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NUCLEAR DATA PROJECT EVALUATION ACTIVITY REPORT *

Y.A. Akovali, A. Artna-Cohen, J.C. Blackmon, D. Radford, M.S. Smith, C.-H. Yu

Physics Division, Oak Ridge National Laboratory
Oak Ridge, Tennessee, 37831-6371, USA

This report summarizes the activities of the ORNL Nuclear Data Project since the IAEA Advisory Group meeting in October 1996. The group's future plans are also included.

The ORNL Nuclear Data Project's structure has changed greatly during the last fiscal year. The present Nuclear Data Project's responsibility includes the compilation/evaluation of astrophysics data, as well as the evaluation of nuclear structure data. The Nuclear Data Project, therefore, is composed of two groups. This change is very much in accord with the 1998 U.S. Advisory Report which recommended nuclear astrophysics to be a high priority of the U.S. Nuclear Data Program. The Nuclear Data Project staff through September 1998 is listed below.

	October 1996–September 1997		October 1997- September 1998	
Professional Staff:				
	Murray J. Martin [e,s]	(100%)	Murray J. Martin [g,s]	
			Yurdanur Akovali [s]	(50%)
			Jeffrey Blackmon [a]	(20%)
	Agda Artna-Cohen [c,s]	(50%)	Agda Artna-Cohen [c,s]	(50%)
			David Radford [s]	(30%)
			Michael Smith [a]	(20%)
			Chang-Hong Yu [s]	(10%)
	M. R. Schmorak [g,s]			
Technical Staff:	Mary Ruth Lay	(80%)	Mary Ruth Lay	(50%)

[e] Editor-in-Chief of the *Nuclear Data Sheets* (retired on July 31, 1997)
[s] Nuclear Structure evaluator
[a] Astrophysics evaluator
[c] Consultant
[g] Guest (unpaid consultant)

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The Nuclear Data Project activity report is divided into two sections. The first section covers the accomplishments of the **nuclear structure data** group for the period of October 1996 through September 1998; the activities and accomplishments of the **nuclear astrophysics data** group are summarized in the second section.

A. NUCLEAR STRUCTURE DATA

I. EVALUATIONS

Completed Work

- Critical evaluations of nuclear structure data pertaining to all nuclei with mass numbers 152, 193, 202, 216, 220, 224, 228 and 246 have been completed, and adopted data, levels, spin, parity and configuration assignments are presented in the following publications:

  Nuclear Data Sheets for A=152, Nucl. Data Sheets **79**, 1 (1996)
  Nuclear Data Sheets for A=216, Nucl. Data Sheets **80**, 157 (1997)
  Nuclear Data Sheets for A=220, Nucl. Data Sheets **80**, 187 (1997)
  Nuclear Data Sheets for A=224, Nucl. Data Sheets **80**, 227 (1997)
  Nuclear Data Sheets for A=228, Nucl. Data Sheets **80**, 723 (1997)
  Nuclear Data Sheets for A=202, Nucl. Data Sheets **80**, 647 (1997)
  Nuclear Data Sheets for A=193, Nucl. Data Sheets **83**, 921 (1998)
  Nuclear Data Sheets for A=246, Nucl. Data Sheets **84**, 901 (1998)

- An extensive review of alpha decay data from all doubly-even nuclei has been completed and published in *Nucl. Data Sheets* **84**, 1 (1998). This evaluation, which has a different mission than the traditional mass-chain evaluations, includes recommendations for half-lives and decay branchings of parent nuclei, as well as energies and intensities of alpha radiations. Nuclear radius parameters for their daughter nuclei and alpha-hindrance factors are calculated. Based on systematic behavior of the calculated radius parameters, irregularities indicating incorrect data and their probable causes are discussed. This systematic study is utilized also to calculate some unmeasured properties of observed alpha transitions and to predict some nuclear properties, such as half-lives, branchings and alpha intensities, for yet unobserved alpha decays of some neutron-deficient nuclei. The radius parameters for odd and odd-odd nuclei (which are essential for hindrance factor calculations) are to be obtained from local trends of the radius parameters for even-even nuclei.

- Evaluations of nuclei with mass numbers 248, 249, 251, 253, 255, 257, 259, 261, 263, and 265 have been completed and submitted to the Brookhaven National Laboratory National Nuclear Data Center. These evaluations have not been reviewed.

Work in Progress

- Nuclei with even-mass numbers 208, 252, 256, 260 and 264 are being evaluated.

Future Plans for Nuclear Structure Evaluations

- The nuclear structure data evaluations for the heavy-mass region will be completed with evaluations of the A=250, 254, 258, 262 and 266 nuclei.

  In accordance with the 1998 U.S. Advisory Report recommendations, and as an integral part of ORNL's forefront research program in nuclear structure physics, the nuclear structure data evaluations have been redirected. As soon as the work for the heavy-mass region is completed, instead of the traditional mass-chain evaluations, the following tasks will be taken:

- Nuclear-structure information for nuclei important to current research programs, in particular for nuclei in the far-from-beta-stability regions on both the neutron- and the proton-rich sides, will be evaluated.

- Systematic studies will be extended to evaluations of other nuclear properties with the purpose of providing a guide to researchers and evaluators and as a means of gaining new insight into nuclear structure phenomena. Horizontal evaluation of nuclear states will be the first of these planned studies.

II. REVIEWS AND EDITING

- Nuclear structure data evaluations for nuclei with mass 51, 58, 77, 84, 100, 101, 108, 120, 137, 146, 151, 186, 194, 224, 228 and 238 were reviewed and edited.

- The high-spin data for nuclei with 64 and 163 mass numbers were reviewed and edited

- The horizontal evaluation of alpha decay from even-even nuclei was reviewed.

- The evaluations appearing in the *Table of Isotopes* for nuclei with mass numbers 21-120 and A>121 were reviewed.

III. DATABASE DEVELOPMENT

- We have set up a FTP/www server site on the ORNL Physics Division local area-network for compilation and distribution of nuclear-structure data. The data on this site are in the "RadWare" "Graphical Level Scheme" format, which is very widely used by the international reaction gamma/nuclear structure community. Members of this community are being encouraged not only to make use of this service, but also to contribute their own data by anonymous FTP. Contributed data use the same format, accompanied by additional information describing, for example, the experiment(s) that generated the level scheme, the names and institutions of the researchers involved, and references to any publications of the data. Contributed data will not be evaluated in any formal way, but simply checked for internal consistency.

- As of September 30, 1998, the response to the site in terms of the number of contributed level schemes has been somewhat limited, resulting in only 24 schemes. It is hoped that efforts to publicize the service and to encourage RadWare users to submit their schemes will increase the activity. Efforts in this area are being coordinated with those of other centers to begin a compilation of non-evaluated nuclear structure data from recent publications.

- A selection of RadWare-format level schemes created from ENSDF files, by means of a conversion program, have also been placed on the site with the intent of generating a displayed level scheme. The response of RadWare users (nuclear structure experimentalists) has been very encouraging, with an average of about three file retrievals per day. There have been retrievals from at least 78 different computers over the past five months. Some restrictions in the present design of the RadWare format exist, if tabulation of data is requested. Extensions to the RadWare format to allow greater compatibility with ENSDF-type data are planned for the near future.

- On-line conversion of selected data sets from ENSDF-format to RadWare format is also being developed, with the aim of using this method to replace the present archive of ENSDF-converted schemes.

- The RadWare software for data analysis is also available to users. Documentation for Radware is given at http://radware.phy.ornl.gov.

SUMMARY OF THE NUCLEAR STRUCTURE EVALUATIONS

Previous Responsibilities of Nuclear Data Project

- Evaluations of nuclear structure information for nuclei with $A \geq 200$
- Scientific editorship of the *Nuclear Data Sheets*
- Text editorship of the *Nuclear Data Sheets*

Redirected responsibilities

- Evaluation of nuclear structure information that is of importance to community's research programs for nuclei in the far-from-beta-stability regions
- Horizontal evaluation of structure properties for nuclei in the far-from-beta-stability regions on both neutron- and proton-rich sides

B. NUCLEAR ASTROPHYSICS DATA

Overview

- We have a new program of evaluating and disseminating nuclear data of vital importance for studies in nuclear astrophysics. Research programs in nuclear astrophysics address some of the most fundamental questions in nature about the origins of the elements, about the formation and evolution of the solar system, the sun, the stars, and the galaxy. Measurements in the nuclear laboratory form the empirical foundation for the sophisticated theoretical models of these astrophysical systems. In many cases, however, new nuclear physics measurements are not rapidly disseminated to the research community nor rapidly incorporated into astrophysical models. For this reason, progress in many fundamental problems in nuclear astrophysics can be significantly aided by more effectively utilizing nuclear data. Our effort addresses this problem by providing new evaluations of important reactions and disseminating them to the research community in user-friendly formats that are easily incorporated into astrophysics models. Our evaluation work is initially focused on capture reactions on radioactive isotopes on the proton-rich side of stability-reactions that are important for understanding the element synthesis and energy generation in stellar explosions. Our work utilizes the latest advances in Internet- and www-based information services to disseminate evaluated data to the astrophysics research community. Lists of nuclear astrophysics data projects for the previous two fiscal years, and proposed projects for the current fiscal year, are given below.

Accomplishments

- A www site was established for nuclear astrophysics data. This site has the first electronic dissemination of one of the most important compilation of reaction rates (see below), links to other web sites relevant to nuclear astrophysics data work, and information on organizational activities in the nuclear data community. The address of this site is http://www.phy.ornl.gov/astrophysics/data/data.html.

- The first electronic dissemination of one of the most important compilations of reaction rates by G.R. Caughlan and W.A. Fowler [1] was provided. This site gives the information as originally published - the reaction rates in text format and in tabular values of rates versus temperature - as well as a downloadable FORTRAN subroutine of all ^{16}O of the reaction rates and their inverses.

- Analytic expressions were generated for the $^{14}O(\alpha,p)^{17}F$ and $^{17}F(p,\gamma)^{18}Ne$ stellar reaction rates by using the most recent indirect experimental measurements of relevant reaction parameters. These reactions can occur in the extremely hot, dense astrophysical environments where hydrogen is expected to burn explosively, such as nova explosions, supernova explosions, and X-ray bursts. Both reactions are targeted for measurements at ORNL's Holifield Radioactive Ion Beam Facility in the near future, and this evaluation work is an integral part of our preparation for these measurements. Our work gives the first complete expression for the $^{14}O(\alpha,p)^{17}F$ rate incorporating recent experiment information, and corrects an error (as large as 13% at high temperatures) in the previously-published $^{17}F(p,\gamma)^{18}Ne$ rate. A paper on this work has been published [2].

- The usefulness of our posting of the Caughlan and Fowler reaction rates was extended by adding GIF and Postscript plots of each of the rates. A technique to automatically generate plots of such reaction rates was developed, so future modifications may be done with ease. The temperature derivatives of these reaction rates were also calculated which are important for coupling nucleosynthesis calculations to hydrodynamics simulations to provide more accurate modeling of stellar explosions. These very complex rate derivatives are posted online in a text format, along with a downloadable fortran subroutine. We also created a graphical user interface based on the chart of the nuclides to allow users to search for rates of interest. Members of the research community have informed us that this online rate compilation has been very useful to their work.

- Our new evaluations of the $^{14}O(\alpha,p)$ and $^{17}F(p,\gamma)$ reactions were posted on our www site. We utilized the two most popular formats for analytical rate expressions that are currently used in astrophysics models.

- Evaluations of the 12 reactions of greatest importance to the synthesis of isotopes in the early universe [4] were posted on our www site for the first time, in a format that can easily input into astrophysics models.

- A new evaluation of the cross sections for the 19 reactions of greatest importance to the study of the solar interior has been made[6]. These cross sections will be converted into reaction rates in an analytical format, input into astrophysics models, compare the analytical approximations with the rates derived from numerical integration, determine the rate uncertainties from the cross section uncertainties, and examine the differences between these new rates and previous rates. Reaction Rates for these 19 reactions and differences between these new rates and previous rates will be posted in our www site.

- The U.S. Astrophysics Task Force which was chaired by M. Smith of ORNL, submitted a proposal to the DOE for Nuclear Astrophysics Data work involving five national laboratories (ANL, LBNL, LLNL, LANL, ORNL) and one university (University of California at Santa Cruz). A funding decision on this proposal is still pending. Previous efforts in organizing nuclear astrophysics data activities led by ORNL have included an extensive documentation of the overlap of expertise of the nuclear data community with the needs of the nuclear astrophysics community[5].

Future plans

- The $^{17}O(p,\alpha)^{14}N$ reaction is very important in determining the relative abundance of oxygen isotopes in the envelopes of red giant stars, which can be used as a tracer of the convection process occurring in these stars. This reaction is also important for interpreting oxygen isotope anomalies observed in meteorites. A recent measurement of this rate [3] changed the previous rate estimates by more than a factor of 10 at certain temperatures. Our work will give a complete expression for the current $^{17}O(p,\alpha)^{14}N$ rate incorporating all experimental information that can then be easily incorporated into astrophysics models. The final rate and plots will be posted online. This work was initiated in 1998 and will be completed in 1999.

A Nuclear Astrophysics Bibliography was initiated. It is being produced and will be posted on our www site. This will be a useful resource for producing evaluations of nuclear reaction and structure information important for astrophysics. This bibliography will include references to astrophysical journals and reports which are outside the normal scope of Nuclear Science References. The first phase of this project, which will include over 1000 references, will be completed and posted online in FY99, and it is anticipated that this bibliography will grow steadily in time.

Our future plans include evaluating reactions important for explosive hydrogen burning studies, such as $^{18}F(p,\gamma)^{19}Ne$ and $^{18}F(p,\alpha)^{15}O$, collaborating with Argonne National Laboratory on evaluations of explosive hydrogen burning reactions on isotopes with mass between 30 - 50, and continuing to provide disseminated data to the research community in user-friendly formats.

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