Summary of the 2013 IAEA Standards Technical Meeting

Plans for the Next International Standards Evaluation

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of
The CSEWG meeting
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Summary of 2013 IAEA Technical Meeting

- In order to improve the standards on a continuing basis, an IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards" was initiated.
  - 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 data libraries.

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International Atomic Energy Agency

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INDC International Nuclear Data Committee

Summary Report from the Technical Meeting

Toward a New Evaluation of Neutron Standards

8 – 12 July 2013
IAEA, Vienna

Attendees of the IAEA Technical Meeting on a New Evaluation of the Neutron Standards

Summary of the 2013 IAEA Technical Meeting

The topics of the meeting were:

- Updating the standards experimental database.
- Update for an evaluation of the ^{252}Cf spontaneous fission neutron spectrum.
- Update for an evaluation of the ^{235}U(n_{th},f) neutron spectrum.
- Adding "Reference" cross section to our evaluation effort. These do not have the quality of the standards but they are convenient for certain applications.
    - Reference cross sections for measurements of prompt gamma-ray production cross sections.
    - Au(n,γ) reference cross section for capture cross section measurements for astrophysics (below the standards energy region).

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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,α$_1$γ)	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

Summary of the 2013 IAEA Technical Meeting

- Updating of the standards database.
  - All the experiments completed or underway since the completion of the standards evaluation were reviewed.
    - The experiments suggest improvements have been made for the H(n,n), Li(n,t), ^{10}B(n,α), Au(n,γ), and ^{238}U(n,γ) cross sections.
    - There are inconsistencies for the ^{3}He(n,p), C(n,n), ^{238}U(n,f) and ^{239}Pu(n,f) cross sections.
    - These experiments will be discussed in the Measurements Committee session

Summary of 2013 IAEA Technical Meeting

- Neutron spectra

  - No new measurements have been completed of the ^{252}Cf spontaneous fission neutron spectrum. There are new measurements of the ^{235}U(n_{th},f) neutron spectrum made by Kornilov et al. and Vorobyev et al.

  - The most recent measurements of the ^{235}U(n_{th},f) neutron spectrum have been made with a ^{252}Cf source located outside the beam. Thus ratio measurements of these spectra were obtained. The GMA code is being used for a simultaneous evaluation of these two fission spectra by Pronyaev.

  - A separate Baysean approach for evaluations of these spectra will be used by Mannhart

  - The evaluation of the reference spectra in this project will contribute to the CRP on evaluation of PFNS for a wide energy range of incident neutrons and for a number of nuclides. For the CRP, PFNS models are required and this reference evaluation can be used to test PFNS models.

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- Reference cross sections for measurements of prompt gamma-ray production cross sections.
  - Many nuclides and reactions were considered
    - ^{nat}Ti with large yields of two gamma-lines, 984 keV from ^{48}Ti(n,n'γ) and 160 keV from ^{48}Ti(n,2nγ) and ^{47}Ti(n,n'γ) reactions appears to be one of the most suitable for use as a reference cross section. More work needs to be done to improve the experimental database.
      - New measurements by Nelson using GEANIE have been made and are being analyzed.
      - An improved evaluation by Simakov has been done.
    - Li(n,n'γ) also appears to be a reasonable candidate
      - New measurements have been made by Nelson with GEANIE
      - There is little high quality data at higher neutron energies except the Nelson work

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- Au(n,γ) reference cross section for capture cross section measurements for astrophysics (below the standards energy region)
  - The measurements cited below all support the results of the standards evaluation. They indicate the Ratynski and Käppeler results are low by about 5-7% from 15 to 25 keV.
    - Wallner using AMS with a simulated Maxwellian neutron source spectrum of 25 keV mean energy obtained a ratio to the standards evaluation for gold capture of 1.04 ± 0.05
    - Lederer reanalyzed n_TOF gold capture data of Massimi and folded a simulated Maxwellian neutron source spectrum of 25 keV mean energy into that data. The result was 564 ± 23 mb compared with the standards evaluation of 575 mb. That is a 2% difference with an uncertainty of 4%.
    - The Au(n,γ) cross section measurements of Borella et al. support the standards evaluation. Schillebeeckx repeated that experiment of Borella et al. with considerable concern about corrections to the data. The new results support the standards results and the Borella et al. data.

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- Other cross sections being considered for reference cross sections status
  - The $^{27}Al(n,\alpha)$ reaction cross section is considered by many experimenters as a reference cross section for activation measurements. Evaluation of the cross section and covariance matrices was done for the Neutron Dosimetry library by Zolotarev and can be used as a reference cross section.
  - The $^{209}Bi(n,f)$ cross section is being considered as a possible reference reaction above 20 MeV . It has applications for the development of accelerator-driven systems with liquid lead being used. In 1997 it was pointed out that this cross section could be a useful reference standard in the neutron energy region above about 50 MeV. More data are now available so an improved evaluation should be possible.
  - Pb(n,f) also shows some promise.

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- Cross Section Evaluations
  - A new R-matrix evaluation for $^{1}H+n$ with covariances will cover the energy range up to 200 MeV. The evaluation will be done by Hale and Paris. Covariances will be available
  - An evaluation of the ^{nat}C standard will be produced from separate R-matrix isotopic evaluations for the $^{12}C+n$ and $^{13}C+n$ systems by Hale and Young. Covariances will be produced.
  - The $^{6}Li(n,t)$, $^{10}B(n,\alpha)$, $^{10}B(n,\alpha_1\gamma)$, $Au(n,\gamma)$, $^{235}U(n,f)$ and $^{238}U(n,f)$ standards will again be produced using the improved combination procedure developed for the previous standards evaluation. The $^{238}U(n,\gamma)$ and $^{239}Pu(n,f)$ non-standards will also be produced
    - GMA will be used for the simultaneous non-model input
    - For the R-matrix input, the EDA code by Hale will be used and possibly 2 additional codes:

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- Cross Section Evaluations (cont.)
  - The two additional R-matrix codes will require some changes before they can be used in the combination procedure.
    - AMUR written by Kunieda has the options of treating the statistical and systematical uncertainties in two ways: with separate treatment of these two components as statistical and normalization and with covariance matrices constructed from these two components. However a method for adding polarization data must be added to this R-matrix code.
    - FDRR written by Xi and Tao needs considerable work before it can be used. Improvements must be made in the handling of uncertainties and it does not produce output covariances. This code is still in the developmental stage.

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- Milestones for the Standards Release
  - **July 2014 -** Deadline for submission of experimental data to be included in the **preliminary** GMA fit of standards. Hydrogen data must be available at this time for the R-matrix evaluation.
  - **December 2014 – Deadline for submission of experimental data** to be included in the new standard and reference evaluation.
    - A Technical Meeting will take place to discuss:
      - The R-matrix evaluations
      - Preliminary GMA fit with inclusion of all data
      - Preliminary combined least squares fit of ^{252}Cf(sf) and ^{235}U(n_{th},f) prompt fission neutron spectra
      - Preliminary least squares fits of (n,n'γ) reference gamma-ray production cross sections
      - Preliminary evaluation of other reference cross sections
  - **January 2016** - Release of the standard and reference evaluations for validation

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- Milestones for the Standards Release (cont.)
  - **Summer 2016 -** The final technical meeting will be held.
    - Participants will decide about the final release of standards and reference evaluations. To avoid a delay in the release of the evaluation, the description of the evaluation will be summarized in the last meeting report and the working papers presented at the meeting. They will be published electronically.
    - The final evaluation of standards and reference data will include evaluated cross sections, spectra and uncertainties in tabular form, and in the ENDF-6 format.
  - A report of the activities at the meeting with all the contributions (through hyperlinks) of the participants is available at: http://www-nds.iaea.org/publications/indc/indc-nds-0641.pdf

Recommendations

- Though a new international evaluation of the standards is now underway, it is important to think to the future by continuing to maintain an active program of measurements and evaluation activities for improvement of the standards.

- Some of the evaluation activities will be done under the IAEA Nuclear Data Development Project "Maintenance of the Neutron Cross Section Standards". This project is important since it allows improvements in the experimental database, considerations for additional standards, the maintenance of evaluation codes and periodic updates of the standards so they are available for new versions of nuclear data libraries.