as V_{II} must be joined on the OPEP at a distance of (say) 1.5f.[5]

The potential V_{II} seems to provide as accurate a description of the singlet-even scattering data as a "hard-core" model. It remains to be seen whether such an approach will also be successful for other spin states of the system.

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Anomalous Neutron Scattering of Ar^{36}†

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The thermal neutron scattering of argon is unusual in that it shows a large amount of incoherent scattering, even though it is even-even and practically monoisotopic. The incoherence has been ascribed by Henshaw to a large scattering cross section for Ar^{36}. Measurements with the BNL fast chopper for a gas sample enriched to 63% Ar^{36} have shown that the total cross section from 0.1 ev to 6 kev varies in such a way as to reveal the presence of a negative energy level. The parameters $\Gamma_n^0=82$ ev, $E_0=-9.8$ kev, and $\Gamma_\gamma=1.85$ ev have been deduced for this level. The consequences of this anomalous scattering for neutron studies of atomic motions in a liquid are discussed.

I. INTRODUCTION

THE element argon shows unusual behavior in its thermal neutron scattering properties in that, although it is even-even and practically monoisotopic, it displays a large amount of incoherent scattering. Henshaw[1] has shown that this incoherence results from the presence of the small (0.34%) Ar^{36} component, which has a remarkably high cross section.

It has been suggested that it may be possible to prepare a completely incoherent scatterer by mixing argon isotopes in the proper amounts. In principal, if $\sum_i f_i\alpha_i=0$, where f_i are the isotopic abundance factors, and α_i the corresponding scattering amplitudes, then complete incoherent scattering is obtained. Such a scatterer would permit the use of subthermal neutrons to investigate the atomic motions in a liquid, since for the completely incoherent case the experimental data are amenable to a rather simple interpretation in terms of a self-correlation function describing the motion of the atom.

The potential or "hard sphere" scattering amplitude is defined to be positive. A negative scattering amplitude is obtained only when a nearby resonance is present at an energy above the thermal region. In this case the negative resonance amplitude can overwhelm the hard-sphere component.

It is the purpose of this paper to show that the high thermal scattering amplitude of Ar^{36} is due to the presence of a resonance at negative energy (i.e., below the neutron binding energy). Hence, the Ar^{36} scattering length is positive and of the same sign as that for elemental argon.[2] This implies that both Ar^{36} and Ar^{40} have the same sign (+) for their scattering length. Complete incoherence, therefore, for argon cannot be achieved.

II. EXPERIMENT

The total neutron cross section of a sample of argon gas enriched to 62.7% of Ar^{36} was determined by transmission methods with the Brookhaven fast chopper and time-of-flight apparatus operating at the BNL graphite research reactor. The gas sample was enclosed at a pressure of 1800 lb/in.[2] in a specially designed iron sample holder which fits into the sample slot of the fast chopper entrance stator.[3] These holders were previously used in transmission measurements on xenon and krypton isotopes.[4] The argon sample was prepared by the

Table I. Analysis of argon sample.

Isotope	Atomic %
Ar^{36}	62.7±1.0
Ar^{40}	33.8±1.0
Ar^{38}	2.2±0.2
N^{14}	~1.0

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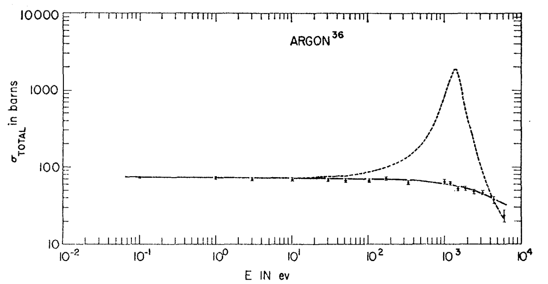

FIG. 1. This figure shows a plot of σ_{total} for Ar^{36} versus incident neutron energy. Points are measured cross sections, while the solid curve is the one calculated with negative-energy resonance, with parameters as given in the text. Dotted curve is the cross section calculated on the basis of a positive-energy resonance and is in disagreement with the data.

isotope diffusion group at Yale. The isotopic analysis of the sample is given in Table I.

The total sample thickness was 6.72×10^{21} atoms/cm^2, obtained by condensing 72.8 ± 0.7 cc of gas (measured at STP) into the sample holder, of internal dimensions $2.05\times2.75\times0.1$ cm. The thick walls of the holder, necessary for confining the gas at high pressure, produced a beam loss of some 40%.

The sample was run at one slit of the BNL fast chopper at speeds ranging from 388 to 10 000 rpm in order to cover an energy range from 0.1 ev to 6 kev. The transmission was obtained by cycling a similar, empty holder with the one containing the argon gas. A later measurement established that the sample holder and dummy holder were identical to 1% with regard to wall thickness in the beam. After small corrections for the other gases in the sample, a cross section for Ar^{36} was obtained. Figure 1 shows the data points in the region from 0.1 ev to 6 kev. A decreasing cross section is clearly seen.

III. RESULTS AND DISCUSSION

Previous work on Ar^{36} include the studies of Henshaw[1] and work by McMurtrie and Crawford.[5] Henshaw found, at 0.076 ev, a total cross section of 77 ± 9 barns. Extrapolation of the present data below 0.1 ev gives a value of 74 ± 11 barns, in agreement with Henshaw's measurement. McMurtrie and Crawford have measured the absorption cross section for Ar^{36} with pile neutrons. At 0.076 ev their measurement implies a capture cross section of 4 barns. These previous measurements, when combined with an estimated radius parameter, R', of 4.5 fermis, can be satisfied by either one of a pair of resonances, one at positive, the other at a negative energy. Figure 1 shows that the positive energy choice is ruled out by the present experiment. The statistical errors on the data points of Fig. 1 range from 2.6% at 0.1 ev to 7% at 3 kev. There is present, however, an additional systematic error of 14% which reflects uncertainties in sample thickness, which are aggravated by the relative thinness of the sample ($T\approx0.8$) over most of the energy range covered.

The solid curve through the data points was obtained from the following best fit parameters in the Breit-Wigner single-level formula:

$$E_0=-9.8\pm1.0 \text{ kev},$$
$$\Gamma_n^0=82\pm10 \text{ ev},$$
$$\Gamma_\gamma=1.85\pm0.22 \text{ ev}.$$

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Elastic Scattering of 24-Mev Neutrons by Al, Fe, Sn, Bi†

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Angular distributions have been measured for angles between 15° and 90° in 5° steps. Cylindrical scatterers were $\frac{1}{2}$ or $\frac{3}{4}$ mean-free path in diameter as calculated on the basis of total cross sections. These cylinders were bombarded with neutrons from the $T(d,n)He^4$ reaction, and the scattered neutrons were detected in a plastic scintillator. Biases were set at energies between 14 and 24 Mev. Corrections for effects due to scatterer size were calculated with a Monte Carlo code on the Univac and IBM 704. The corrected cross sections are in good agreement with optical model calculations by Bjorklund and Fernbach.

I. INTRODUCTION

THE validity of an optical model description of the nucleon-nucleus interaction is well established. Of primary interest now are the features of this potential, such as spatial extent, shape and magnitude, and the dependence of the parameters on the energy of the incident nucleon. The energy dependence of the potential is of particular interest because the saturation property of nucleon binding energy inside a nucleus requires that the potential be velocity dependent. Both

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