NUCLEAR DATA PROJECT ACTIVITY REPORT

March 1998–March 1999

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The present NDP's responsibility includes the compilation of high-spin data, compilation/evaluation of astrophysics data, as well as the evaluation of nuclear structure data. The Nuclear Data Project staff for FY 1998 and FY 1999 are listed below.

	FY 1998		FY 1999	
Professional Staff:				
	Yurdanur Akovali [s]	(50 %)	Yurdanur Akovali [s]	(50 %)
	Jeffrey Blackmon [a]	(20 %)	Jeffrey Blackmon [a]	(20 %)
	Agda Artna-Cohen[s, c]	(50 %)		
	David Radford[s]	(30 %)	David Radford[s]	(30 %)
	Michael Smith[a]	(20 %)	Michael Smith[a]	(20 %)
	Chang-Hong Yu[s]	(10 %)		
Technical Staff:	Mary Ruth Lay	(50%)	Mary Ruth Lay	(50%)

[s] Nuclear Structure evaluator

[a] Nuclear Astrophysics evaluator

[c] Consultant

The Nuclear Data Project activity report is divided into two sections. The first section covers the accomplishments and the future plans of the **nuclear structure data** group; the accomplishments and the future plans of the **nuclear astrophysics data** group are summarized in the second section for the period of March 1998 through March 1999.

A. NUCLEAR STRUCTURE DATA

I. EVALUATIONS

Completed Work

X Critical evaluations of nuclear structure data pertaining to all nuclei with mass numbers 193 and 246 have been completed, and adopted data, levels, spin, parity and configuration assignments are presented in *Nuclear Data Sheets* **83**, 921 (1998) and *Nuclear Data Sheets* **84**, 901 (1998).

X The horizontal evaluation of alpha decay data from all doubly-even nuclei is published in *Nucl. Data Sheets* **84**, 1 (1998) . This evaluation 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, tabulated and plotted as a function of neutron number for each element. 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 nuclear-structure data for nuclei with mass numbers 248, 249, 251, 252, 253, 255, 256, 257, 259,260, 261, 263, 264 and 265 have been completed and submitted to the Brookhaven National Laboratory National Nuclear Data Center. These evaluations are being reviewed.

Work in Progress

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

Plans for Nuclear Structure Evaluations

- The nuclear structure data evaluations for the A=250, 254, 258, 262 and 266 nuclei will be completed which will bring the structure information for the heavy-mass region up-to-date. These evaluations should serve basis for understanding of some nuclear properties from their systematic behavior in the region and for expectations of these properties in the heavier-mass region. Such studies should be valuable for contemplated experiments for nuclei in super-heavy regions when such programs will be feasible in a near future.

X Nuclear-structure information for nuclei important to current research programs in the far-from-beta-stability regions, and in a collaborative effort with the theory group at ORNL where calculations for the proton-rich nuclei with Z=32 - 41 have been carried, experimental nuclear-structure information for these nuclei in the far-from-beta-stability regions will be evaluated and compared with theoretical calculations. This will be in accordance with the 1998 Advisory Report recommendations, and is an integral part of ORNL's forefront research programs in nuclear structure physics.

II. DATABASE DEVELOPMENT

X The FTP/www server site on the ORNL Physics Division local area-network for compilation and distribution of nuclear-structure data has been set up. 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. The nuclear structure physicists are encouraged to make use of the service.

- The members of the reaction gamma/nuclear structure community are being encouraged 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 are not evaluated in any formal way, but simply checked for internal consistency.

- 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.

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

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

III. NUCLEAR INFORMATION PROGRAM

- An user nuclear information program, NUCI, has been created by W. T. Milner and M. R. Lay. The motivation for this work was to provide our local staff and visiting scientist with an easier and more rapid access to information contained in the Evaluated Nuclear Structure Data file, ENSDF. Decay data for all (1557 radioactive and 241 stable) nuclei were extracted using the NNDC On-Line Data Service NUDAT program. A directory to the database was generated and a user program NUCI was written which provides instant retrieval, display and logging of any data that is available. Nuclear masses are also provided. A list of commends and examples illustrating the available features are given in the 1999 ORNL Physics Division Progress Report.

IV. REVIEWS

Nuclear structure data evaluations for nuclei with mass A=249, 253, 255, 257, 259, 261, 263, and 265 were reviewed.

V. RESEARCH ACTIVITIES

The Nuclear structure evaluators are also involved in ORNL research programs. The following papers have been published/ submitted.

Deformed Rotational Bands in 63Zn and 62Cu , S. D. Paul, et al., Proceedings of Nuclear Structure'98 Conf., Gatlinburg; to be published (1999)

Superdeformed Band in 61Zn, C.-H. Yu, et al., Proceedings of Nuclear Structure'98 Conf., Gatlinburg; to be published (1999)

Highly Deformed Rotational Bands in 65Zn, C.-H. Yu,et al., Proceedings of Nuclear Structure'98 Conf., Gatlinburg; to be published (1999)

Band Structures in the N=Z nucleus, 68Se, S. D. Paul, et al., ORNL Phys. Div. Progress Report, to be published (1999)

Gamma-Ray Spectroscopy of 188Pb with Recoil Mass and Decay Tagging, W. Reviol, et al., ORNL Phys. Div. Progress Report, to be published (1999)

Status of CLARION: Clover Array for Radioactive Ions , D. C. Radford, et al., ORNL Phys. Div. Progress Report, to be published (1999)

The HYBALL Charged-Particle Detector System, A. Galindo-Uribarri, et al., ORNL Phys. Div. Progress Report, to be published (1999)

Spectroscopy of Cross-Conjugate Nuclei 46Ti - 50Cr and 47V - 49Cr Near the f7/2-Shell Band Termination,   J. A. Cameron, et al., ORNL Phys. Div. Progress Report, to be published (1999)

Decay Out of the Doubly-Magic Superdeformed Band in the N=Z Nucleus 60Zn, C. E. Svensson, et al., Phys. Rev. Lett.; to be published (1999)

Smooth Termination of Rotational Bands in 62Zn: Evidence for a Loss of Collectivity, C. E. Svensson, et al., Phys. Rev. Lett. **80**, 2558 (1998)

Smoothly Terminating Rotational Band in 64Zn, A. Galindo-Uribarri, et al., Phys. Lett. B**422**, 45 (1998)

Band Structure in 79Y and the Question of T=0 Pairing, S. D. Paul, et al., Phys. Rev. C **58,** R3037

(1998)

Band Terminations in the Valence Space of 86Zr, J. Doring, et al., Phys. Lett. to be published (1999)

In-Beam Gamma-Ray Spectroscopy in the Ground-State Proton Emitter 113Cs, C. J. Gross, et al., Proceedings, 2nd International Conference on Exotic nuclei and Atomic Masses, 1998; and Proceedings of Nuclear Structure'98 Conf., Gatlinburg; to be published (1999)

The Oak Ridge HRIBF Recoil Mass Spectrometer, T. N. Ginter, et al., Proceedings of Nuclear Structure'98 Conf., Gatlinburg; to be published (1999)

Identification of Excited States in 125Ce, E. S. Paul, et al., Phy. Rev. C**58**, 801 (1998)

Extruder Proton-Hole Band in the Near-Drip-Line Nucleus 127Pr, S. M. Mullins, et al., Phys. Rev. C**58**, R2626 (1998)

In-Beam Spectroscopy Study of the Proton Emitter 151Lu, C.-H. Yu, et al. Phys. Rev. C**58**, R3042 (1998)

Identification of Excited States in 125Ce, C.-H. Yu, et al., Phys. Rev. C**58**, R3042 (1998)

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: What are the origins of the elements that make up our bodies and our world? How did the solar system, the sun, the stars, and the galaxy form, and how do they evolve? 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. The ORNL 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 focused primarily 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. We are also working on reactions that are important for understanding Red Giant Stars and the Solar Neutrino Problem. Our work utilizes the latest advances in Internet- and WWW-based information services to disseminate evaluated data to the astrophysics research community.

Additionally, M.S. Smith chairs an Astrophysics Task Force which submitted a proposal to the DOE for a coordinated U.S. Nuclear Astrophysics Data effort involving 5 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. This information is posted on our nuclear astrophysics data website [1]. Lists of nuclear astrophysics data projects for the period April 1998 to April 1999 follows.

I. REACTION RATE EVALUATIONS & ASSESSMENTS for NUCLEAR ASTROPHYSICS

- **Evaluation of the 17O(p,alpha)14N Reaction Rate**

This 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 [2] changed the previous rate estimates by more than a factor of 10 at certain temperatures. Our work, still in progress, will give a complete expression for the current 17O(p,alpha)14N rate incorporating all recent experimental information in a format that can be easily incorporated into astrophysics models. The final rate and plots will be posted at our WWW site.

- **Evaluation of the 18F(p,alpha)15O and 18F(p,alpha)19Ne Reaction Rates**

We have recently started to evaluate two reactions that are very important for understanding of stellar explosions such as nova and X-ray bursts: 18F(p,gamma)19Ne and 18F(p,alpha)15O. These are among the so called 'explosive hydrogen burning reactions' that were identified by the Astrophysics Data Steering Committee in 1996 as being a high priority to evaluate. These two reactions in particular are important because they help determine the amount of stellar material that can be processed from the mass A < 20 region to higher masses. Our evaluation work will provide reaction rates which incorporate all the recent indirect measurements and the newest direct measurements with radioactive ion beams.

- **Solar Fusion Reaction Rate Assessment**

A new evaluation of the cross sections for the 19 reactions of greatest importance to the study of the solar interior has recently been made by Adelberger et al.[3] We will convert these cross sections into reaction rates in an analytical format easily 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 other rate assessments.

II. DISSEMINATION OF NUCLEAR DATA for NUCLEAR ASTROPHYSICS

- **Improvements to the WWW posting of the Caughlan and Fowler Reaction Rate Collection**

We extended the usefulness of our posting of one of the most important reaction rate collections, by Caughlan and Fowler [4], by completing a graphical user interface based on the chart of the nuclides to allow users to search for rates of interest. This collection is a central part of the nuclear astrophysics data that we have posted at ORNL at the address http://www.phy.ornl.gov/astrophysics/data/data.html. This new improvement is in addition to improvements made in early 1998 of adding GIF and Postscript plots of each of the rates, along with a technique to automatically regenerate plots if future modifications are needed. We have also calculated the temperature derivatives of these reaction rates, important for coupling nucleosynthesis calculations to hydrodynamics simulations to provide more accurate modeling of stellar explosions. These very complex rate derivatives were posted online in a text format, along with a downloadable Fortran subroutine. Members of the research community have informed us that this online rate compilation has been very useful to their work.

- **WWW Posting of Big Bang Nucleosynthesis Rates**

  Evaluations of the 12 reactions of greatest importance to the synthesis of isotopes in the early universe [5] were posted WWW for the first time, in a format that can easily input into astrophysics models.

- **Nuclear Astrophysics Bibliography**

  A Nuclear Astrophysics Bibliography has been produced and posted on our WWW site. This is a useful resource for producing evaluations of nuclear reaction and structure information important for astrophysics. This bibliography includes references to astrophysical journals and reports which are outside the normal scope of Nuclear Science References. The first phase of this project, which includes over 1200 references, has recently been completed. It is anticipated that this bibliography will grow steadily in time.

References

[1] M.S. Smith et al., U.S. Nuclear Reaction Data Network Astrophysics Task Force Report (1995): http://www.phy.ornl.gov/astrophysics/data/task/taskforce_report.html.

[2] J.C. Blackmon et al., Phys. Rev. Lett. **74**, 2642 (1995).

[3] E.G. Adelberger et al., Rev. Modern Phys. **70**, Part 2, 1 (1998).

[4] G.R. Caughlan, W.A. Fowler, At. Data Nucl. Data Tables **40**, 283 (1988).

[5] M.S. Smith, L.H. Kawano, R.A. Malaney, Astrophys. J. Supplement **85**, 219 (1993).