The $E3$ decay of isomers in mass A $\sim$ 215 Region: Compilation and Evaluation

P. S. Rawat[1*] and S. Kumar[1]
[1] *Department of Physics and Astrophysics, University of delhi, New Delhi-110007, INDIA*

Introduction

In the mass $A \sim 215$ region, many nuclei have isomeric states those are characteristic by the $E3$ decay and an octupole excitation. The octupole isomers are those which have their origin in the particle-vibrational coupling of an octupole vibration to the single particle states and found to decay via enhanced $E3$ transitions. This mass region is found to be most influenced by octupole correlations [1] (octupole vibration and static otupole deformation) due to presence of closely spaced single particle $\Delta j = \Delta l = 3$ proton and neutron orbitals near Fermi level. The octupole correlations breaks the reflection symmetry in nuclei and leads to the experimental observations such as parity doublets and low-lying negative parity states in even-even [2], interleaved opposite parity simplex band structure in odd-A nuclei [3], octupole isomeric states, and enhanced $E1$ & $E3$ transition rates.

Methodology for data evaluation and compilation

In the present work, a data evaluation and compilation of $E3$ decay transitions and corresponding octupole isomeric levels in various nuclei having $Z = 80-92$ near $N = 126$ closed shell has been performed. The experimental data is collected from the 'ENSDF (Evaluated Nuclear Structure Data File)' Database from NNDC website [4]. The compilation includes the energy, half-life, spin-parities, configuration and g-factor of the isomeric states; multipolarity, energy, branching ratio, and transition strength of the $E3$ decay branch. All the references in ENSDF Dataset are checked in order to compile the data for Angular Distribution, Conversion coefficients, and polarization measurements.
The XUNDL (Experimental Unevaluated Nuclear Data List)' Database [4] is also checked for any new measurement for given isomeric level after latest ENSDF evaluation. If any new half-lives or transition strength measurements are found, the new measurements were considered to evaluate the half-live and $B(E3)$ transition rates using the data evaluation codes [5].

Systematic

Many isomeric states are identified in the mass $A \sim 215$ region those decay by the $E3$ transitions [6, 7]. In this work, the half-lives and $B(E3)$ transition strength are compiled along with other properties as mentioned above. A systematic variation of half-lives and $B(E3)$ transition strength as a function of neutron number for some of the isomeric states in different isotopes of $Z = 80 - 92$ is shown in Fig. 1 and probable part of configurations which lead to the $E3$ decay as listed in Table I. The 11^- isomer in even-even nuclei decay to two 8^+ levels (in some cases, only one branching out of the two is observed and in a few cases both the branches are experimentally observed), one by enhanced $E3$ decay rates of order of $18 - 50$ *W.u.* to $(\pi h_{9/2} f_{7/2})_{8^+}$ showing signatures of enhanced octupole colectivity. The other to $(\pi h^n_{9/2})_{8^+}$ level with low $B(E3)$ values (< 15 *W.u.*).

However, the E3-decay of $15/2^-$ and $29/2^+$ isomers in even-odd and odd-even nuclei is observed due to the interaction of $\Delta j = \Delta l = 3$ orbitals showing effect of octupole correlations in nuclear structure. The odd-odd nuclei are found to have a 10^+

*Electronic address: prernasinghrawat4@gmail.com

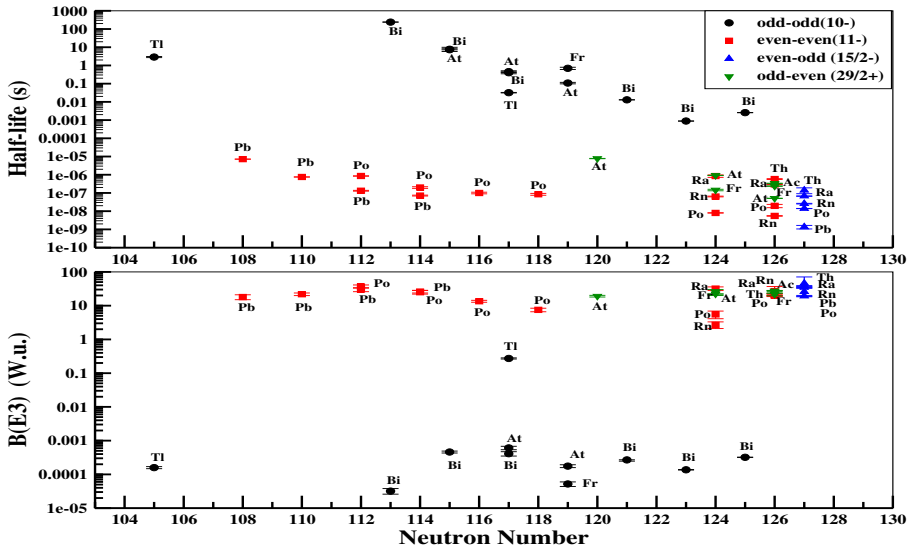

FIG. 1: Half-lives (upper panel) and $B(E3)$ values (lower panel) as a function of neutron number for various isomeric states in $Z = 80 - 92$ [data is taken from ENSDF database and references therein]

TABLE I: the single particle configurations involved in the E3 decay branch of various isomeric states

Nuclei	Isomer	transition involved
even-even	11^-	$\pi h^n_{9/2} i_{13/2} \rightarrow \pi h^n_{9/2} f_{7/2}$
	11^-	$\pi h^n_{9/2} i_{13/2} \rightarrow \pi h^{n+1}_{9/2}$
even-odd	$15/2^-$	$\pi h^n_{9/2} \nu j_{15/2} \rightarrow \pi h^n_{9/2} \nu g_{9/2}$
odd-even	$29/2^+$	$\pi h^n_{9/2} i_{13/2} \rightarrow \pi h^n_{9/2} f_{7/2}$
odd-odd	10^-	$\pi h^n_{9/2} \nu i_{13/2} \rightarrow \pi h^n_{9/2} \nu f_{5/2}$

isomeric states with half-life in *ms-s* range which decays to 7^+ state by transition of a neutron-hole from $\nu i_{13/2}$ to $\nu f_{5/2}$ orbital. The large half-lives or smaller $B(E3)$ values indicate that these isomers are probably the k-isomers or a result of quadrupole-octupole interaction. Further, the compilation of angular distribution co-efficients provides the recommendation value of A_2 and A_4 which are useful to find the value of DCO and polarization asymmetry for E3 transition. In future we are planning to estimate the reduced hindrance factor for all E3 transitions which may help in characterization of E3 isomers.

Acknowledgments

One of the author(P.S. Rawat) acknowledges the financial assistance from UGG-DAE-KC with project CRS/19/NP07/0918/0960. Further, The research grant (lOE/FRP/PCMS/2020/27) under faculty research programme (FRP) of Institute of Eminence(IOP), university of Delhi is also acknowledged.

References

[1] P. A. Butler and W Nazarewicz, Rev. of Mod. Phys. **68**, 349 (1996).
[2] J. F. C. Cocks *et al.*, Phys. Rev. Lett., **78**, 2920 (1997).
[3] Pragati *et al.*, Phys. Rev. C **97**, 044309 (2018).
[4] https://www.nndc.bnl.gov/ENSDF and XUNDL website.
[5] http://www−nds.iaea.org/public/ensdf_pgm/Codes.
[6] Ashok Kumar Jain *et al.* Nucl. Data Sheet **128**, 1 (2015).
[7] F.G. Kondev *et al.*, Atomic Data and Nuclear Data Tables **103**, 50 (2015).