Radiation Widths in the Slow Neutron Resonances of Hafnium*

G. IGO AND H. H. LANDON
Brookhaven National Laboratory, Upton, New York
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The parameters of the 1.100-ev and the 2.39-ev resonances in hafnium have been determined from total cross section measurements using the Brookhaven crystal spectrometer. The methods of analysis used take into account the Doppler broadening and the finite resolution of the instrument. The radiation widths of the 1.100-ev and the 2.39-ev resonances are 0.067 ev and 0.060 ev, respectively. The remaining one-level parameters for each resonance are presented.

INTRODUCTION

THE radiation widths of neutron resonances in the energy interval up to 5 ev can be measured with an accuracy of about 3% by using the BNL crystal spectrometer. From this work[1] as well as from other sources,[2] the dependence of radiation widths on atomic number has been determined. They show a gradual decrease with increasing atomic number in the interval $A=100$ to 185. For one isotope the radiation widths of different resonances have been generally assumed to be equal within the experimental error. However, in the resonances of Eu^{151} and In^{115}, two distinct values of Γ_γ are found.[3] The present experiment is a measurement of the single-level parameters of two slow neutron resonances in Hf.[4]

Experimental Description

Hafnium foils were used in the measurements. The $1/N$ values for the foils were 5180, 1484, 109.3, and 34.10×10^{-24} cm^2, where N is the number of nuclei per cm^2.

The crystal spectrometer used in these measurements has been described previously.[5] The transmission, T, was measured as a function of energy for each of the samples. The total cross section, σ_T, was determined by the relation

$$\sigma_T=(1/N)\ln(1/T).$$

The total cross section is plotted in Fig. 1. The curve represents the data of all samples. The probable error on each experimental point is less than 3%.

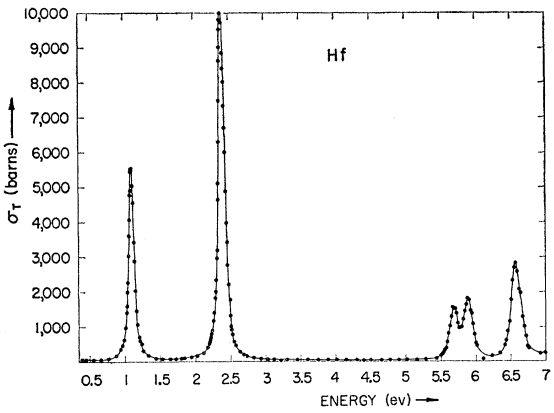

FIG. 1. The total neutron cross section of hafnium.

TABLE I. Parameters for the 1.100-ev resonance and the 2.39-ev resonance in Hf^{177}. With the exception of $\sigma_0\Gamma^2$, the quantities are obtained from the analyses of the central parts of the resonances. The quantity $\sigma_0\Gamma^2$ is obtained from wing analyses.

Parameter	1.100±0.005 ev resonance	2.39±0.01 ev resonance
Γ_t (ev)	0.069±0.002	0.069±0.001
$\sigma_0\Gamma$ (ev barn)	452±2	934±5
$\sigma_0\Gamma^2$ (ev^2 barn)	32.2±0.9	64.6±0.6
σ_0 (barn)	(655±12)×10^1	(13.5±0.2)×10^2
Γ_n (ev)	0.0021±0.00005	0.0093±0.0002
Γ_γ (ev)	0.067±0.002	0.060±0.001

RESULTS AND DISCUSSION

The 1.100-ev resonance and the 2.39-ev resonance were analyzed in order to obtain the parameters of the single-level Breit-Wigner formula. The methods of analysis are described in reference 3. The central part of the peak, after correction for the finite resolution of the spectrometer, was analyzed in terms of the single-level formula modified by Doppler broadening. The shape and the area under the central part of the peak together determined the parameters. The wings of the resonance were analyzed taking into account the effects of Doppler broadening and of the contributions of neighboring resonances. Table I lists the parameters obtained in the analysis. The experimental uncertainties listed in the table are due to the statistical error of 3% in most of the data, to a 1% uncertainty in sample thickness, and to an uncertainty in the energy scale of about 0.2% at 2 ev. The values for Γ_γ obtained from the central and the wing analysis agree within 2% or less. The values of Γ_γ for Hf^{177} differ, as in Er^{151} and In^{115}. The difference, 0.009 ev, is several times larger than the experimental uncertainties in the measured Γ_γ's.

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[1] H. H. Landon, Phys. Rev. **100**, 1414 (1955).

[2] D. J. Hughes and J. A. Harvey, Nature **173**, 942 (1954); J. S. Levin and D. J. Hughes, Phys. Rev. **98**, 1161(A) (1955); A. Stolovy and J. A. Harvey, Phys. Rev. **99**, 611(A) (1955); J. S. Levin, thesis, Cornell University (unpublished). The latter reference contains a rather complete compilation of measured values of Γ_γ and references to the work from which they come.

[3] H. H. Landon and V. L. Sailor, Phys. Rev. **98**, 1267 (1955).

[4] Earlier work on the resonances of Hf is described in articles by P. A. Egelstaff and B. T. Taylor, Nature **167**, 896 (1951) and by L. M. Bollinger *et al.*, Phys. Rev. **92**, 1527 (1953).

[5] L. B. Borst and V. L. Sailor, Rev. Sci, Instr. **24**, 1416 (1953).