$^{165}$Ho Fast Neutron Cross Sections*

J. MEADOWS, A. SMITH and J. WHALEN
Argonne National Laboratory, Argonne, Illinois

T. D. BEYNON
University of Birmingham, Birmingham, England

Received November 20, 1970

Total neutron cross sections of $^{165}$Ho were measured from 0.1 to 1.5 MeV with resolutions of $\approx 2.5$ keV. The observed total cross sections varied slowly with energy and displayed no significant structure. Differential neutron elastic and inelastic scattering cross sections were determined at intervals of $\approx 50$ keV from 0.3 to 1.5 MeV. The inelastic excitation of states in $^{165}$Ho at; 98, 214, 371, 460, 517, 586, 712, 824, 995, 1104 and 1143 keV was positively observed with probably identification of several additional states. The observed excited structure and the respective cross sections were correlated with known single-particle and collective states and with excited structure postulated from systematics. The measured cross sections were compared with calculated values based upon spherical and deformed optical-potentials, and compound-nuclear processes. Total cross sections were best described by a spherical potential while the differential elastic angular distributions were better represented by deformed-potential calculations. Resonance interference effects were found small and, at the energies of the present experiments, the contribution of direct processes was not large.

1. Introductory Remark

It was the objective to study by means of experiment and calculation the fast neutron cross section of the heavy, odd-Z and deformed nucleus $^{165}$Ho. These cross sections were not well known. Total cross sections have been determined at energies below 1.5 MeV and in more detail at higher energies$^1-7$. At a few energies spin-spin interactions have been

* This work supported by the U.S. Atomic Energy Commission.
1 Stupegia, D.: Private communication.
4 Langsdorf, A.: Private communication.
studied using aligned targets. Isolated measurements of scattering angular distributions have been reported but not with a good resolution of elastic and inelastic components. Generally, no internally consistent set of total and partial scattering cross sections of $^{165}$Ho existed over a wide enough energy range for a comprehensive comparison with calculation. The effect of deformation had not been quantitatively defined in the context of appropriate nuclear models nor had the interplay between direct- and compound-nuclear reactions been well delineated.

Radioactive decay and coulomb excitation studies have provided knowledge of the excited structure of $^{165}$Ho. At relatively low excitations this structure is characterized by single-particle and associated rotational and vibrational configurations. Pairing energies appear to be strong, causing appreciable departure from the predictions of the unified model of Nilsson. Above excitation energies of $\approx 600$ keV the excited structure of $^{165}$Ho becomes increasingly uncertain and this is a region that can be practically studied by inelastic neutron excitation.

Fast neutron cross sections of appreciable applied interest are those of the heavy-deformed-nuclei; the fissile, the fertile, and the fission product. In many cases quantitative experimental measurements are technically difficult or impossible and as a result calculation must be used to provide the needed information. These calculational procedures have not been widely verified by comparison with experiment. The present study of $^{165}$Ho provides a good "bench mark" comparison of experiment and calculation in a region of considerable applied importance.

Subsequent portions of this paper deal with; a) the quantitative experimental determination of an internally consistent set of total and elastic and inelastic neutron scattering cross sections of $^{165}$Ho, b) a correlation of experiment and calculation inclusive of the effects of deformation, direct-reactions, compound-nucleus formation and resonance-interference effects, and c) a comparison of observed inelastic excitations with known single-particle and collective-structures and with the postulates of the Nilsson model and systematics. It is hoped that the results will contribute to the basic knowledge of this and similar deformed nuclei and of the calculational procedures important to applied needs.

---