National Institute of Standards and Technology

Nuclear Data Verification and Standardization Program

PROGRESS REPORT

USNDP Meeting
Brookhaven National Laboratory
November 6, 2009

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, (about 1 FTE) in structure and decay studies is supported by NIST. The effort is in support of needs for radioactivity and radiopharmaceutical applications.

•Nuclear Reaction Activities: Neutron Cross Section Standards – Measurements

H(n,n)H Angular Distribution Work

•A journal publication on the measurements at 14.9 MeV is nearly completed. This work was initiated to resolve problems with the hydrogen database used for the ENDF/B-VI hydrogen evaluation. To improve that database, measurements were made at laboratory proton recoil 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. The data were obtained by detecting the recoil proton.

(collaboration of NIST, Ohio University, LANL and the University of Guelma)

H(n,n)H Angular Distribution Work

•In order to make measurements at smaller scattering angles an experiment has been designed where the primary objective is detection of the scattered neutron instead of the scattered proton.

•The work is being done at the Ohio University accelerator facility. Measurements have been made at laboratory neutron scattering angles of 20 and 25 degrees for 14.9 MeV incident neutrons. Measurements will continue in 5 degree steps up to 70 degrees. Then measurements will be made at 10 MeV incident neutron energy to help fill in the small angle gap in the work done by this collaboration at 10 MeV and 14.9 MeV.

•For this work, the neutron detector efficiency must be determined accurately. At lower energies ^{252}Cf spectra will be used. At the higher energies, several methods are under investigation including the use of a well characterized ^{235}U fission chamber to implement the ^{235}U(n,f) cross section standard

•Plans are being made to continue hydrogen angular distribution measurements using a Time Projection Chamber which will provide higher counting rates than are possible with the other methods. It is expected that work using this chamber can begin early in 2010.

(collaboration of NIST, Ohio University, LANL and the University of Guelma)

Nuclear Reaction Activities: Neutron Cross Section Standards – Measurements (cont.)

^{3}He(n,p) Work

•The NIST collaborative work on the measurement of the spin-dependent portion of the n-^{3}He coherent scattering length using a polarized neutron beam and a polarized ^{3}He target has been published. The data from this measurement will allow separation of the real part of the two spin channels of this interaction. These data are complementary to NIST measurements previously made of the n- ^{3}He coherent scattering length which were recently published. 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

•Measurements are now underway of the ^{6}Li(n,t) cross section standard at ~ 4 meV neutron energy. These are the first direct and absolute measurements of this cross sections in this neutron energy range using monoenergetic neutrons. A primary effort has been focused on measuring the fluence accurately. These fluence measurements 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. The fluence (efficiency) has now been determined with an uncertainty of less than 0.1%. The solid angle uncertainty is about 0.1%.

The ^{6}Li(n,t) cross section measurement is made using solid state detectors and a thin 6Li target. The limitation on the accuracy of the ^{6}Li(n,t) cross section measurement is the mass uncertainty of the ^{6}Li target. The present uncertainty is about 0.25%. It is expected that an uncertainty less than 0.3% for the cross section can be obtained from this experiment.

(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.

Fluence Determination Work

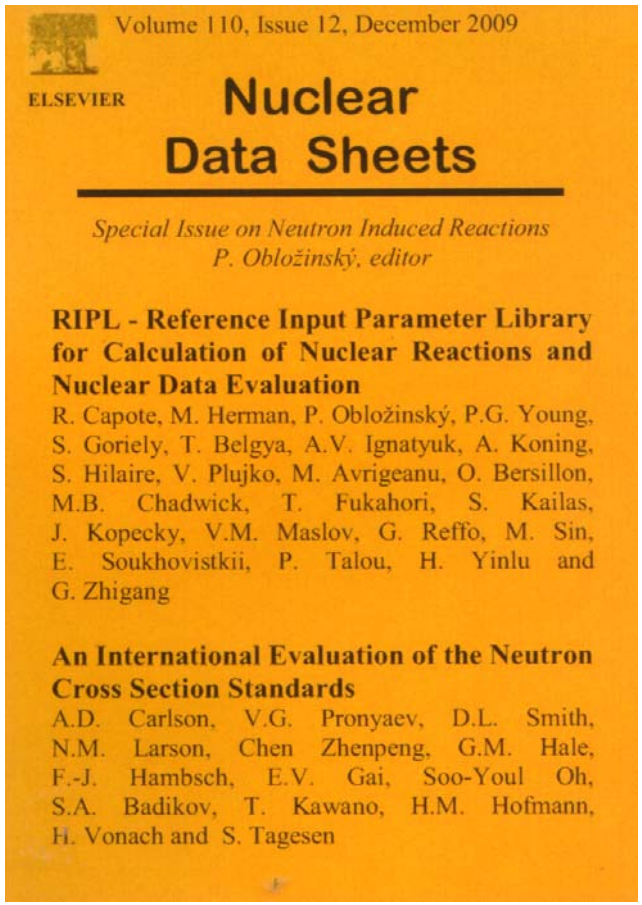
•Improvements in the determination of the source strength for NBS-I are now underway. This work will have an impact on cross section measurements that have used this source as a standard and any future measurements made using this source.

•Additional work is now underway on an independent determination of the neutron intensity of NBS-I for comparison with the established value obtained from manganese sulfate bath measurements and calculations. The new work is in principle only limited in accuracy by the uncertainty in nu-bar of ^{252}Cf, 0.12%. The determination is being 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. Preliminary results indicate a 1.7 % difference with a 0.9 % uncertainty for this determination compared with the NBS-I value. It is expected that a 0.3% uncertainty in the calibration will be possible.

•Comparing the results obtained using the various fluence measuring methods available at NIST with that obtained using this ^{252}Cf method can provide an independent determination of nu-bar for ^{252}Cf, but significant effort, would be required to improve its uncertainty.

Nuclear Reaction Activities: Neutron Cross Section Standards –Evaluations

•A comprehensive paper has been written for publication in Nuclear Data Sheets. This work documents the activities that led to the international evaluation of the neutron cross section standards. The standards and other evaluated data from this effort became ENDF/B-VII files. The paper will be one of two papers in the December issue of the journal.



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

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

•A Talk, “Fission Cross Section and Spectrum Standards” was given at the LANL-LLNL Fission Workshop, February 3, 2009 at Los Alamos Research Park.

•A section is being written for a special edition of the journal Metrologia on Neutron Metrology. The section will discuss the neutron cross section standards - how they are measured, evaluated and used.

The Nuclear Data Development Project, "Maintenance of the Neutron Cross Section Standards".

Work continues on:

- Updating of the standards database.
- Comparing measured and calculated fission neutron spectra
- Investigating accelerator-based neuron sources vs fission neutron spectra
- Reference cross sections for gamma-production cross section measurements
- Extension of Au(n,γ) cross sections as reference cross sections for astrophysics
- Smoothing procedures for ^{238}U(n,γ) and Au(n,γ) cross sections
- Use of the covariances from the standards evaluation
- The next Consultants' meeting is scheduled for November 2010

Other Work

•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 a member on the International Program Committee for the 2010 International Conference on Nuclear Data for Science and Technology. Also a summary has been submitted for that conference, “An Update of the Nuclear Data Standards Activities”, which describes the activities of the Nuclear Data Development Project, “Maintenance of the Neutron Cross Section Standards”.

•NIST has two members on the International Program Committee for the International Symposium on Radiation Dosimetry, ISRD-14 (2011).

Recommendations

•Though the international evaluation of the standards has been completed, maintaining an active program of measurements and evaluation activities is essential for improvement of the standards. We maintain a modest experimental program and encourage work on the standards through collaborations and independent research. Some of the evaluation activities are being done under the IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards". This project will pursue improvements in the experimental database, consider additional standards, maintain evaluation codes and periodically update the standards so they are available for new versions of nuclear data libraries.