GAMMA-RAY SPECTRA FROM NEUTRON CAPTURE IN RESONANCES OF Mn^{55}[†]

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Following the discovery that reduced neutron widths fluctuate over a very broad range,[1] a considerable experimental effort was expended in attempting to determine the form of the distribution functions of the partial widths of slow-neutron resonances. By now the distributions of the neutron, the fission and the total radiation widths are fairly well understood. However, no direct experimental information has been reported concerning the distributions of the partial widths $\Gamma_{\gamma i}$ for radiative transitions from highly excited compound states to a low-energy state. Gamma-ray spectra from capture in neutron resonances have been measured with single NaI scintillators.[2-4] These studies fail to give information about the distribution of widths because of the technical difficulty, in the extremely complex spectrum, of observing individual transitions directly from the initial state. By applying coincidence techniques to the study of γ-ray cascades following resonant capture of neutrons, we have overcome this difficulty enough to observe transitions to the first few excited states. These data give quantitative information concerning the distribution of $\Gamma_{\gamma i}$.

In our study of resonant capture, the Argonne fast chopper was used to select the energy of the incident neutrons on the basis of their time of flight. The gamma-ray spectra resulting from capture of these timed neutrons were measured with two 4-in. NaI(Tl) scintillators using a fast-slow coincidence scheme. One scintillator was required to detect a narrow band of high-energy photons, thereby restricting the number of low-lying levels fed directly. Thus the low-energy spectra observed by the second scintillator are directly related to probabilities of single high-energy transitions.

The measurement of the total cross section[5] of Mn suggested that it would be a favorable case to study since the spins of the resonances at 337 $(J = 2^-)$, 1080 $(J = 3^-)$, and 2360 $(J = 3^-)$ ev were known. The γ-ray coincidence spectra associated with capture in these resonances were determined. In addition, an extensive investigation of the low-lying excited state of Mn^{56} was made by means of coincidence measurements on the γ rays following capture of thermal neutrons. The levels found confirm the (d,p) results of Green *et al.*[6]

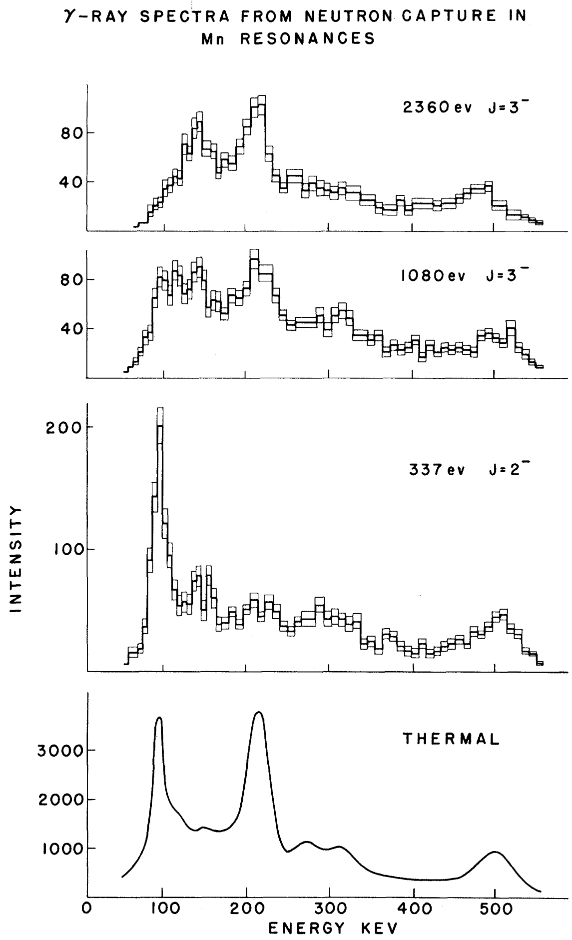

FIG. 1. The γ-ray spectra from neutron capture in manganese resonances.

Figure 1 shows the low-energy spectra obtained using the technique described above. The high-energy window covered a range from 6.4 to 7.6 Mev. Since the binding energy of Mn^{56} is 7.26 Mev,[7] only direct transitions to the first few excited states are observed. The time gate for each resonance ranged from 10 to 15 μsec so the duty cycle was only about 0.3%; hence a running time of about 5 days was required to obtain the data for each resonance. Figures 2(a) and 2(b) show the data in a more quantitative manner and also the specific transitions involved. From the decay scheme it is seen that by observing the lines at 83, 210, 320, and 270 kev one is actually measuring the 7152-, 7046-, 6915-, and 6781-kev transitions; thus the measurement is equivalent to observing the high-energy γ ray with an effective resolution of

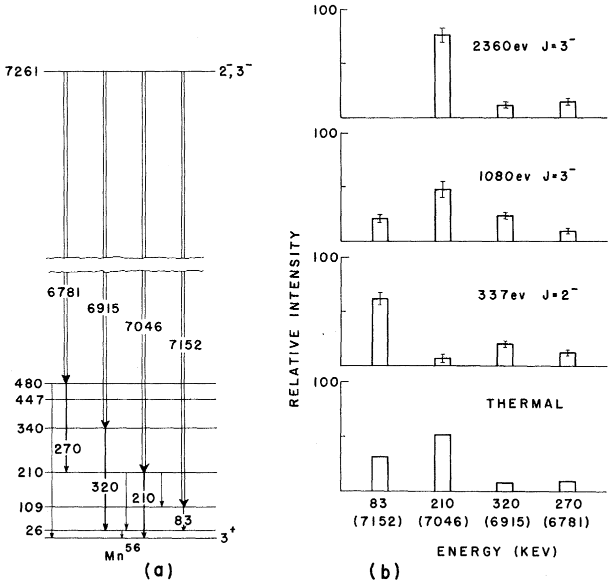

FIG. 2(a). The low-lying states of Mn^{55} and the transitions observed following neutron capture in Mn^{55}. (b) The relative intensities of the transitions observed following neutron capture in manganese resonances. Corrections have been made for γ-ray branching and the sum of the intensities for each resonance is normalized to 100.

about ½%. The reality of this high resolution is demonstrated by the relative ease with which the 320- (6915-) kev line is observed. Although its intensity is about 1%, Bartholomew and Kinsey[7] did not observe it, possibly because of masking by the strong (6.5%) 7046-kev line. The intensities shown in Fig. 2(b) have been corrected for branching. The wide fluctuations in intensity are apparent and clearly are much greater than the statistical uncertainty of the experiment.

Although the measurements are of a preliminary nature, some rather significant conclusions can be drawn from them. The marked difference between the γ-ray spectra resulting from the capture of thermal and 337-ev neutrons is of considerable interest and had not been anticipated. This difference suggests that the thermal cross section is strongly influenced by a resonance at negative energy and not only by the 337-ev resonance, as had previously seemed probable. Quantitative calculations show that this suggestion is not inconsistent with the total cross section measurements.[5] Of more fundamental importance, the spectra for the resonances at 1080 and 2360 ev differ from each other in a marked way even though the compound nucleus has the same spin state in both cases. Thus the data may be an indication that $\Gamma_{\gamma i}$ is not constant but varies in a statistical manner, possibly as proposed by Porter and Thomas.[8]

An extensive program is underway to study several nuclides. It is hoped that spins and lifetimes can be assigned to the low-lying levels and that additional information can be obtained regarding the actual distribution of $\Gamma_{\gamma i}$.

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HIGHER-ORDER EFFECTS IN THE ALLOWED BETA DECAY OF F^{20}†

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It has been proposed by Gell-Mann[1] that the usual vector interaction in beta decay should be modified by addition of a small correction term due to the effect of virtual meson currents around the nucleons. This term is proportional to the difference of the anomalous magnetic moments of protons and neutrons and is of the order of 0.1% per Mev beta energy. This correction term, if it exists, gives rise to a slight deviation from the well known allowed shape of the beta spectrum. An experiment to study this effect has been suggested.[1]

We consider here another way of studying this effect, namely the beta-gamma angular correlation. Normally the beta-gamma angular correlation of an allowed transition is isotropic. The