

Regional regularities in various mass regions of even nuclei

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With the development of experimental techniques more and more experimental data are accumulated and compiled. For over five decades the proton neutron interaction has been considered the key ingredient in the development of collectivity and ultimately deformation in atomic nucleus. Phenomenologically, the correlation of the integrated valance proton – neutron interaction with the onset of collectivity and deformation has been considered in terms of $N_p N_n$ scheme [1]. The observables well known measure of collectivity are $R\left(\frac{4}{2}\right) [= E4_1^+/E2_1^+]$ and $E2_1^+$ in even nuclei which are directly obtained from experiment. As far as the external parameter $N_p N_n$ is concerned it is the product of valance proton and neutron numbers counted to the nearest closed shell. Clearly there is a general growth in $R\left(\frac{4}{2}\right)$ from doubly magic nuclei towards midshell (largest $N_p N_n$ values). However, closer interpretation shows an intriguing phenomenon. The ratio $R\left(\frac{4}{2}\right)$ grows to saturation at different rates in different quadrants [2].

The purpose of the present work is to investigate the strength of interaction i.e. $N_p N_n$ values along with the ratio $R_{4/2}$ and the quadrupole deformation β in different quadrants. Our study in the present work will include Zr($Z = 40, 40 \leq N \leq 62$), Ce ($Z = 58, 66 \leq N \leq 92$), Sm ($Z = 62, 72 \leq N \leq 92$), and

Pt ($Z = 78, 98 \leq N \leq 120$) isotopes. We investigate that the hh pair (hole – hole pair) or hp pair (hole – particle pair) or pp pair (particle – particle pair) have different strength of interaction. In clear words whether the interaction are unequal when both protons and neutrons are in the first half of the shell (or both in the second half) compared to one filling below and the other above mid shell.

Table – I

Comperison of Strength of $R_{4/2}$ and β for Zr Nuclei

Zr ($Z = 40, 40 \leq N \leq 62$)				
A	$N_p N_n$	Pairs	β	$R_{4/2}$
82	10×10	hh	0.367	2.55
84	10×8	hh	0.251	2.34
86	10×6	hh	0.151	2.21
88	10×4	hh	0.185	2.02
90	10×2	hh	0.089	1.41
92	10×0	-	0.103	1.60
94	10×2	hp	0.090	1.60
96	10×4	hp	0.080	1.78
100	10×8	hp	0.355	2.65
102	10×10	hp	0.427	3.15

Pair strength comparisons for equal values of $N_p N_n$ but having different pairs in $R_{4/2}$ and deformation parameter β are given in table – I, II, III and IV for isotopic chain Zr, Ce, Sm and Pt. It is inferred that in isotopic chain Zr ($Z = 40, 40 \leq N \leq 62$) the hole – hole interaction strength is lower than that of the strength of hole – particle for $R_{4/2}$ and deformation parameter β both (Table – I).

Table – II
Comperison of Strength of $R_{4/2}$ and β for Ce Nuclei

Ce (Z = 58, 66 ≤ N ≤ 92)				
A	$N_p N_n$	Pairs	β	$R_{4/2}$
126	8×14	ph	0.325	-
128	8×12	ph	0.298	2.93
130	8×10	ph	0.258	2.79
132	8×8	ph	0.264	2.63
134	8×6	ph	0.195	2.56
136	8×4	ph	0.170	2.38
138	8×2	ph	0.126	2.31
140	8×0	-	0.101	1.30
142	8×2	pp	0.128	1.90
144	8×4	pp	0.166	2.36
146	8×6	pp	0.193	2.59
148	8×8	pp	0.251	2.86
150	8×10	pp	0.320	4.28

It is observed that in isotopic chain Ce (Z = 58, 66 ≤ N ≤ 92) for $N_p N_n < 80$ the interaction strength in pp is almost same as in ph but, for $N_p N_n \geq 80$, the pp strength is more than the ph strength. This is the inference received from β growth and $R_{4/2}$ both (Table – II).

Table – III
Comperison of Strength of $R_{4/2}$ and β for Sm Nuclei

Sm (Z = 62, 72 ≤ N ≤ 92)				
A	$N_p N_n$	Pairs	β	$R_{4/2}$
134	12×10	ph	0.366	-
136	12×8	ph	0.293	-
138	12×6	ph	0.208	2.69
144	12×0	-	0.087	1.32
148	12×2	pp	0.142	2.14
150	12×4	pp	0.193	2.31
152	12×8	pp	0.306	3.01
154	12×10	pp	0.341	3.28

We are unable to comment on relative strength of pairs in this isotopic chain since there is no rule in the strength of pairs pp and ph in

deformation β . In $R_{4/2}$ ratio, we don't have sufficient data to investigate the strength systematics (Table – II).

Table – IV
Comperison of Strength of $R_{4/2}$ and β for Pt Nuclei

Pt (Z = 78, 98 ≤ N ≤ 120)				
A	$N_p N_n$	Pairs	β	$R_{4/2}$
176	4×16	ph	0.190	-
180	4×20	ph	0.256	2.69
182	4×22	ph	-	2.69
184	4×22	hh	0.224	2.67
186	4×20	hh	0.198	2.56
188	4×18	hh	0.186	2.52
190	4×16	hh	0.149	2.61
192	4×14	hh	0.153	2.48
194	4×12	hh	0.143	2.47
196	4×10	hh	0.129	2.46
198	4×8	hh	0.114	2.42

In isotopic chain of Pt (Z = 78, 98 ≤ N ≤ 120) the interaction strength of ph is stronger than that of hh as noted from Table – IV.

On investigating the strength of interaction in pairs pp, ph and hh is different for different mass region therefore, regional regularities is obtained in various mass region of even nuclei.

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