KERNFORSCHUNGSZENTRUM

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Institut für Angewandte Kernphysik
Projekt Schneller Brüter

The Total Neutron Cross Section of Boron 10 between 90 and 420 keV

R.R. Spencer, H. Beer, F.H. Fröhner

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ABSTRACT

The neutron total cross section of ^{10}B has been determined between 90 and 420 keV neutron energy by means of a transmission measurement of an enriched ^{10}B sample. Deviations in shape to other measurements are within the statistical accuracy of the present measurement and smaller than 1.5 %. In the measured energy region no indication of narrow resonance structure was found, and the deviation of the total cross section from an $E^{-1/2}$ energy dependence above 100 keV was confirmed.

Der totale Wirkungsquerschnitt von Bor 10 zwischen 90 und 420 keV

ZUSAMMENFASSUNG

Der totale Wirkungsquerschnitt von ^{10}B wurde zwischen 90 und 420 keV Neutronenenergie mit Hilfe einer Transmissionsmessung an einer angereicherten ^{10}B-Probe bestimmt. Abweichungen des Wirkungsquerschnittsverlaufs zu anderen Messungen sind innerhalb der statistischen Genauigkeit der vorliegenden Messung und kleiner als 1.5 %. In dem gemessenen Energiebereich wurde kein Anzeichen einer schmalen Resonanzstruktur entdeckt. Die Abweichung des totalen Wirkungsquerschnitts von einer $E^{-1/2}$ Energieabhängigkeit oberhalb von 100 keV wurde bestätigt.

INTRODUCTION

The ^{10}B neutron absorption cross section is one of the important standard cross sections for neutron flux determination. Much of the present information about this cross section has been obtained through measurements of the ^{10}B neutron total cross section [1]. From thermal energies up to about 100 keV the total cross section is well described by a $E^{-1/2}$ energy dependent $^{10}B(n,\alpha\gamma)$ cross section and a constant scattering cross section. But measurements with monoenergetic neutrons performed by Bockelman et al. [2] and Mooring et al. [3] revealed a broad resonance structure in the total cross section at about 230 keV neutron energy. The flight time measurements at the Harwell Electron Linac of Diment [4] resulted in averaged cross section data points from 100 eV up to 1 MeV which are in good agreement with the values of Mooring et al. [3] in the overlapping energy region. Using the measured scattering cross section of Mooring et al. [3] Diment [4] concluded that an $E^{-1/2}$ energy dependence of the absorption cross section can be used up to 300 keV.

At the Karlsruhe 3 MV Van-de-Graaff accelerator the ^{10}B neutron total cross section was investigated with the flight time method primarily to provide additional confirmation of the shape of this important cross section in the region between 100 and 400 keV.

EXPERIMENTAL DESCRIPTION

The transmission measurement was performed by time-of-flight-technique. The Karlsruhe 3 MV Van-de-Graaff-accelerator was used to provide 1 ns wide bursts of protons at selected repetition rates in order to produce neutrons by means of the $^{7}Li\ (p,n)^{7}Be$ reaction on thick lithium targets. For the energy range $90 \leq E_n \leq 290$ keV a repetition frequency of 250 kHz and for $230 \leq E_n \leq 420$ keV a repetition frequency of 500 kHz was used. The neutrons were detected by a 4 3/8" dia X 1/2" thick ^{6}Li loaded glass scintillator[+)] mounted on an XP 1040 photomultiplier [5] after a flight path of 4.962 meters.

The flight time spectra from both sample and an empty identical sample container, alternately cycled into the neutron beam, were recorded with a Laben digital time sorter and a CAE 510 on-line computer. The sample (4.37 g boron powder,

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[+)] Nuclear Enterprise NE 905

enriched in ^{10}B to 92.2 atomic-percent) was placed into a thin-walled aluminum container of 1.1 cm diameter.

TABLE I. The composition of the boron sample

Element	Abundances (weight-percent)
B	85.07
O	11.57
H	0.84
C	1.00
Cu	0.45
K	0.40
Ni	0.39
Ca	0.12
Fe	0.09
Mg	0.02
Mn	0.02
Na	0.01

The boron sample was analysed by the Institut für Material- und Festkörperforschung, Kernforschungszentrum Karlsruhe, and the Metallgesellschaft AG, Frankfurt in addition to the analysis of Oak Ridge National Laboratory, Tennessee which supplied the sample.

The different samples taken for the chemical analyses showed small deviations in the oxygen and hydrogen abundances introducing a $\pm$ 5 % systematic uncertainty of the ^{10}B cross section. However good agreement was obtained throughout the whole energy region with [2], [3] and [4] by taking the chemical analysis of the Institut für Material- und Festkörperforschung (Table I).

RESULTS AND DISCUSSION

The transmission values and their statistical uncertainties were computed from the data by means of the Fortran IV code TRAMI [6]. The backgrounds for the sample and open beam flight time spectra were determined from the region between the prompt γ-ray peak and the onset of the neutron distribution. With a special version of the Fortran IV code FANAL II [7] the transmission data were corrected for the sample impurities, and the ^{10}B total cross section was computed (Fig. 1). The ^{11}B and oxygen content of the sample was taken into account by using the ^{11}B - and oxygen total cross sections of Mooring et al. [3]. The hydrogen contribution was determined by means of the formula of Gammel [8] and for the carbon impurity correction the carbon total cross section formula of Meadows and Whalen [9] was used. The other impurities are so small that they don't affect the ^{10}B cross section significantly. They were taken into account assuming for each one a constant cross section taken from [10].

The shape of the ^{10}B total cross section in the present measurement is in good agreement with previous experimental results [2], [3] and [4] (Fig. 1). Deviations are within the statistical accuracy and smaller than 1.5 %. There is no indication of narrow resonance structure and the cross section deviates from an $E^{-1/2}$ dependence above 100 keV, in agreement with the above authors.

ACKNOWLEDGEMENT

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FIGURE CAPTION

Fig. 1. The neutron total cross section of ^{10}B between 90 and 420 keV.

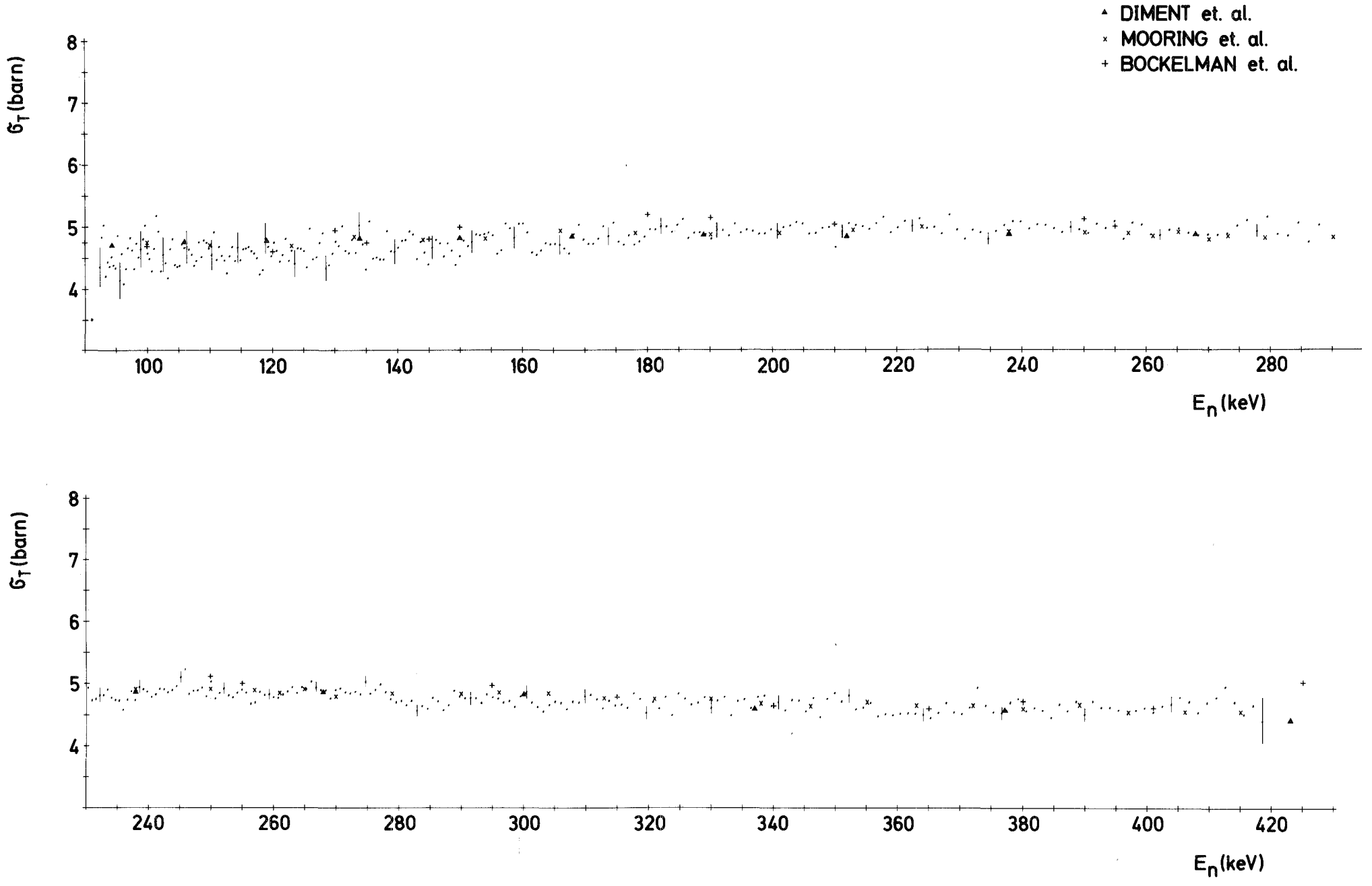
▲ DIMENT et. al.
× MOORING et. al.
+ BOCKELMAN et. al.
σ_T(barn)
8
7
6
5
4
100
120
140
160
180
200
220
240
260
280
E_n(keV)
σ_T(barn)
8
7
6
5
4
240
260
280
300
320
340
360
380
400
420
E_n(keV)

Fig. 1