Z^2/A \) concerned write

\[
F = a - b(Z^2/A)
\]

A new possibility of estimating \( a \) and \( b \) is given by the measurements of the threshold for photo-fission. Taking \( F = 5.7 \text{ Mev} \) for \( 28 \) and \( F = 6.1 \text{ Mev} \) for \( 02 \) one gets

\[
F = -0.52(Z - 92) + 0.1(A - 238)
\]

The values derived from this interpolation formula are given in the second column of the Table on page 3 where the numbers in the first column refer to the values of \( Z \) and \( A \) of the compound system. In the third column are given the values for \( F - W \) which in the case of the first 3 first isotopes are roughly estimated by comparison with the curves on Figure 1 and 2. The resultant values of \( W \) given in the fourth column would seem quite reasonable. In particular the difference in \( W \) for nuclei of even and odd values of \( A - Z \) is of the order of magnitude to be expected from general evidence as regards the radioactive properties of such nuclei.
3. Comparison between level spectra of 28 and 25 at low energies.

The discussion is based on the dispersion formulae

\[ \sigma_R = \pi \lambda^2 \frac{\Gamma_N \Gamma_R}{(E - E_0)^2 + (\Gamma/2)^2}, \quad \sigma_F = \pi \lambda^2 \frac{\Gamma_N \Gamma_F}{(E - E_0)^2 + (\Gamma/2)^2} \]

Since in 28 we have \( \Gamma_F = 0 \) and \( \Gamma_N \ll \Gamma_R \), the width of the lines will be determined by \( \Gamma_R \) and since in 25, \( \Gamma_F > \Gamma_R \) the width will in this case be determined by \( \Gamma_F \). For both cases we have, therefore,

\[ B = \int \sigma dE = 4 \pi \lambda^2 \Gamma_N \sim 1/v \]

From the curve for \( \sigma_F^{25} \) in Fig. 4 one finds that \( Bv \) for the levels below 10 ev is almost 100 times smaller than for the wellknown level at 7 ev in 28. Assuming that, as indicated in Fig. 4, the spectrum in 25 consists of both weak and strong lines with a different level spacing, the latter levels are found to have values of \( Bv \) comparable with the 28 line.

A suggested explanation of the appearance of the two level systems
is schematically represented in Fig. 5 in which is also indicated a possible explanation of the remarkable increase in \( \gamma_{25} \) in the region below 100,000 ev, where the neutrons may be able to give angular momentum to the nucleus with the result that the difficulty in forming levels of the compound state with spin S-1 may disappear. This suggestion has given rise to discussions about impact of neutrons with \( l \neq 0 \) which have not yet been concluded and which are hoped to show whether the suggested peculiar increase in \( \Gamma_{1} \) within the S-1 level system actually does take place.