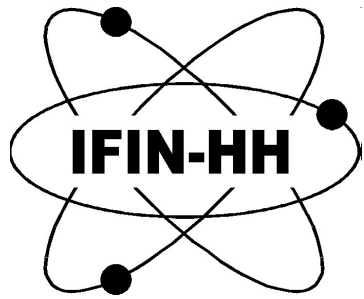


Lecture 1.4

Nuclear Structure

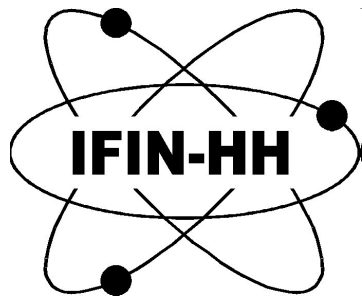
Observables

Alexandru Negret



Outline

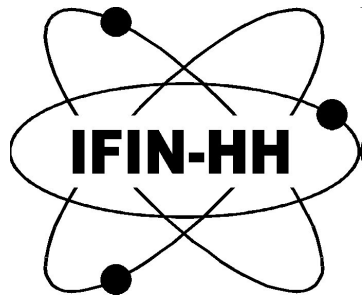
- The ENSDF database – generalities
- The structure of the database
- How to access the information
- The Chart of nuclides
- XUNDL, NSR



ENSDF – general information

The Evaluated Nuclear Structure Data File

- Hosted by Brookhaven National Laboratory, USA. Freely available.
- Maintained by a network of evaluators (~30 people). Generally, each mass chain is evaluated once every few years. Sometimes the nuclei are updated individually. The mass chain updates are published in Nuclear Data Sheets.
- Purely experimental. Theoretical information included sometimes as comments.



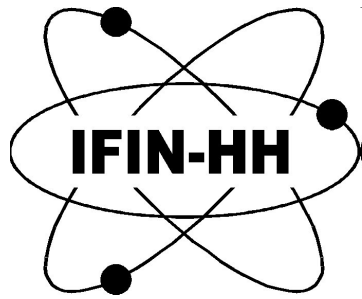
ENSDF – structure

For each nucleus:

- Adopted Levels, Gammas
- Decay datasets
 - Decay dataset 1
 - Decay dataset 2
 - ...
- Reaction datasets
 - Reaction dataset 1
 - Reaction dataset 2
 - ...

^{152}Sm

<input type="checkbox"/> ADOPTED LEVELS, GAMMAS
<input type="checkbox"/> 152PM B- DECAY (4.12 M)
<input type="checkbox"/> 152PM B- DECAY (7.52 M)
<input type="checkbox"/> 152PM B- DECAY (13.8 M)
<input type="checkbox"/> MUONIC ATOM
<input type="checkbox"/> 152EU EC DECAY (13.537 Y)
<input type="checkbox"/> 152EU EC DECAY (9.3116 H)
<input type="checkbox"/> 252CF SF DECAY
<input type="checkbox"/> INELASTIC SCATTERING
<input type="checkbox"/> 150ND(A,2NG)
<input type="checkbox"/> 150SM(T,P)
<input type="checkbox"/> 150SM(T,PG)
<input type="checkbox"/> 151SM(N,G) E=THERMAL
<input type="checkbox"/> 151SM(D,P)
<input type="checkbox"/> 152SM(G,G')
<input type="checkbox"/> 152SM(N,N'G)
<input type="checkbox"/> COULOMB EXCITATION
<input type="checkbox"/> 153EU(T,A)
<input type="checkbox"/> 154SM(P,T)
<input type="checkbox"/> 154SM(12C,14C)
<input type="checkbox"/> 155GD(N,A)



ENSDF

Browser address bar: http://www.nndc.bnl.gov/useroutput/AR_12645357DDF07F866E2931B95E7E7F02_1.html

Navigation icons: DFN, Yahoo! Mail, NNDC, NSDD Evlts' Corner, QCalc, Geocaching, ROFAIR, Verbix, Cambridge Dictionary, Dictionar

Transition from spherical to deformed shape in Sm: [1993Ya19](#).

Transition probabilities: [1995De22](#), [1995Go14](#), [1995Pi12](#), [1995Ra01](#), [1995Sm07](#), [1995Vo10](#), [1995Zh26](#), [1992Za07](#), [1985Su01](#), [1985Su08](#).

For g.s. band members with $J > 10$ g-factor can be given as: $g(J) = g(0)(1 + \alpha J^2)$ where $g(0) = +0.37728$ and $\alpha = 0.37 \times 10^{-3} 18$ ([1989Ra17](#)).

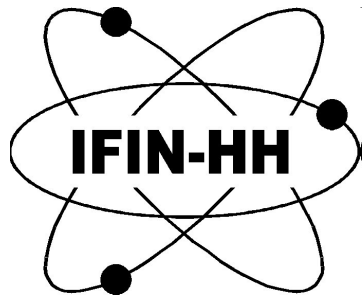
Cross References (XREF) Flags

- [A](#) ¹⁵²Pm β⁻ Decay (4.12 min)
- [B](#) ¹⁵²Pm β⁻ Decay (7.52 min)
- [C](#) ¹⁵²Pm β⁻ Decay (13.8 min)
- [K](#) Coulomb Excitation
- [L](#) Inelastic Scattering
- [M](#) ¹⁵³Eu(t,α)

EXERCISE: Check the ENSDF for a few nuclides.

<http://www.nndc.bnl.gov/ensdf>

121.7817 [#] 3			KIMNOPQRST	J^π : E2 γ to 0 ⁺ g.s.
				$T_{1/2}$: weighted average of 1.396 ns 8 (¹⁵² Eu ϵ decay (13.537 y)) and 1.433 ns 24 (Coul ex).
				Q: other: -1.702 17 (1989Ra17,1978Ya11).
				Isotope shift: 1995Be19, 1994Jf08 .
366.4795 [#] 9	4+	57.7 ps 8	ABCDEFGHIJKL MNPQR	$\mu = +1.68 20$ (1989Ra17,1987By02); Q = -2.6 14
				J^π : E2 γ to 2 ⁺ level; $\sigma(\theta)$, analyzing power (inelastic scattering).
				$T_{1/2}$: other: 60 ps 5 (¹⁵² Eu ϵ decay (13.537 y)).
				Q: From Coul ex.
684.701 [#] 15	0+	6.2 ps 4	ABCDEFGHIJKL MNPQR	J^π : E0 transition to 0 ⁺ g.s.; $\gamma\gamma(\theta)$ (¹⁵² Eu ϵ decay (9.3116 h)).
706.88 [#] 4	6+	10.1 ps 2	BCDEFGH IJKLMN	$\mu = +2.4 3$ (1989Ra17,1987By02)
				J^π : $\sigma(\theta)$, analyzing power (inelastic scattering); E2 γ to 4 ⁺ level, no γ to 2 ⁺ level.
810.453 [#] 5	2+	7.4 ps 6	ABCDEFGHIJKL MNPQR	$\mu = +0.76 19$ (1989Ra17,1987By02)



The Chart of Nuclides

The Adopted Levels, Gammas are available also in a graphical form:

ADOPTED LEVELS, GAMMAS for ¹⁵²Sm

Author: AGDA ARTNA-COHEN Citation: Nuclear Data Sheets 79, 1 (1996)

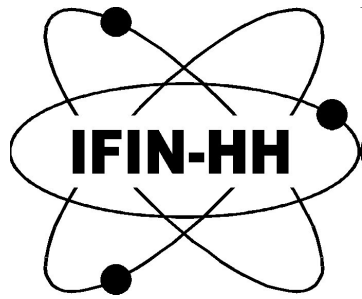
Full ENSDF file

Q(β⁻)=-1874.3 keV 7 S_n= 8257.7 keV 7 S_p= 8662 keV 5 Q_α= 220.3 keV 21

References:

- A: ¹⁵²Pm β- decay (4.12 m)
- B: ¹⁵²Pm β- decay (7.52 m)
- C: ¹⁵²Pm β- decay (13.8 m)
- D: ¹⁵²Eu ε decay (13.537 y)
- E: ¹⁵²Eu ε decay (9.3116 h)
- F: ¹⁵⁰Nd(α,γ_{2n})
- G: ¹⁵¹Sm(n,γ) E=thermal
- H: ¹⁵¹Sm(d,p)
- I: ¹⁵²Sm(γ,γ')
- J: ¹⁵²Sm(n,n'γ)
- K: Coulomb Excitation
- L: Inelastic Scattering
- M: ¹⁵²Eu(t,α)
- N: ¹⁵⁴Sm(p,t)
- O: Muonic atom
- P: ²⁵²Cf SF decay
- Q: ¹⁵⁰Sm(t,p)
- R: ¹⁵⁰Sm(t,yp)
- S: ¹⁵⁴Sm(¹²C, ¹⁴C)
- T: ¹⁵²Gd(n,α)

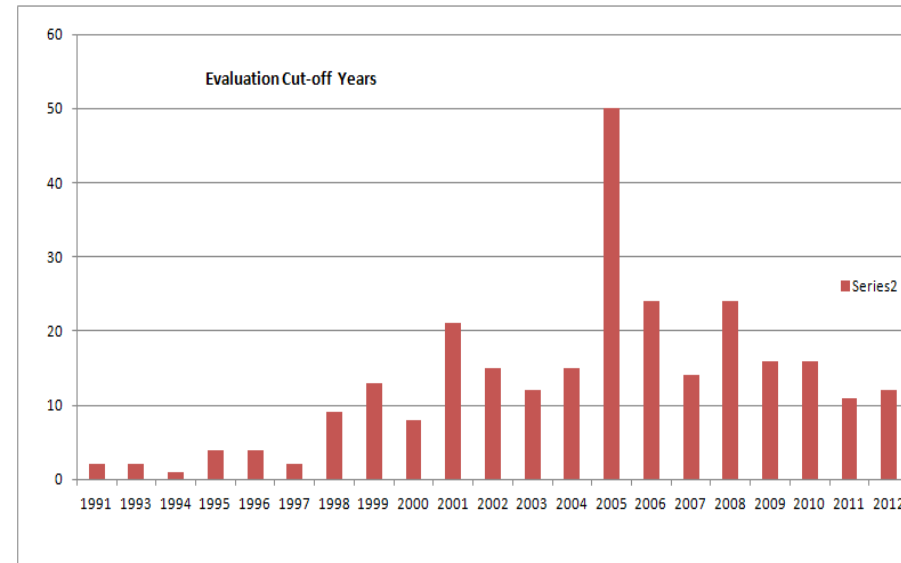
E _{level} (keV)	XREF	J _π	T _{1/2}	E _γ (keV)	I _γ	γ mult.	Final level
0.0	ABCDEFGHIJKL NOPQRS	0+	STABLE				
121.7817 3	ABCDEFGHIJKLMNQRST	2+	1.400 ns 11	121.7817 3		E2	0.0 0+
366.4795 9	ABCDEFGH JKLMN QR T	4+	57.7 ps 8	244.6975 8		E2	121.7817 2+
684.701 15	A DEF H JKL N QR	0+	6.2 ps 4	562.93 2 684.85 20	100.0 13	E2 E0	121.7817 2+ 0.0 0+
706.88 4	BCD F H JKLMN	6+	10.1 ps 2	340.40 14		E2	366.4795 4+
810.453 5	AB DEFGH JKLMN Q	2+	7.4 ps 6	125.69 13	1.9 6	[E2]	684.701 0+

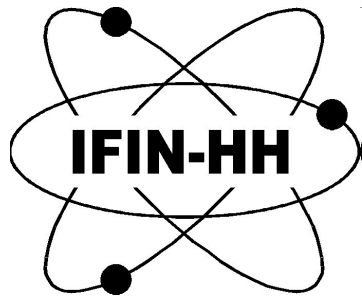


Status of ENSDF

In January 2013:

- Nuclides: 3174
- Datasets: 17638
 - Adopted datasets: 3174
 - Decay datasets: 4110
 - Reaction datasets: 9503
- Size: 202MB

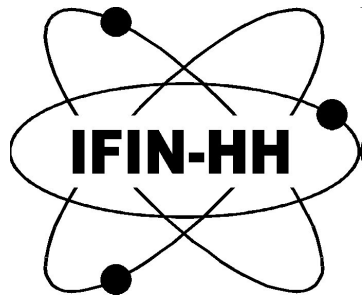




XUNDL

EXperimental Unevaluated Nuclear Data List

The screenshot shows the National Nuclear Data Center (NNDC) website. The browser address bar displays <http://www.nndc.bnl.gov/>. The page header includes the NNDC logo and the Brookhaven National Laboratory logo. A search bar is visible on the right. The main navigation menu at the top contains links for NSR, XUNDL (circled in red), ENSDF, NuDat, Databases, MIRD, Sigma, CSISRS, and ENDF. Below the navigation menu is a large chart of nuclides with various data resources overlaid, including 'Atlas of n Resonances', 'Empire', 'Nuclear Wallet Cards', 'Tools and Publications', 'Nuclear Data Sheets', 'Networks', 'CSEWG', and 'USNDP'. The right sidebar contains news items: 'ND2013 Conference', 'Nuclear Wallet Cards just released for your Android phone!', 'ENDF/B-VII.0 Milestone', and 'The Big Paper has reached 500+ citations in Scopus!'. The main content area at the bottom is organized into a grid of links under the 'Main' tab, including 'AMDC Atomic Mass Data Center', 'Covariances of Neutron Reactions', 'ENDF Evaluated Nuclear (reaction) Data File', 'NMMSS & DoE NMIRD', 'Atlas of Neutron Resonances Parameters & thermal values', 'CSEWG Cross Section Evaluation Working Group', 'ENSDF Evaluated Nuclear Structure Data File', 'NSR Nuclear Science References', 'CapGam Thermal Neutron Capture γ -rays', 'CSISRS alias EXFOR Nuclear reaction experimental data', 'IRDF International Reactor Dosimetry File', 'Nuclear Data Sheets Nuclear structure & decay data journal', 'Chart of Nuclides Basic properties of atomic nuclei', 'Empire Nuclear reaction model code system', 'MIRD Medical Internal Radiation Dose', and 'Nuclear Wallet Cards Ground & isomeric states properties'.



NSR

Nuclear Structure References

NSR | JNDL | ENSDF
Nuclear Databases | MIRD
Sigma | CSISRS | ENDF

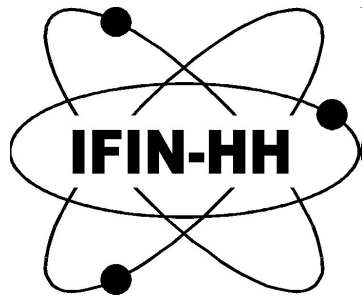
Chart of Nuclides | Atlas of n Resonances
Empire | Tools and Publications
Nuclear Wallet Cards | Nuclear Data Sheets
Networks
CSEWG | USNDP

ND2013 Conference
Nuclear Wallet Cards just released for your Android phone!
ENDF/B-VII.0 Milestone

The Big Paper has reached 500+ citations in Scopus!

Nuclear Wallet Cards (8th Edition) Release

Main	Structure & Decay	Reactions	Bibliography	Networks & Links	Publications	Meetings
AMDC Atomic Mass Data Center, Q-value Calculator	Atlas of Neutron Resonances Parameters & thermal values	CapGam Thermal Neutron Capture γ -rays	Chart of Nuclides Basic properties of atomic nuclei			
Covariances of Neutron Reactions	CSEWG Cross Section Evaluation Working Group	CSISRS alias EXFOR Nuclear reaction experimental data	Empire Nuclear reaction model code system, <i>Reference paper</i>			
ENDF Evaluated Nuclear (reaction) Data File, Sigma	ENSDF Evaluated Nuclear Structure Data File	IRDF International Reactor Dosimetry File	MIRD Medical Internal Radiation Dose			
NMMSS & DoE NMIRD Safeguards & inventory decay data	NSR Nuclear Science References	Nuclear Data Sheets Nuclear structure & decay data journal, <i>Quarterly</i>	Nuclear Wallet Cards Ground & isomeric states properties, <i>Handbook</i>			



Citation of ENSDF

152 Sm: A. Artna-Cohen, Nucl. Data Sheets 79, 1 (1996)

Data from AR_15964E03AE2E816F31D9047712EA87D3_1.ens

Download: [AR_15964E03AE2E816F31D9047712EA87D3_1.ens](#) View: [Levels](#): PostScript level schemes in the Nuclear Data Sheets style
[Bands](#): PostScript band drawings in the Nuclear Data Sheets style

¹⁵²Sm

Adopted Levels, Gammas

Published: 1996 Nuclear Data Sheets.

$Q_{\beta^-} = -1874.3$ 7 $S_n = 8257.7$ 7 $S_p = 8662$ 5 $Q_{\alpha} = 220.3$ 21 [1995Au04](#)

History

Date	Type	Author	Citation	Cutoff Date	Comments
16-Jul-2007	Errata	J. Tuli			Fixed typo in comment
		Agda Artna-Cohen	Nuclear Data Sheets 79, 1 (1996)	1-Jul-1996	

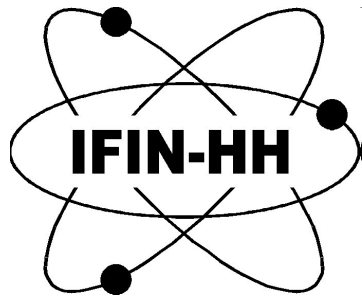
¹⁵²Sm levels

Calculations, systematics:

Analysis of scattering and fission cross sections of ¹⁵²Sm(¹⁶O, ¹⁶O) and ¹⁵²Sm(¹⁶O, ¹⁶O'): [1995Iz01](#).

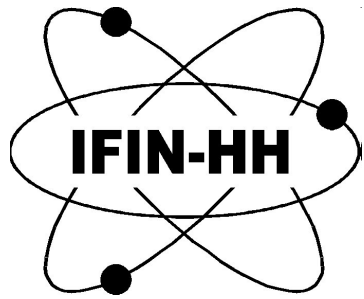
β decay of 1+ states: [1993Dz04](#).

Charge density, $\langle r^2 \rangle$, isotope shift: [1995Fr22](#), [1995Gu09](#), [1992Ot02](#), [1987Ri05](#).



Exercise: use the NNDC website

- Which is the energy, spin and parity of the first excited level in ^{57}Fe ?
- Who is the first author of the latest article published on ^{75}Kr ?
 - We are going to run an experiment where we will observe the beta decay of ^{199}Tl . Which should be the strongest gamma transition we will see?
 - Who is the author of the latest evaluation of $A=84$?
 - We are running an experiment at ISOLDE implanting ^{34}Mg ions on a foil for a few hours while measuring the gamma rays. Which nuclei will we be able to study?



Summary

- The ENSDF database – generalities
- The structure of the database
- How to access the information
- The Chart of nuclides
- XUNDL, NSR