Centre Report from India – ENSDF evaluations and Horizontal Evaluations

Ashok Kumar Jain*, Sukhjeet Singh**, Paresh Joshi*** and Gopal Mukherjee****

*AINST, Amity University U.P., NOIDA, India
** Akal University, Talwandi Sabo, Punjab
***HBCSE, TIFR, Mumbai, India
****Variable Energy Cyclotron Center, Kolkata, India

Mass Chain Evaluation-Present status (A=215-229):

India has the responsibility of mass chains A=215-229. The present status of these mass chains is presented in the table below.

Mass Chain	Year of Evaluation	Reference/Journal	Earlier Evaluator	New data sets to be included/Present status as on March 14, 2019
215	2013	NDS 114, 2023 (2013)	B. Singh *et al.*	13
216	2007	NDS 108, 1057 (2007)	C.Wu	09
217	2003	NDS 147, 382 (2018)	F.G. Kondev *et al.*	NIL
218	2006	NDS (2019)	Balraj Singh et al.	Submitted to NDS (2019)
219	2001	NDS 93, 763 (2001)	E. Browne	Submitted to NNDC
220	2011	NDS 112, 1115 (2011)	E. Browne and JK Tuli	05
221	2007	NDS 108, 883 (2007)	Ashok Jain, Sukhjeet Singh, Suresh Kumar, Jagdish Tuli	Submitted (Dec. 2018)
222	2011	NDS 112,2851 (2011)	Sukhjeet Singh,AK Jain, Jagdish Tuli	04
223	2001	NDS 93, 763 (2001)	E. Browne	Being evaluated BRNS workshop, HBCSE-2016
224	2015	NDS 130,127 (2015)	Sukhjeet Singh & Balraj Singh	02
225	2009	NDS 110, 1409 (2009)	A. K. Jain , R. Raut , J. K. Tuli	02
226	1996	NDS 77, 433 (1996)	Y.A.Akowali	Being evaluated

227	2016	NDS 132, 257 (2016)	Kondev et al.	02
228	2014	NDS 116, 163 (2014)	Khalifeh Abusaleem	01
229	2008	NDS 109, 2657 (2008)	E. Browne and JK Tuli	10

Progress in Mass chain evaluations:

Nuclear data sheets of A=221 (Submitted to NDS-2018)

Nuclear data sheets of A=219 (Submitted to NDS-2018)

Nuclear data sheets of A=217 (NDS 147, 382 (2018)

(A=217 mass chain was evaluated as a part of ICTP workshop -2016 : Sushil Kumar (Punjab, India) participated in this workshop and contributed in the evaluation of ^{217}Ra)

Nuclear Data Sheets of A=218 (Submitted by Balraj Singh)

(A=218 mass chain was evaluated as a part of ICTP workshop-2018: Ritwika Chakraborti, (Mumbai), Debasmita Kanjilal(Kolkata), Indu Bala,(IUAC, New Delhi), Soumen Nandi (VECC, Kolkata) participated in this evaluation work).

Mass Chains in Progress:

Nuclear data sheets of A=226

Nuclear data sheets of A=223

Horizontal Evaluations:

1. **Nuclear radius parameters (r_0) for even-even alpha emitters**

   Sukhjeet Singh, Sushil Kumar, Balraj Singh and A.K. Jain,

   (Submitted to Nuclear Data Sheets, Feb. 2019)

The decay data for 186 even-even alpha emitters have been analyzed to extract nuclear radius parameters (r_0) using Preston's spin-independent formalism for alpha decay probabilities. A suite of databases available at the website of National Nuclear Data Center (NNDC), Brookhaven National Laboratory, USA was consulted to ensure the completeness and reliability of available experimental data pertaining to alpha decays of all the even-even nuclides in the entire nuclear landscape. After a comprehensive literature review, 26 new even-even alpha emitters have been added to the previous evaluation published by Y.A. Akovali [1998AK04].

2. **Table of MR and AMR Bands**
   Sukhjeet Singh, Sushil Kumar, Deepika Choudhuri, Balraj Singh, A.K. Jain
   (In Progress)

We present a recent picture of all the experimentally observed MR bands pertaining to mass region 58<A<206.

In the earlier compilation by Amita *et al*. (2000), there were total 120 MR bands in 56 nuclei and another subsequent compilation consisting of total 178 bands observed in 76 nuclides was published online (2006).

Presently, we have updated the earlier compilation by including 41 MR bands observed in 31 new nuclides. Additionally, 19 MR bands (already available in earlier compilation) have been extended to higher spins. So, in totality, we added 358 M1 and 196 E2 transitions in the previous compilation. The maximum number (total 55) of MR bands have been identified in the Pb isotopes. Among all the 219 MR bands, total 160 MR bands are of regular nature whereas and 53 show irregular behavior, 14 bands exhibit signature splitting and 77 show a back-bending phenomenon.

In the present compilation, we have also extracted AMR bands with their probable configuration assignments. Till date, 16 AMR bands have been observed in 12 different nuclides. The lightest and heaviest nuclides where AMR bands have been reported are ^{100}Pd and ^{144}Dy respectively. The maximum number (total 5) of AMR bands are observed in Cd and In isotopes.

3. **Atlas of Nuclear Isomers - Update**

A.K. Jain, Bhoomika Maheshwari, Swati, Alpana Goel, Balraj Singh

Our earlier publication in Nuclear Data Sheets 128 (2015) 1–130 contains a listing of 2469 isomers having a half-life greater than 10 ns.

This is an active area of research with many measurements being reported.

Since 2015, we have come across 70 new cases of nuclear isomers.

Three cases reported earlier have been discarded.

We have already compiled these cases and the data. An updated Atlas will be ready soon.

The limit of 10 ns was used in contrast to ENSDF where the limit has been 100 ns. We feel that 10 ns is a very useful limit although we had to use even lower half-lives in showing the existence of odd-multipole decaying seniority isomers.

New Isomers (70 cases):

^{26}P	^{120}I	^{160}Nd	^{179}Tl
^{52}Co	^{123}Sn	^{160}Sm	^{184}Tl: two cases
^{72}Co	^{127}Cd	^{161}Pm	^{189}Re: two cases
^{76}Co: two cases	^{128}Cd	^{161}Sm	^{191}Re: two cases
^{79}Zn	^{130}In	^{162}Sm	^{195}Bi: two cases
^{92}Rh	^{133}Xe	^{163}Eu	^{203}At: two cases
^{94}Rb	^{135}Ba	^{163}Gd	^{208}Pb : three cases
^{96}Y	^{140}Sb	^{164}Gd	^{209}Tl: two cases
^{96}Cd	^{150}Pr	^{165}Tb	^{212}Ra
^{97}Cd	^{152}Pr	^{166}Tb	^{213}Ra: two cases
^{98}Y two cases	^{156}Lu	^{167}Tb	^{220}Pa: two cases
^{98}Ag	^{158}Nd	^{168}Tb	^{254}Rf: two cases
^{98}Cd	^{158}Pm	^{172}Dy	^{258}Rf: two cases
^{119}Sn	^{159}Pm	^{172}Ta: two cases	

Discarded cases (3):

61	75	^{136}Pm	27.3+X	This isomer has now been deleted from the table as it was a misprint.
57	73	^{130}La	110.4 keV isomer with T1/2=17(5) ns from 1996XU01 is not verified by 2014IO01, as the latter group saw only a prompt transition with an upper limit of half life set at <10 ns. Hence, this isomer is removed from our compilation.	
30	43	^{73}Zn	The isomer with 5.8 s half life is removed based on 2017VE05 work.	

Isomers with revised half-life (62):

^{16}N	^{94}Ru	^{132}Te: two cases	^{184}Pt
^{26}Al	^{94}Pd: two cases	^{132}Xe	^{187}Re
^{31}Mg	^{96}Pd	^{134}Te	^{191}Re
^{34}Al	^{96}Cd	^{134}Nd	^{193}Bi: three cases
^{58}Co	^{98}Y:two cases	^{135}Ba	^{194}Po
^{65}Fe	^{99}Tc	^{136}Xe	^{195}Bi
^{66}Co	^{107}Cd	^{136}Ba	^{199}Pt
^{70}Br	^{119}Sn	^{137}Ba	^{200}Pb
^{72}Co	^{121}Sn	^{152}Tm	^{203}At
^{76}Ni	^{124}Sn	^{153}Ho	^{208}Pb
^{90}Nb	^{125}Sn	^{159}Sm	^{210}Pb
^{90}Mo	^{127}Xe	^{173}Ta:two cases	^{229}Th
^{92}Ru	^{130}In	^{179}Tl	^{235}U
^{93}Ru	^{131}La	^{180}Ta	^{251}Fm

This Atlas has led us to many new physics results.

1. **Seniority isomers decaying by E1 decay mode predicted and seen for the first time.**
2. **B(E2) anomaly in the decay of the first 2+ levels of Sn isotopes resolved for the first time.**
3. **Generalized seniority scheme shown to be more broadly valid.**
4. **Generalized Seniority Schmidt Model for magnetic moments proposed.**

Publications from the isomer work:

1. **Atlas of Nuclear Isomers**
   A. K. Jain, B. Maheshwari, S. Garg, M. Patial and B. Singh
   Nuclear Data Sheets 128, 1 (2015)
2. **6+ isomers in neutron rich Sn isotopes**
   B. Maheshwari, A. K. Jain and P. C. Srivastava
   Phys. Rev. C 91, 024321 (2015).
3. **Odd-tensor electric transitions in high-spin Sn-isomers and generalized seniority**
   B. Maheshwari and A. K. Jain
   Phys. Lett. B 753, 122 (2016).
4. **Asymmetric Behavior of the B(E2; $0^+ \rightarrow 2^+$) values in $^{104\text{-}130}$Sn and gen seniority**
   B. Maheshwari, A. K. Jain and B. Singh
   Nucl. Phys. A 952, 62 (2016).
5. **Goodness of Generalized Seniority in Semi-magic Nuclei**
   A. K. Jain and B. Maheshwari
   Nuclear Physics Review 34, 73 (2017)
6. **Generalized Seniority States and Isomers in Tin Isotopes**
   A. K. Jain and B. Maheshwari
   Physica Scripta 92, 074004 (2017).
7. **$\Delta v = 2$ seniority changing transitions in yrast 3^- states and B(E3) systematics of Sn isotopes**
   B. Maheshwari, S. Garg and A. K. Jain
   Pramana-Journal of Physics (Rapid Comm.)89, 75 (2017)
8. **Generalized Seniority Schmidt Model and the g-factors in Semi-magic nuclei**
   B. Maheshwari and A. K. Jain, under review.

Additional points for the Future Update:

It has been suggested by Balraj Singh that we must further lower the half-life limit of isomers to 1ns. This entails including 900 more cases as per the ENSDF data base. We would like to have the opinion of the network members if it is a very useful idea.

Present Atlas of Isomers has been read almost 800 times but cited only 16 times.