NIST Nuclear Reaction Data Activities

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Evaluation activities

The ENDF/B-VI standards evaluation was completed in 1987. At that time evaluations were produced for all the standards, i.e. H(n,n), ^{3}He(n,p), ^{6}Li(n,t), ^{10}B(n,α), C(n,n), Au(n,γ), and ^{235}U(n,f). Some additional important reactions were also evaluated. Many important standards measurements have been made since the completion of that evaluation. Studies have shown that some of these data will cause important changes in an evaluation of the standards. This has caused concerns about the quality of the standards and the need to improve them. This led to the formation of an international collaboration effort to update the ENDF/B-VI standards evaluation by including standards measurements performed since that evaluation was completed. Efforts to increase participation and improve the structure of the collaboration are underway. Much of the work so far has been focused on investigating the database, finding the experimental data through papers, reports, etc and examining them so the data can be prepared for use in the evaluation. A detailed investigation of the experiments will be done to determine uncertainties and correlations within and among data sets. The evaluation procedure to be used is still under study. One proposal which is being given serious consideration is to follow a procedure similar to that used for the ENDF/B-VI standards evaluation. The standards would then be obtained by combining the results of a simultaneous evaluation and R-matrix analyses. The simultaneous evaluation would allow ratio measurements, shape and absolute data to be included properly. The R-matrix analyses would provide a method that allows charged-particle measurements, including angular distribution and polarization work, involving the same compound nucleus to be included in the evaluation. The simultaneous evaluation program, the R-matrix program and the databases used in the ENDF/B-VI evaluation are all available for the new evaluation. Consideration is being given to an improved way of doing the combination process. A new evaluation of the H(n,n) cross section by Hale is already underway at LANL. This evaluation is being done independently of the process described above. This charge independent R-matrix evaluation makes use of a large data base of n-p and p-p experimental data. The evaluation will extend to about 150 MeV neutron energy. Since this cross section is being evaluated, all measurements in the simultaneous evaluation and the R-matrix analyses which were measured relative to the hydrogen standard will have to be converted to cross sections using the new hydrogen standard. In addition to the H(n,n) work being done by Hale, some work has been done on other standards for energies above 20 MeV. This work was driven by the need for cross section measurements in this energy region where there is a lack of standards. The concern led to an IAEA consultants meeting. The limited scope and manpower available for that work did not allow evaluations to be made. But a study was done of the database for possible standards which led to some recommendations and the fitting of data to provide useable standards in this energy region. More work needs to be done to improve these standards.

Measurement Activities

There have been some concerns expressed about the ENDF/B-VI hydrogen scattering cross section. The concern is greatest at back angles, near 180°in the CMS, from about 10 to 15 MeV neutron energy region. This cross section is one of the most important neutron cross section standards and it is frequently used at 0°in the laboratory system which corresponds to 180° in the CMS . New measurements are needed to resolve these concerns for standards applications and for a better understanding of the very basic interaction of neutrons by hydrogen. Measurements have been completed of the hydrogen scattering cross section in a Ohio University-NIST-LANL collaborative experiment. These measurements were made at 10 MeV neutron energy at the Ohio University Accelerator Laboratory. The D(d,n) neutron source reaction with a gas target cell is being used as the neutron source. The differential cross section was measured at 11 angles simultaneously with ΔE-E detector telescopes at each angle. This removes problems associated with the very accurate monitoring of the neutron beam intensity which was required with a number of previous experiments for which data were taken one angle at a time. Measurements were made at laboratory angles of 0°, and at equivalent angles on both sides of the neutron beam axis of ±12°, ±24°, ±36°, ±48° and ±60° in order to provide consistency checks on the results. These angles correspond to the range from 180° to 60° in the center of mass system. The data are now being analyzed. Preliminary results appear to be in best agreement with an evaluation by Arndt. Plans are being made for an extension of this experiment to 14 MeV neutron energy after the 10 MeV data analysis has been completed. This will allow direct comparisons with the data sets which caused the large cross sections at back angles in the CMS for the ENDF/B-VI evaluation.

The most accurate measurements of coherent scattering lengths have been made using a special neutron interferometer at the NIST Neutron Interferometry and Optics Facility. Measurements have been made for silicon and ^{208}Pb. For silicon, the coherent scattering length was determined to an accuracy of 0.005% which is an improvement of a factor of 5 in accuracy compared with the best previous measurement. The coherent scattering length is related to the phase shift and can be used directly in certain analysis codes, such as R-matrix analyses, for evaluation of nuclear cross sections. They were used in the H(n,n) evaluation by Hale and in the ^{235}U(n,f) evaluation work by Moxon.

A cryogenic calorimeter has been built so that more accurate determinations of the neutron fluence can be obtained. With the calorimeter the neutron fluence is determined from the heat produced from the ^{6}Li(n,t)^{4}He reaction by monoenergetic neutrons (~ 4 meV) absorbed in a ^{6}Li target which is black to neutrons. The goal is to measure the neutron fluence to an accuracy of 0.1%. The artifact standard neutron source NBS-1 will then be compared with the total emission rate from this calibrated monoenergetic beam by using a manganese bath. It is expected that an improvement in accuracy of the NBS-1 standard source to a total uncertainty of 0.2% to 0.3% will be realized. The neutron beam can be used for very accurate cross section measurements. Also the improvement in the accuracy in NBS-1 will have an immediate effect on a large number of cross section measurements which were made using sources calibrated in baths which have been calibrated with NBS-1.