the displacement of the K ions is thus $\langle s^2\rangle_{Av}+\langle t^2\rangle_{Av}$, the corresponding quantity for Cl and Br ions is only $\langle t^2\rangle_{Av}$.

The indicated microdeformation is of essential importance. A mixed crystal (AB+AC) may be characterized by a certain degree of order. Let the nearest neighbors of the B and C atoms be A atoms. Should an exchange of B and C not cause any displacement of the neighboring A atoms, these A atoms would completely conceal such an exchange from the surroundings. Thereby every correlation between the location of the different B and C atoms in the lattice would disappear. If, on the contrary, a displacement of the surrounding A atoms takes place in consequence of the different "sizes" of the B and C atoms, such a microdeformation would, in the neighborhood of the point under consideration, automatically increase the probability of an exchange contrary to that which has already taken place, thereby provoking a higher or lower degree of order.

Want of knowledge concerning the microdeformation can certainly to some extent be compensated by general assumptions, which implicitly make allowance for the effect of the actual displacements of the atoms. It seems likely however, that such a microdeformation forms the physical background for various assumptions regarding lattice energies, probabilities and ordering forces, which in different papers have been used as the basis for various theories of solid solutions.

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On the Splitting of Heavy Nuclei by Slow Neutrons*

A theory of the disintegrations produced in U and other heavy nuclei by neutron capture by Hahn[1] has been developed by using the "drop" model of the nucleus. According to this model the energy of a heavy nucleus may be considered as due to a *surface energy* $U=\delta A^{\frac{2}{3}}$ ($\delta\sim 9.6$ Mev) and a *volume energy* $E=3(Ze)^2/5r=\epsilon Z^2A^{-\frac{1}{3}}$ because of the Coulomb repulsion of the protons. The radius of the nucleus is related to the value of A by the approximate empirical formula $r\approx 1.4\times 10^{-13}$ cm.

The mutual repulsion between the protons tends to disrupt the nucleus, and this can occur spontaneously as soon as the corresponding increase in the surface energy becomes smaller than the resulting decrease in the electrical volume energy.[2] If the nucleus breaks up into two nuclei corresponding to the values (Z_1, A_1) and (Z_2, A_2), the energy change is

$$\Delta W=E\left[1-\left(\frac{Z_1}{Z}\right)^2\left(\frac{A}{A_1}\right)^{\frac{1}{3}}-\left(\frac{Z_2}{Z}\right)^2\left(\frac{A}{A_2}\right)^{\frac{1}{3}}-\frac{5}{3}\frac{Z_1Z_2}{Z^2}\frac{A^{\frac{1}{3}}}{A_1^{\frac{1}{3}}+A_2^{\frac{1}{3}}}\right]-U\left[\frac{A_1^{\frac{2}{3}}+A_2^{\frac{2}{3}}-A^{\frac{2}{3}}}{A^{\frac{2}{3}}}\right],$$

where the last term in the first bracket represents the Coulomb repulsion of the two resulting nuclei at the separation $r=r_1+r_2$, while $Z=Z_1+Z_2$, $A=A_1+A_2$.

The condition for instability is $\Delta W+\Delta W_1\geqslant 0$ where ΔW_1 is the excitation energy of the nucleus due to the capture of the neutron ($\Delta W_1\approx 8$ Mev). If we omit ΔW_1 and set $Z_1=Z_2=\frac{1}{2}Z$ and $A_1=A_2=\frac{1}{2}A$, for which ΔW has a maximum value, we find $E/U\geqslant 2.17$ as the criterion for instability.

This approximate criterion can also be derived by assuming that in the initial stages of the deviation from the spherical form, the nucleus assumes the form of an ellipsoid or an oblate spheroid. It seems possible that if the ratio E/U is not too large, a stable nonspherical form may be assumed, which proceeds to disrupt into two separate nuclei on increase of this ratio, but a complete proof of this supposition has not been found. The spheroidal and ellipsoidal forms do not appear satisfactory in this respect. If this view should prove correct, the electrical quadrupole moments of the heavier nuclei should be abnormally large.

A theory can also be given of the oscillations which may be set up in the nucleus in the form of surface waves. Such oscillations have been discussed by Bohr on the assumption that they are determined by the surface energy alone, but it is found that actually the electrical volume energy also has an important effect on their behavior. We find for the changes in energy due to the fundamental oscillation

$$\Delta U=2U_0\beta;\quad \Delta E=-E_0\beta,$$

where β is a constant, and U_0, E_0 are the surface and volume energies of the undistorted (spherical) nucleus. Again we find for the criterion of instability $E_0/U_0\geqslant 2$. Instability in the higher types of oscillation requires higher values of this ratio.

This suggests the following three different ways of viewing the explosive rupture process.

(1) The impinging neutron excites the fundamental mode of oscillation of the nucleus, which may be unstable if the ratio E_0/U_0 is sufficiently large, and the nucleus, having started to expand in some direction, may continue to do so until it has completely separated into two nuclei. From this point of view the process is purely "classical," either not occurring at all, or taking place immediately after the capture of the neutron.

(2) A somewhat different possibility consists in assuming the existence of an "activation energy" preventing the immediate rupture even when possible from the energy balance. Rupture would then be impossible on classical theory, but might occur by a quantum-mechanical "tunnel-effect."

(3) If the mean life of the excited nucleus with respect to explosive rupture is large compared with the "relaxation-time" during which the excitation energy is distributed over the different degrees of freedom of the nucleus, then the surface energy might decrease with the excitation energy. Such a decrease might lead to explosive rupture in the absence of an excitation energy.

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* A more complete exposition of the theory will be published in the new journal "Annales Physical, etc." (Russian). The theory was practically completed before the considerations of Bohr were known to the author. (The present letter is an abstract of the manuscript, made at the author's request by E. Hill.)

[1] O. Hahn and F. Strassmann, Naturwiss. **27**, 11 (1939); L. Meitner and O. R. Frisch, Nature **143**, 471 (1939); N. Bohr, Phys. Rev. **55**, 419 (1939).

[2] Similar considerations have been advanced by E. Feenberg, Phys. Rev. **55**, 504 (1939). (Note added by E. H.)