The NNCSC: its history and functions

by S. Pearlstein

Neutron data is extensively used in the design of nuclear power systems and in nuclear physics studies. The National Neutron Cross Section Center, located at Brookhaven National Laboratory in Upton, L.I., N.Y., is a central repository for such data, which is usually in the form of cross sections (neutron-nucleus reaction probabilities). Supported financially by the Divisions of Research and Reactor Development and Technology of the U.S. Atomic Energy Commission, the NNCSC maintains two large data pools—one for experimental neutron data, the other for evaluated neutron data. By way of brief explanation, evaluated data consist of documented interpretations of experimental data and/or nuclear model calculations that are used to produce a set of data for characterizing nuclear properties in scientific studies.

Background

Neutron data compilation was started at BNL in 1951 by D. J. Hughes as a supplementary activity to the neutron measurement program in the Physics Department. Up to his death in 1960, the compilation activity was moved to what is now the Department of Applied Science (DAS) and organized as the Sigma Center. At the same time, a companion group, specializing in cross section theory and data evaluation, was organized and later became known as the Cross Section Evaluation Center.

The computer facilities at the NNCSC permit requests for information to be expeditiously handled

In September 1967 these two centers were merged to form the National Neutron Cross Section Center. In order to strengthen its ability to meet the expanding data requirements of the USAEC and contractors, this new Center was given the status of a division within the Department of Applied Science at BNL. An advisory committee was appointed by BNL to assist the NNCSC in adopting its program to meet the needs of the neutron cross section community. The members of this committee are R. Ehrlich (Knolls Atomic Power Laboratory), H. Goldstein (Columbia University), P. Greebler (General Elcetric Co.), G. C. Hanna (Chalk River Nuclear Laboratory, Canada), R. Lazarus (Los Alamos Scientific Laboratory), and A. B. Smith (Argonne National Laboratory). They meet regularly with the NNCSC staff to review the administrative and technical progress of the Center.

Organization and facilities

The NNCSC is organized into four main technical groups: Cross Section Theory, Cross Section Compilation, Cross Section Evaluation, and Computer Programming Applications—

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The NNCSC hosts meetings to coordinate cross section activities with other laboratories

plus an administrative staff. The personnel consists of 12 scientists, five professionals, and five nonprofessionals. For the last two years there have also been one or two industrial physicists resident at the NNCSC for an extended period while developing nuclear analysis techniques under the auspices of the USAEC Industrial Participation Program.

Recently a computer facility was installed at the Center. The fact that the NNCSC has exclusive use of this machine ensures reliable and efficient handling of the Center's large store of data.

Functions

The main objective of the NNCSC is the acquisition and dissemination of neutron data. NNCSC personnel routinely scan published and unpublished literature for experimental data; data are also received directly from experimenters. The Center generates and collects evaluated neutron data sets for use in physics or engineering calculations. A computerized system is maintained and continually developed for the storage, retrieval, and distribution of data. Data are distributed upon request in a variety of forms, such as listings, cards, tapes, and plots. In addition, the NNCSC publishes widely used compilations of neutron data.

An important corollary to the data file activities is the information analysis performed at the NNCSC. Its personnel develop or adopt new methods of cross section analysis, the results of which are made available to others through journal articles, topical reports, and specialized codes. This work has led to a better understanding of existing data and, more importantly, has resulted in estimates of quantities that have not been measured.

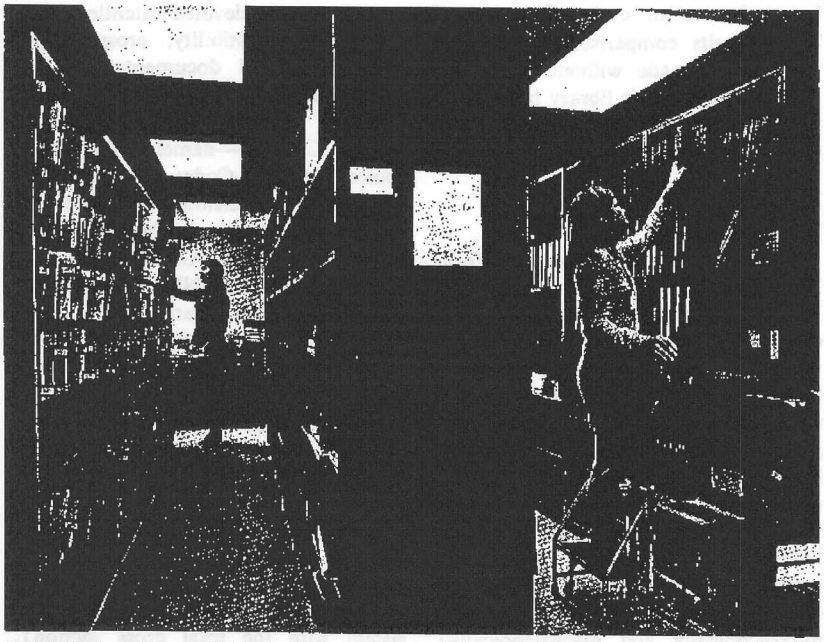
In practice the NNCSC has served as a point of interaction for measurers, evaluators, and users of neutron data. At meetings held regularly at BNL, the NNCSC coordinates many cross section activities with other laboratories. These working arrangements provide an effective basis for cooperation among industrial concerns, academic institutions, and governmental agencies.

Relationship to other centers

Prior to 1965 the BNL staff compiled neutron data produced throughout the world, an effort which accounts for over 80 percent of the present data file contents. There are now four neutron data centers in the world, each responsible for collecting data from a particular geographic area. [A data collection is determined by where the measurements are performed—not where they are published.] The National Neutron Cross Section Center collects data measured in the U.S. and Canada. The Neutron Data Compilation Center (CCDN), located at the Saclay Laboratory near Paris, France, collects data measured in Austria, Belgium, Denmark, France, Germany, Italy, Japan, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. The Center Po Jadernum Dannym (CJD), or Nuclear Data Center in translation, is the new name for the center located at Obninsk, USSR, and is responsible for collecting data from the Soviet Union. The Nuclear Data Section (NDS) of the International Atomic Energy Agency, Vienna, Austria, collects data from the remaining countries and to date has acted as liaison between the CJD and other centers.

There are formal agreements for the exchange of all published and author-released experimental neutron data between the four centers. The exchange of evaluated data, however, is limited to sets of data in particular categories. At the present time such exchange takes place between the NNCSC and CCDN, Australia, and India.

In the U.S. the NNCSC coordinates its activities with those of the Argonne Code Center (Argonne National Lab-



Published and unpublished literature containing neutron data are stored in the NNCSC library

oratory), the Radiation Shielding Information Center and the Nuclear Data Group (both at Oak Ridge National Laboratory), and is in timely contact with other information centers as needed.

The relationship of the NNCSC to other centers, experimenters, and evaluators is shown in the accompanying diagram.

Experimental data library

The experimental neutron data library already exceeds one million points and, as a result of automated experimental techniques, is expanding rapidly at a rate of approximately 200,000 points a year. The neutron data library consists mainly of resonance parameters and energy- and angle-dependent cross sections, although other types of information are also stored. An automated storage and retrieval system has been in use since 1964, but only recently have all available data been entered into the system. Information can be selected according to element, isotope, reaction type, energy range, reference, laboratory, and other criteria. Descriptive text and comments about the data are also part of the library.

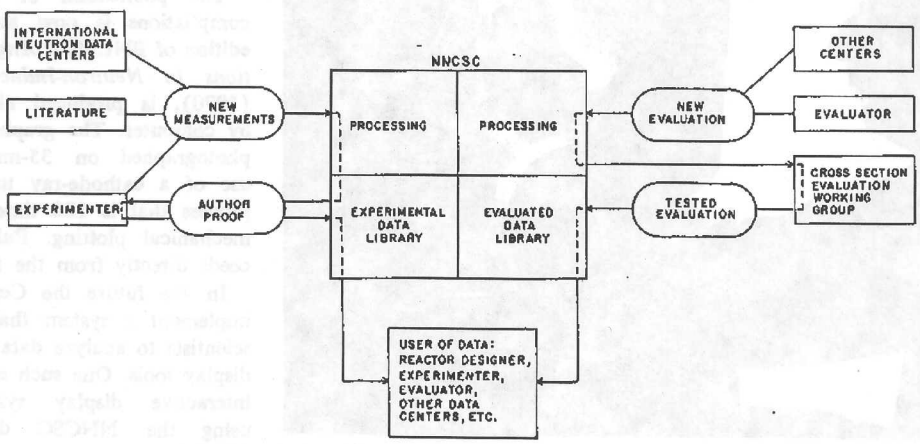
This system, however, is being superseded by an improved version which operates with a greater degree of flexibility. In addition it can retrieve many more types and combinations of information than was previously possible. The new system's requirements have placed a greater burden on hte Center's scientific staff, whose members must now make far more detailed specifications of the experimental information that is constantly received.* This new system is in trial use at the present time; when fully operational, it will be linked to the NNCSC's automated publication of data.

An important adjunct to the Center's storage and retrieval system is the "author proof" system. Basically, this procedure works as follows: After data are received from an experimenter and coded in the storage format, a listing and plot of his data are produced by computer and sent to him for comment. In this way the experimenter is given an opportunity to contribute to the accuracy and reliability of the data library. To date there has been excellent cooperation between the experimenter and the NNCSC in the review of proof material.

Evaluated data library

The Evaluated Nuclear Data File (ENDF) was started at BNL in 1964 by Henry Honeck. The purpose of this library is to place data sets from many different sources into a common format for use in neutronics calculations, thus establishing a link between the data library and processing codes. A flexible format that permits data to be specified in tabular form, power se-

*The NNCSC asks the cooperation of neutron data experimentalists (U.S. and Canadian) in sending new data to the Center (in tabular form, if possible).



The relationship of the NNCSC to other centers, experimenters, and evaluators

ries, and nuclear model formulas is used. A series of file maintenance programs in machine-compatible language is available to create library tapes and to check, correct, and convert the data into readable forms, such as expanded text listings and plots.

The ENDF library is divided into two parts, ENDF/A and ENDF/B, each using the same format. The ENDF/A library consists of data sets that may or may not have been extensively tested. For each isotope there can be more than one data set for a particular reaction from which to choose, but there may not be data sets for all important reactions through the energy range of interest.

The ENDF/B library is intended to provide a reference set of data for use in nuclear calculations. Data for approximately 80 isotopes are recommended for all significant neutron-induced reactions in the energy range 10^{-5} eV to 20 MeV. Included are some thermal scattering data, as well as photon interaction and production data. The library contains approximately 300,000 tabulated data points, with parametric representations of other data as well. After a one- or two-year period the data sets are revised on the basis of new information available. The use of a well-documented, single data set per isotope that can be used over an extended period of time permits comparisons of calculations to be made without ambiguity. Development of this library takes place through working arrangements with other U.S. laboratories.

Cross Section Evaluation Working Group

The Cross Section Evaluation Working Group (CSEWG) was organized in 1966 by the U.S. Atomic Energy Commission, Division of Reactor Development and Technology. Its membership consists of representatives from the data evaluation and/or user groups of approximately 20 laboratories, most of which are under AEC contract. CSEWG meetings are held at BNL about twice annually, with NNCSC personnel directing the proceedings. The main objective of CSEWG is to generate and test (both microscopically and macroscopically) new and revised data for the ENDF/B library. In support of the liquid metal fast breeder reactor (LMFBR) program, CSEWG devotes considerable effort to the comparison of calculated results with those from carefully selected integral experiments. In addition, ENDF/B data are tested in thermal reactors and in shielding and space applications.

There are many problems arising in the use of data to which CSEWG members have devoted attention, such as code compatibility, cross section formalisms, and documentation standards. Much of this work is accomplished by special subcommittees within CSEWG—namely, the Resonance Region, Codes and Formats, Data Testing, Shielding, and Normalization and Standards Subcommittees. In addition to the CSEWG meetings held regularly at BNL, separate subcommittee meetings are held at other times to explore problems in greater detail than is possible at the general meetings.

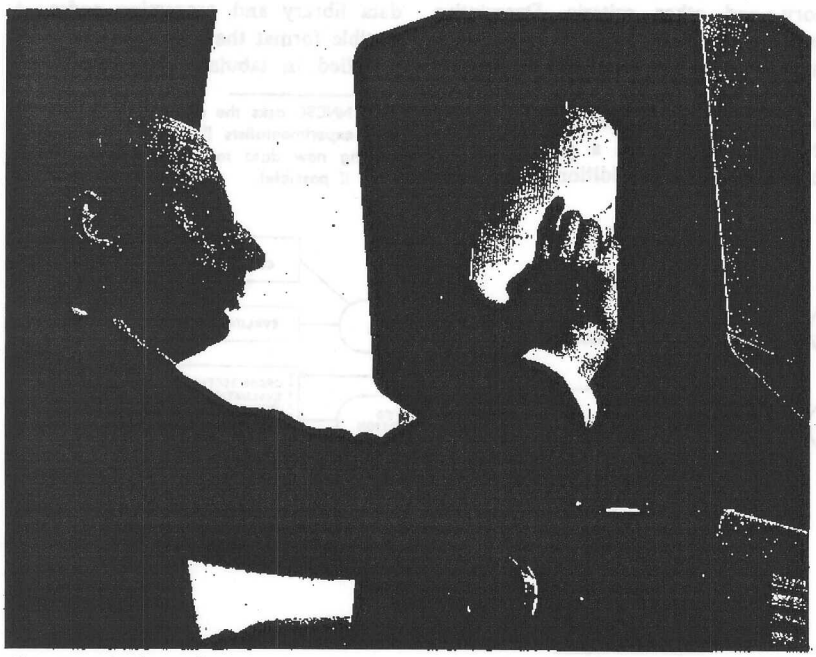
Another important CSEWG activity has been the review of data sets for the fissile elements. Before they can be considered reliable for calculation purposes, it is absolutely necessary that (1) the data in each set be consistent (i.e., the partial cross sections for any one isotope should be consistent with the total cross section), and (2) the ratios of a data set relative to another corroborate those ratios that are independently determined. To ensure consistency in some of these data sets, the NNCSC recently called together a group of experimenters to join CSEWG evaluators in making necessary revisions.

Automation

The NNCSC activities strongly emphasize the computerization of data processing. Computer codes perform comprehensive checks for consistency of the evaluated data by comparing the data with well-known empirical limits and theoretical values. Other codes are developed that perform least-squares fitting of the experimental data.

The publication of neutron data compilations is now automated. An edition of BNL 400, *Angular Distributions in Neutron-Induced Reactions* (1970), is produced almost entirely by computer. The graphics portion is photographed on 35-mm film with use of a cathode-ray tube device—a process that is 100 times faster than mechanical plotting. Publication proceeds directly from the film.

In the future the Center plans to implement a system that will permit scientists to analyze data by means of display tools. One such example of an interactive display system already using the NNCSC data files is SCORE.



Computerized graphics is extensively used in preparing material for publication