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THE LOW ENERGY TOTAL CROSS SECTION OF ^{36}Ar*

S. F. Mughabghab and B. A. Magurno

Brookhaven National Laboratory
Upton, New York 11973

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To compare the predictions of the valence model with measured partial radiative widths of Ar-36 an accurate knowledge of the bound-level parameters is required. This is achieved by carrying out a Breit-Wigner parameter fit to the total cross section of Ar-36 measured by Chrien et al and renormalized to the recommended values of the thermal capture and scattering cross sections. The result is as follows:

$$E_o = -10 \text{ keV}, \ \Gamma_n^o = 92.3 \text{ eV}, \ \Gamma_\gamma = 1.26 \text{ eV}$$

(parameters of bound level of Ar-36)

Introduction

The purpose of the present study is to determine the resonance parameters of the s-wave neutron bound state of Ar-36 in the light of recent cross sections measurements. Accurate knowledge of the reduced neutron and total radiative widths is an important requirement for the calculation of the valence capture component in Ar-36. The calculation can then be compared with experimental capture spectra data. This is carried out in a separate contribution[1] to this conference.

Previously, Chrien, Jain and Palevsky[2] measured the total cross section of Ar-36 in the energy range from 0.1 eV to about 10 keV. From these measurements, the authors[2] derived parameters for a bound level on a basis of a scattering radius of $R' = 4.5$ fermis. Total cross section measurement by Henshaw[3] at a neutron energy of 0.076 eV showed that $\sigma_t = 77 \pm 9$b. A determination of the thermal capture cross section of Ar-36 by McMurtrie and Crawford[4] gave $\sigma_\gamma = 6.5 \pm 1.0$b, based on an isotopic abundance of 0.307% for Ar-36. When this value is normalized to an abundance of 0.34% for Ar-36, one obtains $\sigma_\gamma = 5.9 \pm 0.9$b. This is in agreement with a value of 4.8 ± 0.5b reported by Von Wille.[5] In addition, a comparison of the thermal capture spectra measured by Von Wille[6] and Hardell and Beer[6] favors a thermal capture cross section of 5.0b for Ar-36. Thermal scattering measurements by Krohn and Ringo[7] and later by Andriesse et al[8] gave $\sigma_s = 73.7 \pm 0.4$b and 74 ± 2b respectively. In this evaluation, thermal capture, scattering, and total cross section values of 5.0 ± 0.5b, 73.7 ± 0.4b, and 78.7 ± 0.6b respectively were adopted for Ar-36. The latter value is utilized to renormalize the total cross section data.[2]

Analysis, Results, and Discussion

To calculate the total cross section of Ar-36, a knowledge of the nuclear scattering radius R' is an additional requirement. This is achieved by deriving R' from Ar-40 data by two methods:

(1) A Breit-Wigner multilevel parametric fit of the total cross section of natural argon[9] (99.59% Ar-40) gave $R' = 2.8$ fm.

(2) A coherent scattering amplitude for Ar-40, $a_{coh} = 1.83 \pm 0.05$ fm, and use of the relation:

$$a_{coh} = R' - \sum_j 2.34 \frac{\Gamma_{nj}^o}{E_j}$$

with the aid of the resonance parameters of Ar-40 as reported in BNL-325 (1973) implied $R' = 2.6$ fm. This is based on the reasonable assumption that bound level contributions in Ar-40 are insignificant. This is essentially justified in view of the good agreement between this result and that derived by method(1).

It is interesting to note that a value of $R' = 2.6$ is consistent with a minimum in R' in this mass region as obtained from optical model calculations.

By constraining the thermal capture, scattering, and total cross sections to the adopted values mentioned previously, various combinations for the parameters of the bound level are derived. Fig. 1 shows the calculated Breit-Wigner total cross sections for three such sets illustrated in Table I.

Table I

Set #	E_o (keV)	Γ_n^o (eV)	Γ_γ (eV)
1	- 8	73.82	1.01
2	-10	92.27	1.26
3	-15	138.4	1.9

As described in Fig. 1, the best fit to the experimental data particularly at high neutron energies is achieved for the case of set 2. In addition, with these parameters, the Wescott g factors for capture and scattering were calculated. The results are:

for capture, $g = 1.0016$
for scattering, $g = 1.1128$

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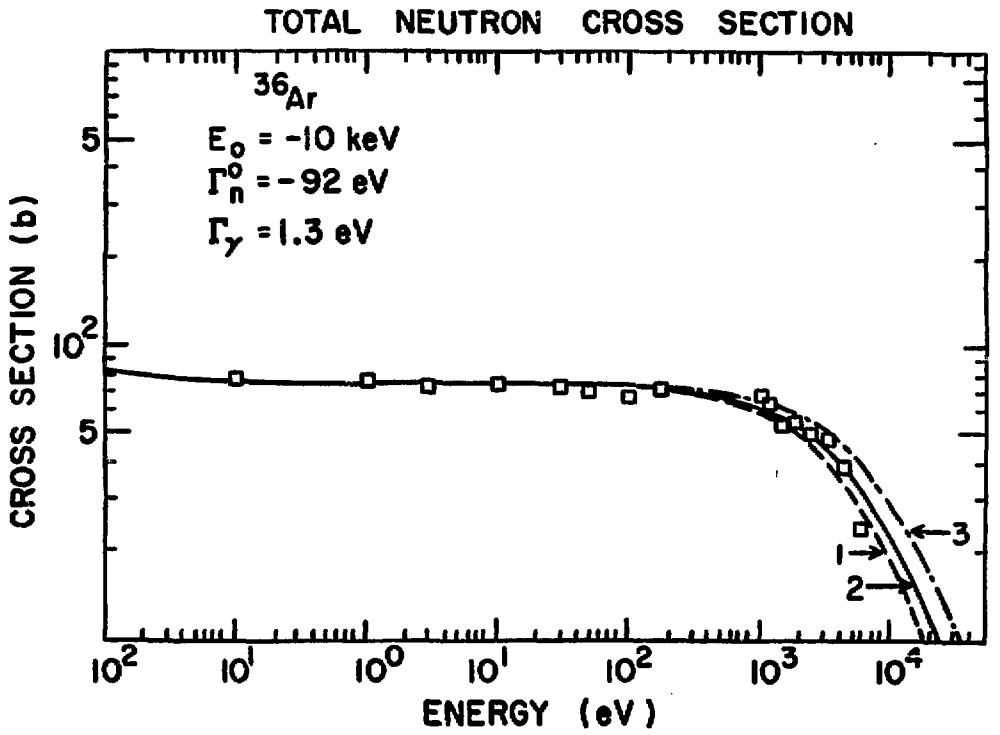

Fig. 1

Comparison of measured and calculated total cross sections of Ar-36

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