Minutes of the Nuclear Reaction Data Working Group (NRDWG)

Brookhaven National Laboratory
April 27, 1998

Chair: Mark Chadwick, LANL

Present: Michael Smith (ORNL), Connie Kalbach (Duke University), Allan Carlson (NIST), Robert MacFarlane (LANL), Robert Haight (LANL), Steven Grimes (Ohio University), Said Mughabghab (BNL), Eric Norman (LBNL), Peter Parker (Yale), Pavel Oblozinsky (IAEA), Vicki McLane (BNL), Mulki Bhat (BNL), Charles Dunford (BNL), Don Smith (ANL), Gerry Hale (LANL), Walter Henning (ANL), Mark Chadwick (LANL), Craig Stone (San Jose State University).

Summary

Progress reports were presented by each participant describing their recent work as part of DOE-ER's Nuclear Data Program. Following this, we had a discussion to determine the resources available within the NRDWG - that is, supported FTEs, collaborative opportunities with other researchers (U.S. and foreign), and "leveraged" support through overlapping interests with nuclear data work funded by other programs within the U.S. (e.g., DOE-Defense Programs). The major part of the meeting was devoted to discussing the needs of the various user-communities of nuclear reaction data: astrophysics; radioactive-ion beams; medical applications (radiotherapy and medical isotopes), as well as new spallation neutron source and accelerator-driven facilities, and users of standards data. The need to ensure that user communities, whether basic or applied, collaborate in a serious way by providing their own resources (time/funding) to collaborative efforts to develop nuclear reaction data was stressed. There was a consensus for the need to develop a WWW-accessible archive of nuclear reaction modeling codes that have played a key role in providing evaluated nuclear reaction data for a variety of user communities. Such statistical and preequilibrium modeling codes will be useful for users who wish to run these codes themselves for obtaining cross section predictions, and will also be useful for those groups developing their own reaction codes who can make use of well-documented and archived subroutines. Input to the Dissemination Working Group was provided, where we discussed forthcoming dissemination needs for providing WWW-access to: nuclear modeling codes and RIB-relevant data. (Issues specifically relevant to astrophysical reaction data dissemination are being worked out by the Astrophysics Task Force with the Dissemination Working Group). The usefulness of international collaborations, often organized under the auspices of the IAEA and the NEA, was discussed. These collaborations enable U.S. researchers to stay abreast of important developments in the wider international nuclear data communities. Large amounts of experimental and evaluated reaction data obtained from foreign data program efforts are obtained at the NNDC for use by U.S. data users. We noted that it is critical that the NNDC continue its important role in compiling measured cross sections (particularly charged-particle induced reaction data), references to publications of data, and its maintenance of the ENDF databases.

Priorities for work in the Reaction Data Working Group in the coming months:

Astrophysical Data

Michael Smith summarized some of the plans that emerged from the recent San Jose meeting, where a consensus was obtained for initiating a new coordinated effort to compile, evaluate, calculate, and disseminate data for astrophysical needs. The particular expertise that workers at each laboratory/university are able to contribute was summarized. Plans to have an outside steering committee to help guide the Astrophysical Task Force were also described.

Some of the particular expertise that can be provided by the Nuclear Data Program include:

- ANL: H and He -burning reactions, emphasis in the A=30-50 region, for understanding stellar explosions.
- BNL : Archiving astrophysical data.
- LANL: n, charged-particle capture reactions with R-matrix analyses, masses and decay properties, levels for A<20, Hauser-Feshbach calculations.
- LBNL: Setup and maintenance of WWW site, evaluation and compilation of structure and decay data.
- LLNL: Calculation of rates from cross sections, development and use of new statistical model code for Hauser-Feshbach calculations.
- ORNL: Evaluation of reaction rates for radioactive isotopes for explosive nucleosynthesis, H and He burning cross sections.
- TUNL: Evaluating S-factors for light nuclei.
- UC Santa Cruz: Hauser-Feshbach calculations, methods to represent reaction rates.

A formal proposal from the Astrophysical Task Force to the DOE will be submitted this summer.

Radioactive Ion Beam Data

To date, the RIB Task Force has interacted with researchers at ORNL, primarily Jerry Garrett. At his request, nuclear reaction cross sections for producing various proton-rich products through (p,xn) reactions have been evaluated, through nuclear model calculations benchmarked to measurements where they exist. Additionally, a compilation of nuclear properties (masses, separation energies, decay properties..) relevant to RIB physics has been completed and published by Moller et al.

In general, a wide-ranging effort on RIB target design is going on around the world, and the NRDWG should keep abreast of these developments and provide data support where necessary. Some of the RIB production-target issues are being coordinated by the OECD MagaScience Forum (Rick Casten is on their working group). The NRDWG could play a stronger role here. In the U.S. proposals for a new ISOL facility are expected to be due by May 1999.

Future needs from this user-community include:

1. Additional data for RIB target design. Chadwick will be meeting Garrett in early May to discuss additional needs at ORNL.

2. Contact should also be made with researchers at ANL, such as Jerry Nolen.

3. Codes such as LAHET, MCNP and HETC are used in RIB target/facility design studies. The ENDF databases are used by these codes. New improved data to higher energies (150 MeV) developed at Los Alamos under DOE-DP funds for accelerator-driven technologies could be used for more accurate predictions of certain important quantities, such as radionuclide production, activation, and shielding requirements.

4. An extension of the work by Moller et al., to include first-forbidden beta decay properties will be important for RIB-and-astrophysics; many of the ingredients needed for such a set of calculations, such as wavefunctions and Q-values, are already in place.

5. A new extensive database of radionuclide production cross sections for incident protons and incident neutrons, on a wide range of target nuclei (over 600 isotopes), should be made easily WWW-accessible for RIB target-design users. If stored in the ENDF format, then graphical and processing codes that exist at the NNDC can be used to access and view these data.

Medical Application Needs for Data

This is another area selected by the OECD MagaScience forum as an area of emphasis. It was also highlighted in the last NSAC Report.

Workers in the NRDWG have already interacted with users in the medical physics community to provide data of importance in proton and neutron radiotherapy. In addition to nuclear model calculations and evaluations of data needed for radiation transport simulations of particle beam therapy, developed in collaboration with medical physicists for the International Commission on

Radiation Units, other work has involved: studies of neutron sources from accelerated-protons on Be for boron-neutron-capture therapy; use of measured charged-particle production cross sections to infer kerma coefficients for neutron energy deposition; and use of the NJOY code to determine neutron heating from ENDF evaluations.

A future priority is the development of photonuclear data for studies of photon therapy, particularly for energies up to 25 MeV, needed for calculations of absorbed dose in the body, and for radiation protection needs because of the photoneutrons produced. Users in the medical community are actively seeking collaborations in this area and have committed to providing a graduate student from MIT to collaborate on developing the required data.

Photonuclear data are also of importance in astrophysics, as well as in certain proposals to make medical isotopes. Also, this is a leveraged area since DOE-DP is partly supporting the development of such data for accelerator-shielding needs. In addition to work at Los Alamos, an experimental data compilation at Livermore has been developed, and BNL also has archived much of the measured data that will be useful in guiding the nuclear model calculations.

Nuclear Reaction Modeling Codes

There was a consensus for the need to develop a WWW-accessible maintained archive of statistical nuclear reaction modeling codes, and a Task Force has been established for this purpose.

Nuclear model codes play a key role in the evaluation of data for a wide variety of users. They should be maintained and enhanced as new theory developments are made, and continually benchmarked to existing measured data.

Some of the motivations for archiving such codes are:

1. There are a number of efforts to develop new reaction modeling codes, e.g., at LLNL for astrophysics Hauser-Feshbach calculations, which will benefit from such a resource.

2. Codes get lost if they aren't archived. It is an appropriate time for Kalbach's PRECO preequilibrium modeling code to be archived for ease of access and use. HMS-ALICE, a widely-used reaction modeling code, needs to be archived now that Marshall Blann has retired. Codes maintained by labs, such as GNASH at LANL, are more likely to survive in the long run, whereas "private" codes die.

3. The IAEA has recently published a library of fundamental parameters needed in statistical model calculations (e.g., level densities, optical models..), known as the Reference Input Parameter Library (RIPL). An archived set of codes that utilize these data would be a valuable complement to this IAEA compilation.

4. Many people would like to have easy access to download and run these codes themselves. We should make this possible and provide the necessary education for outside users to do this.

   We will work with BNL and the dissemination committee to establish a plan for this.

Archiving of Experimental Reaction Cross Section Data at the NNDC

Vicki McLane described how large amounts of measured reaction cross section data are being provided to the NNDC by foreign nuclear data workers through bilateral agreements between the various international Data Centers. This is extremely important and useful for the USA - experimental nuclear physics measurements must by archived, and in addition, some of the data are obtained from countries of the former Soviet Union which were previously unavailable in the West. As part of these same international collaboration agreements, McLane is providing NNDC databases, and retrieval software, to the foreign Data Centers.

Mulki Bhat described his work to generate support for archiving heavy-ion reaction data at the NNDC. Some “trial” compilations of AGS data have been performed.

Additionally, Walter Henning encouraged the NNDC to pursue the possibility of helping to archive future data from CEBAF, and offered to discuss this with researchers at CEBAF.

Nuclear Standards Data

Nuclear standards data are widely used by experimentalists when measuring neutron cross sections to determine the neutron fluence. The cross section standards within the ENDF/B-VI library are adopted internationally and play a fundamental role in other ENDF/B-VI evaluations which were developed to be consistent with the standards. However, recent experimental data pertaining to some of the cross section standards has resulted in a need to update and revise them: (1) The H(n,n) elastic scattering cross section above 90 MeV, and at back angles, is inconsistent with new measurements from Uppsala University and PSI by up to 10%. Also, there are international concerns about this standard in the 10-15 MeV region -- Preliminary results at 10 MeV of a LANL-NIST-Ohio U. collaboration deviate from the ENDF/B-VI evaluation; (2) The 238U and 235U neutron fission cross sections are inconsistent with new high-accuracy data from Los Alamos in the 15-20 MeV region; (3) Several new measurements have improved the 10B(n,alpha) database, which caused significant problems in the ENDF/B-VI standards evaluation process.

Allan Carlson discussed possible ways that the standards might be updated by following the general procedures used in the ENDF/B-VI evaluation, within an international collaborative effort. Insufficient resources are available to proceed as a solely U.S. effort, though Carlson and Hale would play key roles in a future effort. Other researchers in Japan and in Europe are interested in the collaboration. Carlson will explore possibilities of coordinating this work through either the NEA (as part of the Working Party on Evaluation Cooperation), or the IAEA. The subject will also be discussed in detail at the October CSEWG meeting.

Synergy with DOE-Defense-Programs-Supported Data Evaluation and Other Applications

Work is being supported at Los Alamos and Livermore to evaluate nuclear reaction data for Science-Based Stockpile Stewardship (SBSS) needs and for the Accelerator-Production of Tritium (APT) program. These data are being archived within the ENDF system at the NNDC, and since in many cases the data have a wider use than in just Defense Programs, they will be a useful resource for the wider nuclear physics and nuclear technology communities. For example, researchers designing the new Spallation Neutron Source at ORNL have sought access to the new high-energy data for design studies of the mercury spallation target. Likewise, much of these same data are useful for RIB target design, for medical applications involving external beam radiotherapy and accelerator-based transmutation of waste (ATW) proposals that are currently under study in Europe, Japan, and the USA.

New U.S. Experimental Reaction Measurements

Updates of recent U.S. measurements at Los Alamos were provided by Robert Haight and Steven Grimes including: (n,x gamma) measurements using the GEANIE detector at the Weapons Neutron Research facility, for nuclear reaction and nuclear structure physics studies; a comprehensive suite of neutron total cross section measurements from 6 - 600 MeV for over 35 target elements; (n,charged-particle) reactions for a range of targets from Los Alamos. These data will be archived at the NNDC. Steve Grimes also described ongoing experimental work at Ohio University, including n-p scattering measurements and neutron source characterizations.

The Los Alamos charged-particle emission data are used to infer nuclear level densities for excitations up to about 20 MeV, and are thus of importance to nuclear model calculations that depend sensitively on level densities. Said Mughabghab presented an interesting talk on the role of the spin cut-off parameter in inferring nuclear level densities from resonance information, and related uncertainties in the level density parameter to model calculations of neutron production in nuclear reactions.

Key Input for the Data-Dissemination Committee Meeting:

1. We have a new RIB target production-cross-section database that we would like to see on the WWW.

2. A new resource for archived nuclear modeling codes is needed. This would be maintained by the NNDC, and would allow a user to download the codes as well as documentation guiding their use.

3. Excellent recent progress has been made by the NNDC in WWW access to manuals, ENDF, etc. A next priority is WWW access to the experimental data in the CSISRS database - the NNDC expects to have this available shortly.

4. A new home page is needed to reflect the existing nature of the Nuclear Data Program and the Nuclear Reaction Data Working Group. This might also include a set of examples to illustrate the various potential uses of nuclear reaction data, and where a user would look to find out more about data resources available for each subject area.

Attachment: A selection of viewgraphs from the talks are attached to the minutes.