

NUCLEAR STRUCTURE AND DECAY DATA: INTRODUCTION TO RELEVANT WEB PAGES

T. W. Burrows¹, P. K. McLaughlin² and A. L. Nichols²

¹*National Nuclear Data Center
Brookhaven National Laboratory
Upton, New York 11973-5000
USA*

²*International Atomic Energy Agency
Nuclear Data Section
Department of Nuclear Sciences and Applications
Wagramerstrasse 5, PO Box 100
A-1400 Vienna
Austria*

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Summary

A brief description is given of the nuclear data centres around the world able to provide access to those databases and programs of highest relevance to nuclear structure and decay data specialists. A number of Web-page addresses are also provided for the reader to inspect and investigate these data and codes for study, evaluation and calculation. These instructions are not meant to be comprehensive, but should provide the reader with a reasonable means of electronic access to the most important data sets and programs.

1. Introduction

A network of international/national nuclear data centres constitutes the infrastructure for the provision of a wide range of atomic and nuclear data services to scientists worldwide (Table 1). More than 100 data libraries are readily available cost-free from these centres through the Internet, CD-ROM and other media.

Two nuclear data centres of particular note are the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory and the Nuclear Data Section at the International Atomic Energy Agency (IAEA-NDS) in Vienna, Austria. Access to the most relevant databases and associated codes through their web addresses are described below (both main directional web pages are shown in the Annex):

National Nuclear Data Center, Brookhaven - <http://www.nndc.bnl.gov/>

IAEA Nuclear Data Section: <http://www-nds.iaea.org/>

and IAEA-NDS mirror sites at IPEN, Brazil, <http://www-nds.ipen.br/>
and BARC, Mumbai, India, <http://www-nds.indcentre.org.in/>
that are maintained by NDS staff.

All libraries and related documentation held by the Nuclear Data Section are available free of charge to scientists in IAEA Member States. Overviews are given by Schwerer and Obložinský (2001) and in the document *Index of Nuclear Data Libraries Available from the IAEA Nuclear Data Section* (Schwerer and Lemmel, 2002) – also available on:

http://www-nds.iaea.org/indg_intro.html
<http://www-nds.iaea.org/reports/nds-7.pdf> to download as PDF file.

Brief descriptions of the contents and format of most libraries are published in the IAEA-NDS-report series (Lemmel and Schwerer, 2002), while an introduction to NDS database projects and services can be found at <http://www-naweb.iaea.org/napc/nd/index.asp>

2. Nuclear Structure and Decay Data Evaluators' Network

A network of centres has been established that specializes in nuclear structure and decay data (Pronyaev *et al.*, 2004); see also Table 2 for a list and access addresses through the Web and e-mail contacts. These laboratories and institutes are involved in all facets of compilation and production of recommended nuclear structure and decay data (*i.e.*, review, evaluation and processing), sharing the evaluation work by mass chain, and meeting biennially to discuss their common problems and interests under the auspices of the IAEA Nuclear Data Section.

3. World Wide Web (WWW)

The web page of the IAEA Nuclear Data Services can be found at the web addresses <http://www-nds.iaea.org/> (IAEA, Vienna, Austria), <http://www-nds.ipen.br/> (IPEN, Brazil), and <http://www-nds.indcentre.org.in/> at BARC, India; the equivalent web page for NNDC is <http://www.nndc.bnl.gov/>. These pages contain interactive access to the major databases, as well as overviews of all nuclear data libraries and databases available from the IAEA (*IAEA Nuclear Data Guide*) and NNDC, and access to various reports, manuals, nuclear data utility programs, Nuclear Data Newsletters and other informative documentation.

The web addresses specified above provide links with the following highly relevant databases (see also Section 4):

- [ENSDF](#) - evaluated nuclear structure and decay data
- [MIRD](#) - medical internal radiation dose tables
- [Wallet cards](#) - Ground and metastable state properties
- [NUDAT](#) - selected evaluated nuclear data
- [NSR](#) (Nuclear Science References)
- [Masses](#) (Atomic Mass Evaluation Data File)

For example, NSR bibliographic information can be explored through:

Known author name,

Keynumber (*e.g.*, 1970Ya02 consists of the first two letters of the lead author (Ya (of Yamazaki)), year (1970), and number designation (02)); also to be found in *Recent References, Nuclear Data Sheets* (Tuli, 2006), although curtailed since early 2004), and Nuclide,

as well as through other criteria.

The reader is encouraged to access all of these databases, codes and information manuals through an explorative process, and assess their user-friendliness and usefulness. Your feedback is also welcome, and would help us to improve our web services.

4. Access to Relevant Databases and Programs

The data in some of the nuclear structure databases have been evaluated and assembled through the combined efforts of specialists within the international nuclear structure and decay-data evaluators' network (Section 2), while others are effectively more user-friendly derivatives and subsets of these same data files (*e.g.*, Nuclear Wallet Cards and NuDat).

4.1 Primary databases

NSR: Nuclear Science References is a bibliographic database for low and intermediate energy nuclear physics and available on-line (see both <http://www-nds.iaea.org/nsr/> and <http://www.nndc.bnl.gov/nsr/>).

ENSDF: Evaluated Nuclear Structure Data File is the 'master' library for nuclear structure and decay data maintained through the evaluators' network co-ordinated by the IAEA (see

Section 2), and containing evaluated experimental data for most known nuclides in the mass range from 1 to 294; published in *Nuclear Data Sheets* (Tuli, 2006) and *Nuclear Physics A* (Bakker, 2006) and available on-line (see both <http://www-nds.iaea.org/ensdf/> and <http://www.nndc.bnl.gov/ensdf/>). The full library is also available as zipped files from the NDS open area.

4.2 Other specialised and derived databases

Atomic masses 2003 (Wapstra *et al.*, 2003): mass evaluations for over 2900 nuclides; available on-line (see both <http://www-nds.iaea.org/masses/> and <http://www.nndc.bnl.gov/masses/>).

Nuclear Wallet Cards (Tuli, 2005): basic properties of ground and metastable states; available as pocket book and on-line (see both <http://www-nds.iaea.org/wallet/> and <http://www.nndc.bnl.gov/wallet/>). The NNDC site also contains Nuclear Wallet Cards for Radioactive Nuclides (Tuli, 2004), available as a pocket book and online, and Palm Pilot versions of both books.

NuDat: Nuclear Data contains user-friendly extracts of applications data from ENSDF and the Nuclear Wallet Cards, plus thermal neutron data; available on-line (see both <http://www-nds.iaea.org/nudat/> and <http://www.nndc.bnl.gov/nudat/>).

MIRD: Medical Internal Radiation Dose is based on ENSDF and data processed by RADLST to generate, for example, tables of energies and intensities for X-rays and Auger electrons (Burrows, 1988); available on-line (see both <http://www-nds.iaea.org/mird/> and <http://www.nndc.bnl.gov/mird/>).

Reduced Transitional Probabilities: Electric quadrupole transition probabilities for the ground to first 2+ state of even-even nuclides extracted from the evaluation of Raman *et al.* (2001) (see <http://www.nndc.bnl.gov/be2/>).

XUNDL: eXperimental Unevaluated Nuclear Data Library is a compilation of experimental nuclear structure and decay data in ENSDF format – oriented primarily to high-spin data, but also contains some reaction and decay data (see both <http://www-nds.iaea.org/ensdf/> and <http://www.nndc.bnl.gov/ensdf/>).

4.3 Programs

Useful computer codes for the calculation of specific nuclear structure and decay data parameters include the following:

BrIcc: calculates internal conversion electron coefficients based on the “frozen orbitals” approximation (Band *et al.*, 2002 and Raman *et al.*, 2002), internal electron-positron pair formation coefficients based on Schlüter and Soff (1979), and Hoffman and Soff (1996), and E0 electronic factors based on Hager and Seltzer (1969), Bell *et al.* (1970), and Passoja and Salonen (1986);

GABS: calculates absolute γ -ray intensities;

GTOL: undertakes least-squares fits to γ -ray energies and calculates net feeding to nuclear levels;

LOGFT: calculates $\log ft$ values for β and electron-capture decay, average β^\pm energies and capture fractions based on Gove and Martin (1971);

PANDORA: checks “correctness” of the physics in ENSDF;

and others are available through the NNDC web page

http://www.nndc.bnl.gov/nndcscr/ensdf_pgm/.

4.4 Interactive calculational tools

Users can perform calculations interactively over the web by means of four processing tools:

Nuclear Structure Calculational Tools:

- **BrIcc:** calculates internal conversion electron coefficients based on the “Frozen orbitals” approximation (Band *et al.*, 2002 and Raman *et al.*, 2002), internal electron-positron pair formation coefficients based on Schlüter and Soff (1979), and Hoffman and Soff (1996), and E0 electronic factors based on Hager and Seltzer (1969), Bell *et al.* (1970), and Passoja and Salonen (1986) (see <http://www.rsphysse.anu.edu.au/nuclear/bricc/>);
- **HSICC:** calculates internal conversion coefficients based on the theoretical values of Hager and Seltzer (1968), and Dragoun *et al.* (1969 and 1971) (see <http://www.nndc.bnl.gov/hsicc/>);
- **LOGFT:** calculates $\log ft$ values for β and electron-capture decay, average β^\pm energies and capture fractions based on Gove and Martin (1971) (see <http://www.nndc.bnl.gov/logft/>).

Atomic Masses, Q-values and Threshold Energies: calculates reaction Q-values, threshold energies and decay Q-values based on the 2003 Update to the Atomic Mass Evaluation (Wapstra *et al.*, 2003), and retrieves other quantities contained in this evaluation (see <http://www.nndc.bnl.gov/qcalc2/>).

4.5 Other network web sites

Web sites of other members of the Nuclear Structure and Decay-data Network (Table 2) contain much useful information, for example:

Energy Levels of Light Nuclei, A = 3 - 20: evaluations, preprints, lists of recent references, reprints for A = 3 - 20 nuclides, and Palm Pilot applications and databases (see <http://www.tunl.duke.edu/NuclData/>);

jvNubase: ground and metastable state properties, based primarily on ENSDF with some additions derived from more recent data (see <http://www.nndc.bnl.gov/amdc/jvNubase/Nucleus.html>);

RadWare: software package for interactive graphical analysis of gamma-ray coincidence data library of level scheme files in the RadWare ASCII-gls format that have been derived from ENSDF, XUNDL and contributed level schemes (see <http://radware.phy.ornl.gov/>).

4.6 Nuclear structure and decay-data evaluator's corner

<http://www.nndc.bnl.gov/nndc/evalcorner/> is primarily designed for ENSDF evaluators and currently contains:

- an interface to ENSDF which allows evaluators to retrieve ENSDF mass chains and nuclides in a basic format (*i.e.*, COMTRANS has not been run),
- simplified NSR retrieval system designed for ENSDF evaluators,
- new ENSDF analysis and utility codes in β testing, and
- links to relevant manuals and materials from previous ENSDF or NSDD workshops.

5. Concluding Remarks

The contents of this report represent a brief introduction to the means of accessing a powerful set of compiled and evaluated nuclear structure and decay-data libraries, as well as codes for the analysis and development of such data. Useful applications of these data and tools are wide ranging, and the reader is encouraged to explore their potential through the various routes outlined above, and so develop a much greater understanding of their capabilities.

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see also http://www.nndc.bnl.gov/nndcscr/ensdf_pgm/analysis/radlst/radlstdoc.pdf.
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Tuli, J.K., 2005. Nuclear Wallet Cards. 7th Edition, April 2005, National Nuclear Data Center, Brookhaven, USA; see also <http://www.nndc.bnl.gov/wallet/>.

Tuli, J.K., Editor, 2006. Nuclear Data Sheets. Academic Press, Elsevier Science, Amsterdam, the Netherlands, ISSN 0090-3752.

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Table 1. International/National Nuclear Data Centres.

IAEA Nuclear Data Section , Vienna, Austria http://www.nds.iaea.org/
US National Nuclear Data Center , Brookhaven, USA http://www.nndc.bnl.gov/
OECD, NEA Data Bank , Paris, France http://www.nea.fr/
Russian Federation Nuclear Data Centre , Obninsk, Russian Federation http://www.ippe.obninsk.ru/podr/cjd/
9 co-operating specialised centres: PR China, Hungary, Japan, Republic of Korea, Russian Federation and Ukraine

Table 2. Nuclear Structure and Decay-data Network.

<p>US National Nuclear Data Center, Brookhaven, USA (maintenance of master ENSDF database) http://www.nndc.bnl.gov/ Contact: J. K. Tuli (network co-ordinator) e-mail: Tuli@bnl.gov</p>
<p>Nuclear Data Project, Oak Ridge National Laboratory, USA http://www.phy.ornl.gov/ndp/ Contact: M. S. Smith e-mail: MSmith@mail.phy.ORNL.gov</p>
<p>Isotope Project, Lawrence Berkeley National Laboratory, Berkeley, USA http://ie.lbl.gov/ Contact: C. M. Baglin e-mail: baglin@lbl.gov</p>
<p>Idaho National Laboratory, Idaho Falls, USA Contact: C. W. Reich e-mail: CWReich@interplus.net</p>
<p>Triangle University Nuclear Laboratory, Duke University, USA http://www.tunl.duke.edu/NuclData/ Contact: J. H. Kelley e-mail: kelly@tunl.duke.edu</p>
<p>Argonne National Laboratory, Argonne, U.S.A. http://www.td.anl.gov/NDP/ Contact: F.G. Kondev e-mail: kondev@anl.gov</p>
<p>Nuclear Data Centre, Petersburg Nuclear Physics Institute, Russian Federation Contact: I. A. Mitropolsky e-mail: mitrplsk@pnpi.spb.ru</p>
<p>Institute of Atomic Energy, Beijing, PR China Contact: Ge Zhigang e-mail: gezg@iris.ciae.ac.cn</p>
<p>Jilin University, Physics Department, Changchun, PR China Contact: Huo Junde e-mail: jdhuo@mail.jlu.edu.cn</p>
<p>Centre d'Études Nucléaires, Grenoble, France Contact: J. Blachot e-mail: jean.blachot@wanadoo.fr</p>
<p>JAERI Nuclear Data Centre, Tokai-Mura, Japan http://wwwndc.tokai.jaeri.go.jp/ Contact: J. Katakura e-mail: Katakura@bisha.tokai.jaeri.go.jp</p>
<p>Nuclear Data Centre, Physics Department, Kuwait University, Kuwait Contact: A. Farhan e-mail: Ameenah@kuc01.kuniv.edu.kw</p>
<p>Laboratorium voor Kernfysica, Gent, Belgium Contact: D. De Frenne e-mail: denis.defrenne@rug.ac.be</p>
<p>Department of Physics and Astronomy, McMaster University, Hamilton, Canada http://physwww.physics.mcmaster.ca/~balraj/ Contact: J. C. Waddington e-mail: JCW@mcmaster.ca</p>
<p>Department of Nuclear Physics, Australian National University, Canberra, Australia http://wwwrphysse.anu.edu.au/nuclear/ Contact: T. Kibédi e-mail: Tibor.Kibedi@anu.edu.au</p>
<p>Department of Physics, Indian Institute of Technology, Roorkee, India http://www.iitr.ac.in/departments/PH/ Contact: A. K. Jain e-mail: ajainfph@iitr.ernet.in</p>
<p>Atomic Mass Data Center, Centre de Spectrométrie Nucléaire et de Spectrométrie Masse, Orsay, France http://www.nndc.bnl.gov/amdc/ Contact: Georges Audi e-mail: mailto:audi@csnsm.in2p3.fr</p>
<p>IAEA Nuclear Data Section, Vienna, Austria (co-ordination of network meetings) http://www.nds.iaea.org/ Contact: A. L. Nichols e-mail: a.nichols@iaea.org</p>

ANNEX

Directional Web pages for NDS and NNDC

> Mirror Sites



Welcome to the IAEA Nuclear Data Centre

Nuclear Data Services

Search NDS

> Navigation

Content Browser

> Quick Links

ADS-Lib

AMDC

CINDA

DROSG-2000

ENDF

ENSDF

EXFOR

FENDL-2.1

IBANDL

INDL/TSL

IRDF-2002

Masses 2003

Medical Radioisotopes

Production

MIRD

Minsk Actinides

NGATLAS

NMF-90

NuDat 2.1

NSR

PGAA-IAEA

Photonuclear

Photon+Electron

Interaction

POINT2004

Q-values, Thresholds

RIPL

RNAL

Safeguards data

Major Databases

CINDA - neutron reaction data bibliography

ENDF - evaluated nuclear reaction cross section libraries

ENSDF - evaluated nuclear structure and decay data (includes XUNDL)

EXFOR - experimental nuclear reaction data

NSR - Nuclear Science References

NuDat 2.1 - selected evaluated nuclear data

Nuclear Databases and Files

General

[Atomic Mass Data Center](#) - 2003 atomic mass evaluation, NUBASE, PC-NUCLEUS, etc.

[Q-values, Thresholds](#) - atomic masses, Q-values and threshold energies

[RIPL](#) - reference parameters for nuclear model calculations

[Thermal neutron capture gamma rays](#) - by target and by energy

[Wallet cards](#) - ground and metastable state properties

Other evaluated data libraries in ENDF format

[IAEA Photonuclear Data Library](#) - cross sections and spectra up to 140MeV

[INDL/TSL](#) - IAEA Evaluated Nuclear Data Library / Thermal Scattering Law

[IRDF-2002](#) - International Reactor Dosimetry File

[Minsk Actinides Library](#) - evaluated neutron reaction data (Maslov et al.)

[NGATLAS](#) - atlas of neutron capture cross sections ([old-version](#) is here)

[NMF-90](#) - Neutron Metrology File

[POINT2004](#) - Pointwise data of ENDF/B-VI Release 8 at 8 temperatures

[RNAL](#) - Reference Neutron Activation Library

Evaluated libraries in different formats

[ADS-Lib](#) Application test library in ACE and MATXS format for ADS neutronics design

[Charged-particle cross section database for medical radioisotope production](#)

[FENDL-2.1](#) - Fusion Evaluated Nuclear Data Library, Version 2.1

[IAEA-NDS-0](#) - index to IAEA NDS documentation series

[IBANDL](#) - Ion Beam Analysis Nuclear Data Library

[MIRD](#) - medical internal radiation dose tables

[Nuclear Data for Safeguards](#) - IAEA handbook (1997)

[PGAA-IAEA](#) - database of prompt gamma rays from slow neutron capture

[Photon and Electron Interaction Data](#) - EPDL, EADL, EEDL, EXDL and ASF

[Stopping Power Data for Light Ions](#) - Graphs, data, programs, compiled by H. Paul [13/Dec/05]

[WIMSD-IAEA Library](#) - multigroup data library for the WIMS-D code

> NDS Events



Meetings & Workshops

> NDS Services



> Nuclear Data Section



More on Coordinated Research Projects, Technical Cooperation, Nuclear Data Section - people and activities

> NDS Partners



National Nuclear Data Center, Brookhaven, USA



OECD Nuclear Energy Agency, Nuclear Data Services, France

Stopping Power Data
Thermal Neutron Capture Gamma Rays
Wallet cards
WIMS-D Library
XUNDL
> Documents
Chart of the Nuclides 2002
ENDF Manual
ENDF/B-6 Summary
ENSDF, NSR Manuals
IAEA Technical Documents
IAEA-NDS Reports
ICTP 2005 Workshop [New]
INDC Reports
Selected INDC Reports
> Computer codes
EMPIRE-II
ENDF Utils
ENDVER
ENSDF Utilities
PREPRO
SIGACE
ZVVVIEW [26/Aug/05]
> Key
[New] Item is a completely new version
[Mod] Item has been updated or modified
[dd/mm/yy] Date of last update

Electronic Documents

[Citation Guidelines](#) - online data service manual and citation guidelines
[ENDF Format Manual](#) - April 2001 version
[ENSDF and NSR Manuals](#) - ENSDF Feb. 2001 version & NSR Aug. '96 version
[IAEA Technical Documents](#)
[IAEA-NDS Reports](#)
[ICTP 2005 Workshop](#) - workshop material, codes, programme, etc. **[New]**
[INDC Reports](#)
[Selected INDC Reports](#) - selected INDC reports, INDC(AUL) to INDC(VN)

Computer codes

[EMPIRE-II](#) - system of codes for nuclear reaction calculations (Version 2.19)
[ENDF Utility Codes](#) - Release 7.0
[ENSDF programs](#) - ENSDF Analysis and Utility programs (ALPHAD, LOGFT, etc.)
[ENDVER](#) - ENDF File Verification Support Package
[PREPRO](#) - ENDF Preprocessing Codes. Version - June 13, 2005
[SIGACE](#) - package for generating high temperature ACE files
[ZVVVIEW](#) - interactive plotting of nuclear data **[26/Aug/05]**

General information

NDS information

[Co-ordinated Research Projects \(CRPs\)](#) - recently completed and ongoing CRPs
[IAEA Nuclear Data Guide](#) - catalogue of all nuclear data available from IAEA NDS
[Index of nuclear data libraries](#) - comprehensive index of NDS libraries
[Nuclear Data Section](#) - introduction, programme description, activities and staff
[Nuclear data information brochure](#) - the IAEA nuclear and atomic data programme
[Nuclear data newsletters](#) - from 1995 to now **[issue 40, September 2005]**
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Datalinks

[Atomic and molecular data](#) - AMBDAS, ALADDIN, GENIE, etc.
[List of available CD-ROMs](#) - nuclear data and utility codes on CD-ROM
[Nuclear data links for medical applications](#) - relevant sites at the IAEA and worldwide

Other useful links

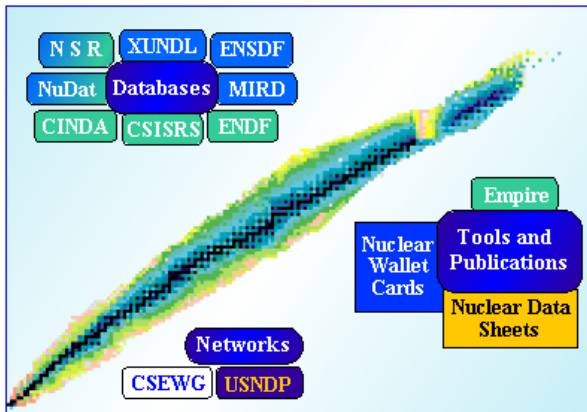
[IAEA home page](#)
[IAEA - Department of Nuclear Sciences and Applications](#)
[International network of Nuclear Structure and Decay Data evaluators](#) - the NSDD network
[Nuclear Reaction Data Centre network](#) - the NRDC network, contacts, webpages, etc.
[Other information resources](#) - collection of links to other nuclear information resources



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 Telephone (+431) 2600-0; Facsimile (+431) 2600-7; E-mail: online@iaeaand.iaea.org



National Nuclear Data Center

BROOKHAVEN
NATIONAL LABORATORY

- Nuclear Structure and Decay Databases
- Nuclear Structure and Decay Tools
- Nuclear Reaction Databases
- Nuclear Reaction Tools
- Bibliography Databases
- Networks and Links
- About the Center
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[Superheavy Nuclei \(\$A \geq 266\$ \)](#) New [CSEWG & USNDP 2005 Proceedings](#)

[Site Index](#) - Search the NNDC:

AMDC Atomic Mass Data Center, Q-value Calculator	CapGam Thermal Neutron Capture γ -rays	CINDA Computer Index of Nuclear (reaction) Data	CSEWG Cross Section Evaluation Working Group
CSISRS alias EXFOR Nuclear reaction experimental data	Empire Nuclear reaction model code	ENDF Evaluated Nuclear (reaction) Data File	ENSDF Evaluated Nuclear Structure Data File
For NMMSS & DoE NMIRDC safeguards & inventory decay data standards	IRDF International Reactor Dosimetry File	MIRD Medical Internal Radiation Dose	NSR Nuclear Science References
Nuclear Data Sheets Nuclear structure and decay data journal	Nuclear Wallet Cards Ground and isomeric states properties	Nuclear Wallet Cards for Homeland Security	NuDat Nuclear structure and decay data
RIPL Reference Input Parameter Library	USNDP U.S. Nuclear Data Program	XUNDL Experimental Un-evaluated Nuclear Data List	Coming March 2006: Atlas of Neutron Resonances

Links ordered alphabetically [Order by category](#)

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Nuclear Data Section
International Atomic Energy Agency
P.O. Box 100
A-1400 Vienna
Austria

e-mail: services@iaeand.iaea.org
fax: (43-1) 26007
cable: INATOM VIENNA
telex: 1-12645
telephone: (43-1) 2600-21710
Web: <http://www-nds.iaea.org>
