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STUDIES OF NUCLEAR REACTIONS

Progress Report

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The research carried out under the auspices of Contract No. E(11-1)-3122 from Sept. 1, 1975 to the present is reported in Section I. A bibliography of reports and publications is presented in Section II.

I. REVIEW OF WORK DURING THE PAST CONTRACT YEAR

The work that is to be described here, except for the final analysis of the data in the ^{32}S + In system, was all carried out at the Lawrence Berkeley Laboratory SuperHILAC. Unfortunately, because of limitations on operating time resulting from fiscal constraints, as well as reconstruction of the experimental area at the SuperHILAC, we were able to carry out only four runs: two in August 1975 and two in January 1976. The work was variously carried out by Mr. G. Catchen; Drs. D. Benson (100% of time until Feb. 1976), L. Kowalski (20% of time), D. Logan (100% of time), and N. N. Lu (100% of time); and Professor J. Miller (50% of time during academic year). In addition, the investigations are carried out in collaboration with Dr. T. Debiak and Professor John Alexander of SUNY Stony Brook.

A) Complete-Fusion Cross Section in the Reacting System of 336-MeV ^{32}S + In

It was reported in the Progress Report for 1974-1975 that the cross section for the formation of evaporation residues in the reactions of 336-MeV ^{32}S with In is 530 ± 150mb after correction is made for the contribution to heavy residues from transfer reactions. This result corresponds to a sharp-cutoff critical angular momentum for the formation of evaporation residues of (72 ± 9) ħ. Contrary to previous measurements in another laboratory, this value is significantly below the angular momentum (84ħ) at which the fission barrier is expected to vanish.

An estimate of the fission cross section in this system from the experimental data yields the result of 330 ± 210 mb. The sum of the cross sections for evaporation residues and for fission, which should be a measure of the cross section for complete fusion is 860 ± 260 mb. This corresponds to a sharp-cutoff angular momentum of (92 ± 14)ħ, a value which is not seriously inconsitent with the 84ħ mentioned above. Thus, contrary to the indication from previous investigations of similar systems, there is no strong indication of complete fusion from entrance channels where the fission barrier is expected to vanish.

B) The Emission of Light Charged Particles in the Reactions of 720-MeV ^{86}Kr with Au

Energy spectra at several angles of the ^{1}H, ^{2}H, ^{3}H, ^{3}He, and ^{4}He emitted in the reactions of 720-MeV Kr with Au and, less completely, Ni have been measured during two 6-shift runs in the period August 1975 through April 1976. The experimental results for the Au targets are appended to this report.

The energy and angular distributions of the light particles from the reactions with Au are, on the whole, consistent with the hypothesis that they are emitted in the equilibrium de-excitation of the excited transfer products formed in these reactions. The consequences of this hypothesis were investigated by means of a Monte Carlo calculation in which the input data included: the energy and angular distributions of the transfer products in the Kr + Pb reactions as reported by Vandenbosch; energy spectra in the equilibrium emission of light particles from Kr-like and Au-like excited transfer products as estimated from a combination of well-known theory and experimental results for excited nuclides similar to those under study. The probability that a given type of light particle is emitted from each of the transfer products was available as a normalization factor which was easily evaluated because the kinematics of the transfer reactions are such that essentially all of the light particles that are observed at angles greater than about 130° in the laboratory frame must have been emitted from Au-like transfer product. Preliminary results yield average probabilities of 0.15, 0.03, 0.02, and 0.23 for the emissions of ^{1}H, ^{2}H, ^{3}H, and ^{4}He from the Au-like transfer product and corresponding values of 0.15, 0.03, 0,02, and 0.11 for the Kr-like product. These probabilities are being used in a preliminary attempt to estimate the average spin of the transfer products.

C) Non-Equilibrium Fission

It has long been known that heavy-ion induced fission occurs from entrance channels with angular momenta avove which the fission barrier in the corresponding compound nucleus, if formed, would vanish. While the mass and kinetic-energy distributions of the fission products from these entrance channels exhibit no obvious abnormalities, the question still remains as to whether the reactions proceed through the formation of a compound nucleus or if there is a non-equilibrium "fast fission" involved. One approach to this problem is through the angular distribution of the fission products: a fast process might well cause the angular distribution of particular fission products no longer to exhibit the symmetry about 90° in the center-of-mass system as is expected for a compound-nuclear process. To that end, measurements have been made of the energy and angular distribution of the fission products resulting from the reactions of 380-Mev Ar with Au. Results to date do not show any obvious asymmetries in the angular distributions.

II. REPORTS AND PUBLICATIONS

Reactions of 336-MeV ^{32}S with In.

N. Lu, D. Logan, J. Miller, T. Debiak, and L. Kowalski; Phys. Rev. C13, 1496 (1976)

Emission of H and He in the Reactions of 725-MeV ^{86}Kr with Au.

D. Benson, G. Catchen, L. Kowalski, D. Logan, N. Lu, J. Miller, U. Singh, J. Alexander, T. Debiak, and M. Guidry. To be submitted to Phys. Rev. Letters.