National Institute of Standards and Technology

Nuclear Data Verification and Standardization Program

PROGRESS REPORT

USNDP Meeting
Brookhaven National Laboratory
November 9, 2007

THE NEUTRON CROSS SECTION STANDARDS

Reaction	Energy Range
H(n,n)	1 keV to 20 MeV
^{3}He(n,p)	thermal to 50 keV
^{6}Li(n,t)	thermal to 1 MeV
^{10}B(n,α)	thermal to 1 MeV
^{10}B(n,$\alpha_1\gamma$)	thermal to 1 MeV
C(n,n)	thermal to 1.8 MeV
^{197}Au(n,γ)	thermal, 0.2 to 2.5 MeV
^{235}U(n,f)	thermal, 0.15 to 200 MeV
^{238}U(n,f)	2 to 200 MeV

Nuclear Structure Activities:

- None are supported by DOE funding.

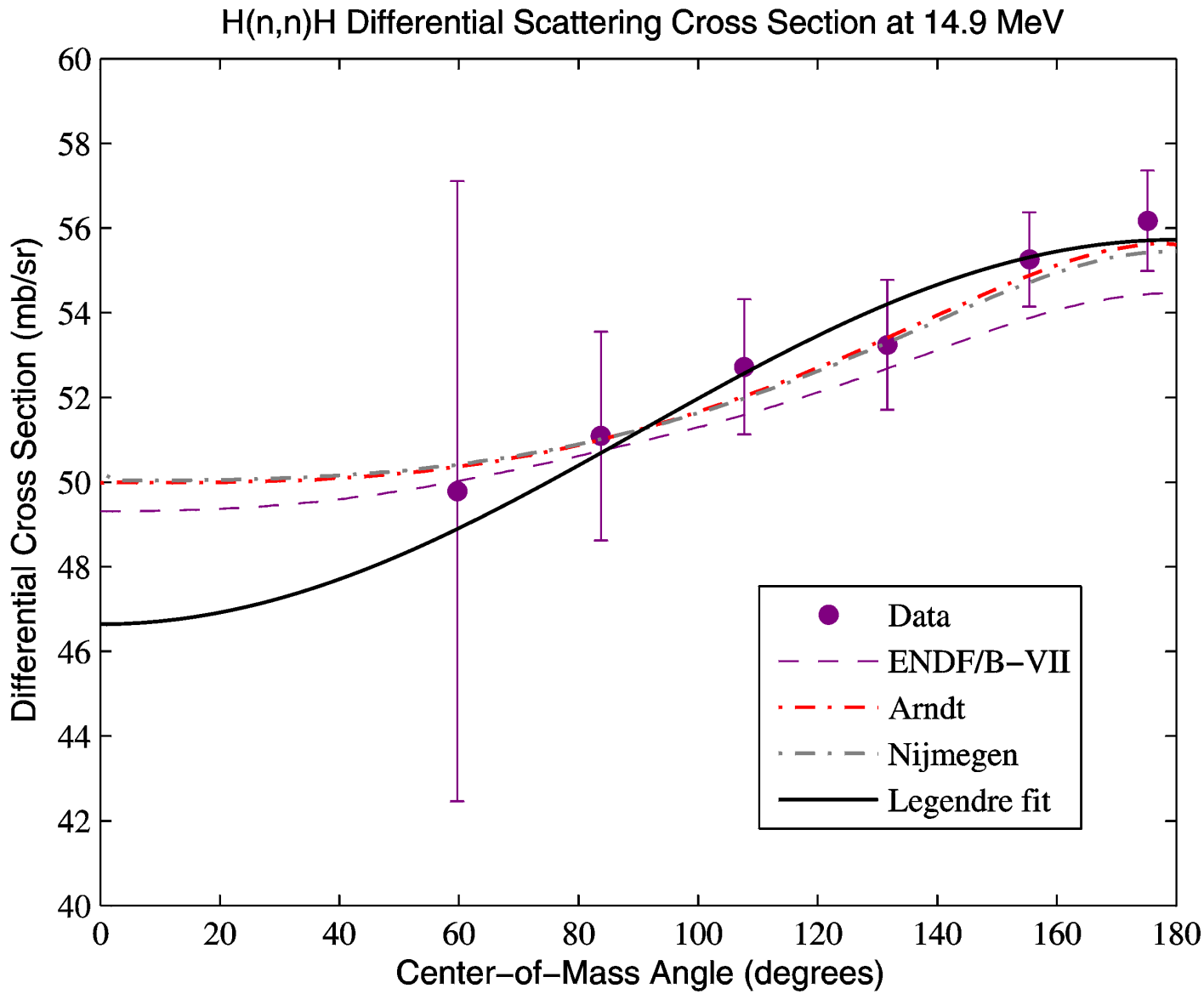
- A modest effort, largely experimental, (1 FTE) in structure and decay studies is supported by NIST. The effort is in support of radioactivity and radiopharmaceutical needs, e.g. ^{67}Ga, ^{223}Ra, ^{211}At.

Nuclear Reaction Activities: **Neutron Cross Section Standards –Measurements**

H(n,n)H Angular Distribution Work

- Measurements were made at laboratory angles of 0 degrees, ± 12 degrees (one on each side of the beam direction), ± 24 degrees, ± 36 degrees, ± 48 and ± 60 degrees at the Ohio University accelerator facility. A paper on this work was given at the ND2007 conference. The data are obtained at 14.9 MeV neutron energy.

- Plans are being made to continue this type of work using a Time Projection Chamber which will provide higher counting rates than are possible with the scattering chamber now being used.
(collaboration of NIST with Ohio University, LANL and the University of Guelma)


H(n,n)H Differential Scattering Cross Section at 14.9 MeV
Differential Cross Section (mb/sr)
Center–of–Mass Angle (degrees)
60
58
56
54
52
50
48
46
44
42
40
0
20
40
60
80
100
120
140
160
180
Data
ENDF/B–VII
Arndt
Nijmegen
Legendre fit

Nuclear Reaction Activities: Neutron Cross Section Standards –Measurements

^{3}He(n,p) Work

•An NIST collaborative experiment employing polarized neutrons and a polarized ^{3}He beam has been designed. This measurement will allow separation of the real part of the two spin channels of this interaction. These data can be used in R-matrix evaluations to improve the ^{3}He(n,p) standard cross section. (collaboration with Indiana University and the University of North Carolina)

Nuclear Reaction Activities: Neutron Cross Section Standards –Measurements

^{6}Li(n,t) Work

•NIST collaborative measurements are being made of the ^{6}Li(n,t) cross section standard at ~ 4 meV. These are the first direct and absolute measurements of this cross sections in this neutron energy range using monoenergetic neutrons.

•The neutron fluence measurements for this experiment are based on counting prompt gamma-rays that originate from neutron capture in a totally absorbing boron target. The gamma-ray efficiency is known accurately from alpha-gamma coincidence measurements using a thin ^{10}B target and also indirectly from measurements using a standard alpha source. A thin ^{6}Li target whose geometry and target mass are both well known was used for the ^{6}Li(n,t) cross section measurement. This procedure is capable of achieving an accuracy of ± 0.25%.
(collaboration with the University of Tennessee and Tulane University)

^{10}B(n,α) Work

•The same basic experimental setup being used for the NIST collaborative measurements of the ^{6}Li(n,t) cross section at ~ 4 meV will be used to measure the ^{10}B(n,α) cross section also.

Nuclear Reaction Activities: Neutron Cross Section Standards –Measurements

Fluence Determination Work

•Cross section measurements have been made using NBS-I as a standard neutron source. An independent determination of the neutron intensity of this source has been made to compare with the established value obtained from manganese sulfate bath measurements and calculations. The new determination is in principle only limited in accuracy by the uncertainty in nu-bar of ^{252}Cf, 0.12%. The determination was made by measuring the neutron source intensity of a bare ^{252}Cf source (from the fission fragment rate into a well defined solid angle measured with a solid state detector and nu-bar), comparing this source to a sealed ^{252}Cf source (by relative counting with ^{3}He neutron detectors) to determine the sealed source intensity, and comparing this result with that obtained from a calibration of the sealed source relative to NBS-I in a large manganese sulfate bath.

•It may be possible to reduce the uncertainty in nu-bar of ^{252}Cf by comparing the results obtained using the various fluence measuring methods available at NIST with that obtained using the ^{252}Cf method.

Nuclear Reaction Activities: Neutron Cross Section Standards –Evaluations

• An invited paper was given at the ND-2007 conference on the International Evaluation of the Neutron Cross Section Standards.

•A detailed IAEA technical report should be published this fall documenting the evaluation activities of the IAEA Coordinated Research Project on the international evaluation of the neutron cross section standards. NIST chaired the Research Coordination Meetings and made significant contributions to the technical report.

•Improvements continue to be made to the experimental data in the standards database as a result of NIST involvement or encouragement.

•An invited talk on the status of the neutron cross section standards will be given at the International Symposium on Reactor Dosimetry-13.

Nuclear Reaction Activities: Neutron Cross Section Standards – Evaluations (continued)

• Work has begun on the IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards".

- Updating of the standards database.
- Investigating the prospect of an inelastic scattering cross section standard.
- Considering adding additional standards energy ranges for the Au(n,γ) cross section.
- Proposing updates for the evaluations of the ^{252}Cf spontaneous fission neutron spectrum and the ^{235}U thermal neutron-induced fission neutron spectrum.
- Developing a procedure to improve the smoothing process for the Au(n,γ) cross section. The objective is to remove non-physical fluctuations (structure) and maintain real structure such as the cusps that occur from competition with inelastic scattering.

Other Work (cont.)

•The NIST National Repository for Fissionable Isotope Mass Standards continues to acquire and monitor samples. A number of laboratories have borrowed samples from the Repository.

•NIST has members of the International Program Committees for both the ND2007 and International Symposium on Radiation Dosimetry-13 (2008) meetings, who are actively involved in such activities as planning, and reviewing the abstracts and submitted papers.

Recommendations

•Though the present international evaluation of the standards has been completed, maintaining an active program of measurements and evaluation activities is essential for improvement of the standards. Standards work which was initiated but not completed in the standards evaluation process needs to be continued. Some of these activities could be done under the IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards". This project will pursue improvements in the experimental database, maintain evaluation codes and periodically update the standards so they are available for new versions of nuclear data libraries.

•It should be stressed that improved understanding of the covariances is essential in obtaining the true uncertainties resulting from the use of evaluated nuclear data.