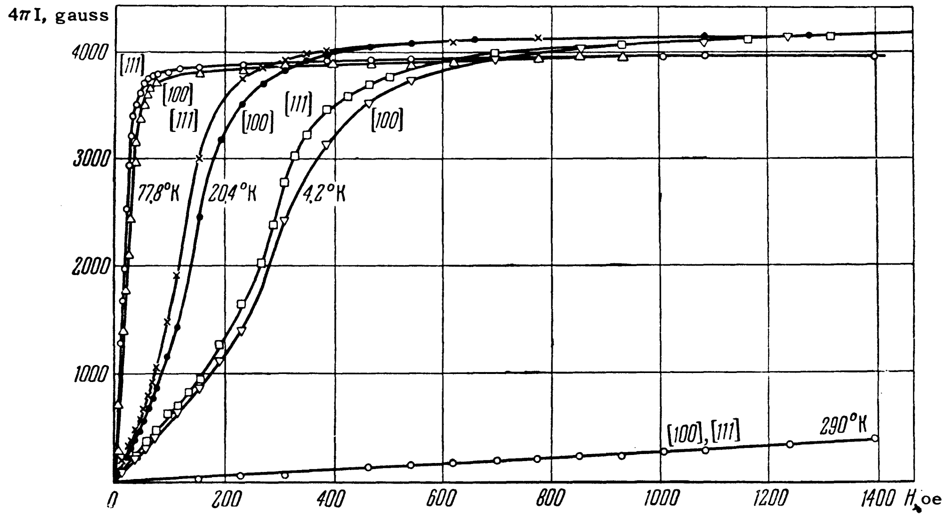

crease significantly on changing the temperature from 20.4 to 4.2°K, the curves for the easy and difficult directions at 4.2°K lie considerably below the curves at 20.4°K and magnetic saturation requires large fields.

It should be remarked that the saturation fields at all temperatures are much smaller than the saturation fields obtained earlier[1,2] in polycrystalline specimens. Measurements of the coercive force H_c show that at nitrogen temperature for all crystallographic directions it is fractions of an oersted, but at hydrogen temperature it is of the order of oersteds. This data differs greatly from the data obtained on polycrystalline specimens in which we obtained for H_c more than a hundred oersted at nitrogen temperature and a thousand oersted at hydrogen temperature. The main explanation for this probably resides in the fact that, because various types of structural distortions are present, polycrystalline specimens are much harder magnetically than single-crystal specimens of the same material.

An analysis of the results obtained shows that the increase of saturation field with decreasing temperature — even for the easy direction of magnetization (see curves for the [111] axis at 77.8, 20.4, and 4.2°K) — cannot be due to an increase in the magnetic anisotropy when the ferromagnetic alloy studied is cooled to a low temperature. A more reasonable assumption is that, at temperatures below nitrogen in the disordered alloy Ni_3Mn, a transition is possible from a ferromagnetic to an antiferromagnetic state with comparatively low critical fields ($\leq 10^3$ oe) at which magnetic saturation is attained (parallel magnetizations of the magnetic sublattices).

From what has been said follows the necessity for neutron diffraction studies and detailed measurements of the temperature dependence of the magnetic anisotropy constant, in order to resolve definitely the unusual magnetic properties of Ni_3Mn alloys in the disordered state at low temperatures.

The authors are grateful to Dr. R. Bozorth and Dr. K. Williams for kindly providing the single crystal for the investigation.

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ASYMMETRY OF URANIUM FISSION AT HIGH PROTON ENERGIES

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AT low bombarding-particle energies, the fission of uranium is mostly asymmetrical. The mass curve of the fission product yield has two maxima with a deep trough between them. As the particle energy increases, the contribution of symmetrical fissions increases and at a certain energy the curve becomes a single-hump one (see, for example, the survey article by Lavrukhina[1]). At the same time, a certain broadening of the mass curve takes place.[1-3] When uranium is bombarded with 660-Mev protons, a relative increase is observed in the number of fission events which are asymmetrical in range with increasing nuclear excitation energy.[4]

We have investigated the asymmetry of the ranges of fission fragments of uranium in P-9 (ch) nuclear emulsions at proton energies of 460 and 660 Mev. The asymmetry in the ranges of the fission fragments corresponds in general to the asymmetry in the masses.

Figure 1 shows the distribution of fission events as a function of the ratio of the ranges of the light and heavy fragments. The figure shows also the corresponding distribution for the case of fission of U^{235} by thermal neutrons.[4] A comparison of the distributions shows that as the proton energy is increased from 460 to 660 Mev, the fissions that are strongly asymmetrical in range make a relatively larger contribution.

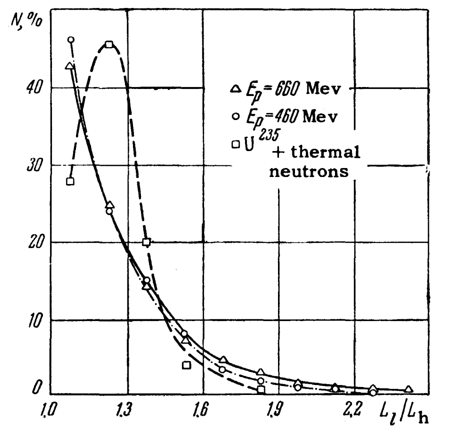

FIG. 1

According to the liquid-drop model, the lowest barrier for uranium fission is possessed by the symmetrical form of fission.[5] Calculations based on this model give a difference of ~ 6 Mev in the value of the energy of deformation for the asymmetrical uranium fission (with dimensional asymmetry of 1.5) and the symmetrical form.[6] If $\Delta E = E_a - E_s$ is the difference in the activation energies for the asymmetrical and symmetrical forms of fission, then, according to statistical theory, the ratio of their probabilities is

$$W = \sigma_s/\sigma_a \sim \exp(\Delta E/T), \quad (1)$$

where T is the temperature of the nucleus.

As the temperature of the nucleus increases, the relative contribution of fissions which are asymmetrical in mass will increase at $\Delta E > 0$, in accordance with (1). We employ this expression to explain the increase in the contribution of the product of asymmetrical (A = 67) and approximately symmetrical (A = 115) disintegrations in the bombardment of uranium by protons of 70 — 340 Mev.[7] We assume that these are all the fission products prior to the evaporation of the nucleons, since the yields of these products are vanishingly small at low excitation energies. We use as the nuclear fission temperature the temperature corresponding to average excitation energy of the nuclei. The average excitation energy was calculated on the basis of the laws of conservation of energy and momentum and the assumption that the momentum of the cascade particles is carried away by a single particle in the direction of the incident protons. The values of the front component of the nuclear momentum necessary for this purpose were determined by interpolating the known experimental values at certain proton energies. According to (1), log W should depend linearly on 1/T at ΔE = const. Figure 2 shows the experimental values of σ_{115}/σ_{67} vs. 1/T in a semilogarithmic scale.

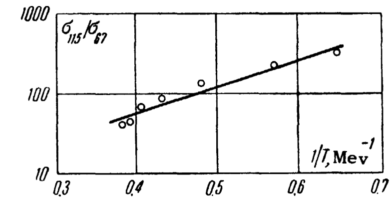

FIG. 2

It was assumed that $T = 2.92\sqrt{U/A}$, where U is the excitation energy and A the mass number of the fissioning nucleus. If a straight line is drawn through the points, the slope of the line determines the difference in the activation energies. For the selected products, $\Delta E \approx 8$ Mev. As the excitation energy is increased, this fission asymmetry will correspond to products with lower mass numbers. If A = 67 and 115 is invariably used for the fission products at the given asymmetry, this analysis will lead to approximately double the value of ΔE. Consequently, and also in view of the roughness with which the nuclear temperature has been determined for symmetrical and asymmetrical fissions from the average excitation energy and in view of the possible contribution due to fission after emission of a certain number of nucleons, the value given for ΔE is only tentative.

At high particle energies the mass curve is a result of superposition of fission products of uranium nuclei before and after evaporation of the nucleons. The fission asymmetry of nuclei with small excitation energy is determined by the influence of certain factors, among which the shell effect can play a large role. At large excitation energy the influence of these factors apparently does not manifest itself during the instant of fission. If it is assumed that fission asymmetry of such nuclei is determined by Eq. (1), so that the most probable is symmetrical fission, and that the relative contribution of the asymmetrical form of fission increases with increasing excitation energy, then the change in shape of the mass curve of the fission products of uranium with increasing particle energy becomes understandable. Fairhall et al.[8] have shown that nuclear fission near bismuth at excitation energies up to ~ 40 Mev occurs prior to neutron evaporation. The increase in the fraction of asymmetrical fission with increasing temperature, in accordance with (1), agrees qualitatively with the observed broadening of the mass curves of the fission products of bismuth with increasing excitation energy.[4,9] The broadening of the mass curve of the fission products with increasing atomic number of the target, found in bombardment by 450-Mev protons,[10] may be, in particular, the rèsult of the increase in the average excitation energy with increasing atomic number of the target.

Among the experiments performed up to now on the fission of nuclei, two groups can be segregated. In accordance with the experiments of the first group, the fission of nuclei near uranium competes successfully with the evaporation of neutrons over a broad range of excitation energies.[11,12] The investigations of the second group[13] are evidence that the fission of uranium bombarded with high energy protons occurs essentially after the excitation energy has been removed by nucleon evaporation. The "cold" nucleus can have a large angular momentum. Consequently, and also as a result of the change in the composition of the nucleons, the fission characteristics of such a nucleus, including the asymmetry, may differ from the characteristics of nuclear fission in the case of small particle energies.

In conclusion, the author expresses his gratitude to Prof. N. A. Perfilov for interest in this work.

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ON THE CROSS SECTION FOR COMPOUND NUCLEUS FORMATION IN THE INTERACTION OF ATOMIC NUCLEI

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THE available data[1] on the nuclear reactions induced by multiply charged ions indicate that one of the basic processes in these reactions is the formation of a compound nucleus with high energy of excitation and its subsequent decay.

The cross section for compound nucleus formation, $\sigma(E)$, can be calculated on the basis of a model in which the colliding nuclei have a sharp