LA-UR -85-1743

RECEIVED BY OSTI JUN 07 1985

CONF-850507--28

LA-UR--85-1743

DE85 012749

TITLE: DOUBLE DIFFERENTIAL NEUTRON EMISSION CROSS SECTIONS OF ^{10}B AND ^{11}B AT 14 MeV AND OF ^{6}Li, ^{7}Li AND ^{12}C AT 14 MeV

AUTHOR(S): M. Drosg, P. W. Lisowski, R. A. Hardekopf, and D. M. Drake

SUBMITTED TO: International Conference on Nuclear Data for Basic and Applied Science, Santa Fe, NM, May 13-17, 1985.

DOUBLE DIFFERENTIAL NEUTRON EMISSION CROSS SECTIONS OF ^{10}B AND ^{11}B AT 6, 10 AND 14 MeV AND OF ^{6}Li, ^{7}Li AND ^{12}C AT 14 MeV

M. DROSG 670
Los Alamos, New Mexico, U.S.A. and University Vienna, A-1090, Wien, AUSTRIA

P. W. LISOWSKI, R. A. HARDEKOPF, and D. M. DRAKE
Los Alamos National Laboratory, Los Alamos, New Mexico, U.S.A. 951 2470

K. TREITL
Institute for Experimental Physics, University Vienna, A-1090 Wien, AUSTRIA 10 9200

Abstract Neutron emission spectra of ^{10}B and ^{11}B were measured at 6, 10 and 14.1 MeV and those of ^{6}Li, ^{7}Li and carbon at 14.1 MeV using time-of-flight technique. Absolute double differential cross sections were obtained by using scattering from hydrogen as a cross section reference. Integration over energy ranges and solid angle yielded integrated elastic and total neutron emission cross sections. At 6 and 10 MeV excellent agreement with total cross section data is found, at 14.1 MeV the new data tend to be higher than expected. The biggest error source in the continuous spectra stems from uncertainties in the input library (ENDF/B-IV) of the Monte Carlo correction for multiple scattering. In particular, the library for ^{11}B appears to be very unrealistic, with a total elastic cross section at 14.1 MeV which should be higher by 50%.

INTRODUCTION

The neutron household of future fusion power generators depends strongly on the neutron emission properties of the blanket. Therefore, the neutron emission cross sections of light nuclei for energies up to about 14 MeV must be known. The lithium isotopes at 6 and 10 MeV[1] and beryllium (at 6, 10 and 14 MeV)[2] have been dealt with before at the Los Alamos National Laboratory. The necessity of measuring neutron continua with rather small cross sections makes such experiments for incoming neutrons above 8 MeV difficult if not impossible, unless a truly monoenergetic neutron source with high neutron yield is available.

EXPERIMENTAL

The data were taken at the Los Alamos National Laboratory in two different experiments, one at the Tandem Van de Graaff using the $^{1}H(t,n)^{3}He$ reaction to produce 6 and 10 MeV neutrons, the other at the Vertical Van de Graaff using the $^{3}H(d,n)^{4}He$ reaction to produce 14.1 MeV neutrons at 90°. In both cases gas targets were used. Figure 1 compares the specific neutron yields of various sources near 14 MeV. Using 90° instead of 0° improves the specific yield by an order of magnitude.

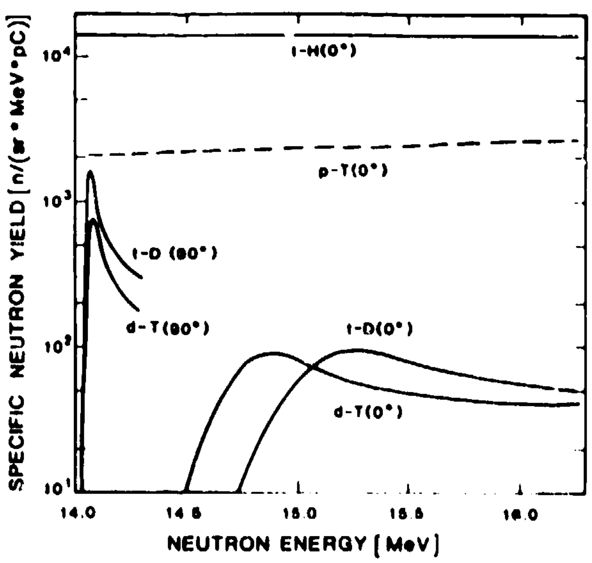


FIGURE 1 Comparison of specific neutron yield from monoenergetic neutron sources near 14 MeV

Time-of-flight technique with a flight path of 2.5 meters was used. The neutron detection efficiency of the detector has been measured previously.[3] All the samples were enriched (>95% purity) and had a mass of about 1 mole. At each of the 10 angles (between 20° and 145°) the samples were measured one after the other, i.e. relative to each other. The set-up was calibrated by measuring the $^{1}H(n,n)^{1}H$ reaction and using cross section predictions by the YALE phase shifts [4]

After combining the fore- and background time-of-flight spectra these were converted into energy spectra and corrected for multiple scattering using the Los Alamos National Laboratory Monte Carlo code MCNP[5] with ENDF/B-IV cross sections. Unfortunately, these data are often not good enough to simulate reality, as can be seen from Figure 2. Therefore, the multiple scattering corrections of the nonelastic contributions of the spectra are not very reliable. To (possibly) improve the correction, the nonelastic contribution in the simulated spectrum was increased from the original values (dotted curves) to the dashed curves which have the same value as the measured distributions. The corrections were increased correspondingly.

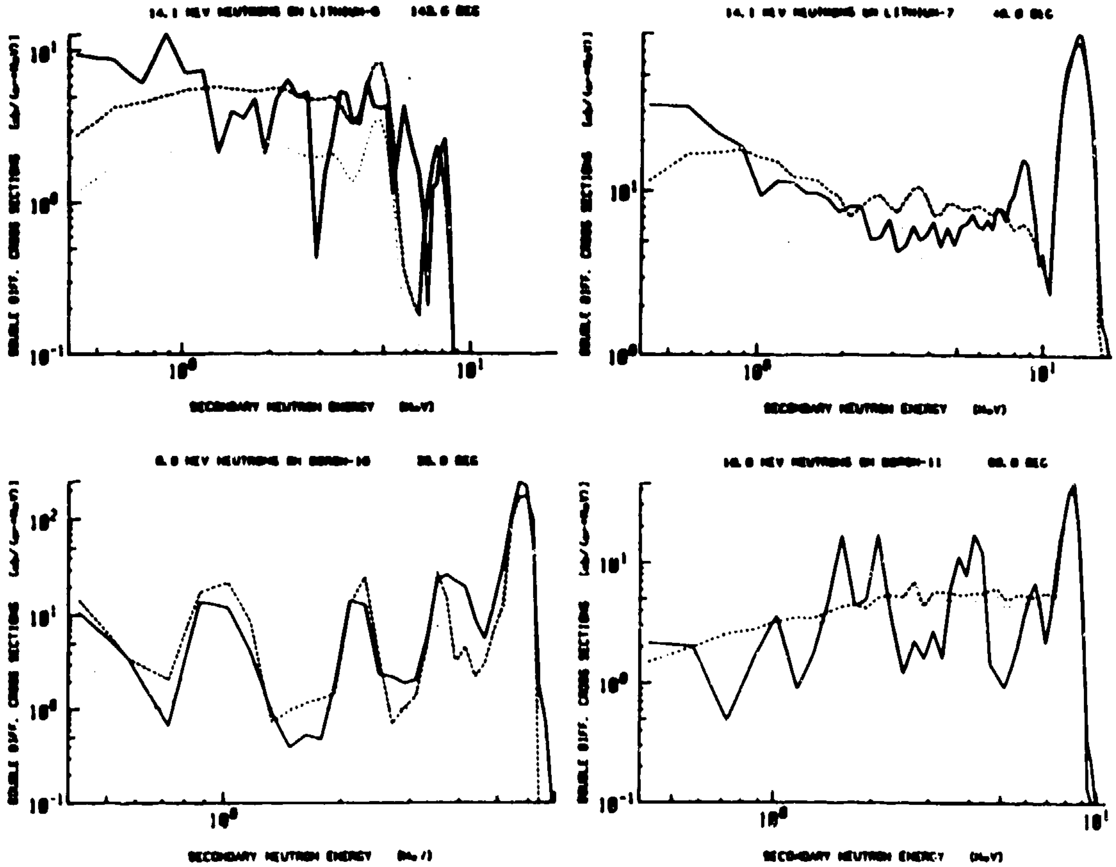
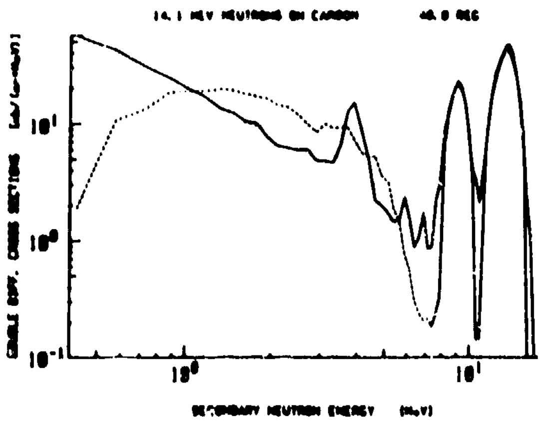


FIGURE 2 Samples of measured spectra (full curves) and their simulation. (See text.)



RESULTS

The numerical values and the graphs of the 90 double differential cross section distributions measured in this experiment will be published in two reports of the Los Alamos National Laboratory. The integrated values are shown in Table I and compared with previous data.

TABLE I Integrated cross sections (Scale errors of elastic cross sections 2.5 to 3%, all data in barns)

Energy	Sample	Elastic exp a)	Elastic eval b)	Total Emission exp a)	Total Emission eval b)	Total Reaction exp a)	Total Reaction Ref. 6
6.0	B-10	0.90 c)	0.92	1.11	1.10	1.51 d)	1.53
	B-11	1.31	1.43	1.67	1.55	1.67	1.66
10.0	B-10	0.85 c)	0.93	1.22	1.20	1.47 d)	1.49
	B-11	0.88	0.89	1.40	1.27	1.42 d)	1.41
14.1	Li-6	0.94	0.96	1.66	1.49		
	Li-7	1.06 c)	1.01	1.75	1.54		
	B-10	0.97 c)	0.95	1.57	1.45		
	B-11	0.90	0.60	1.55	1.34		
	Carbon	0.86	0.80	1.59	1.30		

a) this work
b) ENDF/B-V
c) cross section of unresolved excited states subtracted
d) uses ENDF/B-V values for non-neutron reactions

Special attention deserves the very good agreement between our 6 and 10 MeV data and the total cross sections of Auchampaugh et al.[6] Not only are the absolute deviations small, also their scatter is small At 14 MeV the total neutron emission data appear to be high, although the total elastic data lie in between literature values. Whether these high values are correct or an effect of inadequate multiple scattering corrections remains to be seen.

REFERENCES

1. P. W. Lisowski, G. F. Auchampaugh, D. M. Drake, M. Drosg, G. Haouat, N. W. Hill, and L. Nilsson, Los Alamos Scientific Laboratory Report LA-8342 (1980).
2. D. M. Drake, G. F. Auchampaugh, E. E. Arthur, C. E. Ragan, and P. G. Young, Nucl. Sci. Eng., 63, 401 (1977).
3. M. Drosg, D. M. Drake, and P. Lisowski, Nuclear Instr. Methods, 176, 477 (1980).
4. J. C. Hopkins, and G. Breit, Nucl. Data Tables, A9, 137 (1971).
5. Los Alamos Scientific Laboratory Group X-6, "MCNP - A General Monte Carlo Code for Neutron and Photon Transport", Los Alamos Scientific Laboratory Report LA-7396-M, Rev. (Nov. 1979).
6. G. F. Auchampaugh, C. E. Ragan, S. Plattard, and N. W. Hill, Los Alamos Scientific Laboratory Report LA-6761-MS (1977).