Study of N_pN_n scheme in some near magic light nuclei

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With the development of experimental techniques more and more nuclear data are now available on low mass near magic nuclei. [1]. The evolution of nuclear structure with mass is a preliminary consequence of proton neutron interaction with largely independent of the detailed nature of the forces involved. It is reasonable to suppose that these are respective numbers of valence protons and neutrons. It seems likely then that the product N_pN_n of the valance nucleon numbers will be qualitative measure of the proton neutron interaction strength. This would be the case for example for a proton neutron interaction of quadrupole type deformation (β) in the atomic nucleus. The basic deformation in the atomic nucleus is assumed to have value whose magnitude should vary as the product N_pN_n. Interestingly, the product of proton and neutron boson numbers $N_\pi N_\upsilon$ in interacting boson approximation (IBA) is identical with N_pN_n [2]. To verify this concept the study of big chain of isotopes of a nucleus is necessary so that the value of deformation to both sides of mid shell may be examined. In the current decade the experimentalists have shown a keen interest in getting information on typical mass region near N~Z~28.

Study of N_pN_n is undertaken in present work on light mass near magic even nuclei e.g. Ar, Ca, Ti, Zn, Cr & Ni (Table – I). Besides deformation β, the energy head of ground band $E2_1^+$ is also studied in N_pN_n scheme. It is important to look at both of these quantities β and $E2_1^+$since β is derived from one basic observable $B(E2; 2_1^+ \rightarrow 0_1^+)$ and $E2_1^+$ is another generally known quantity. The values of $B(E2; 2_1^+ \rightarrow 0_1^+)$ and $E2_1^+$ reach their saturation following different physics and as such while $E2_1^+$ values decrease, the β values increase with the increase of N_pN_n values.

Table – I

Nucl.	$E2_1^+$(KeV)	β	N_pN_n
^{34}Ar	2090	0.238	8
^{36}Ar	1970	0.256	4
^{38}Ar	**2167(Max.)**	**0.163(min.)**	**0(Min.)**
^{40}Ar	1461	0.251	4
^{42}Ar	1208	0.275	8
^{44}Ar	1144	0.240	4
^{46}Ar	**1550(Max.)**	**0.175(min)**	**0(Min.)**
^{38}Ca	2206	0.128	2
^{40}Ca	**3904(Max.)**	**0.123(Min.)**	**0(Min.)**
^{42}Ca	1524	0.247	2
^{44}Ca	1157	0.253	4
^{46}Ca	1346	0.153	2
^{48}Ca	**3831(Max.)**	**0.106(Min.)**	**0(Min.)**

Table – I Continued ……

^{42}Ti	**1555(Max.)**	**0.317**	**0(Min.)**
^{44}Ti	1083	0.268	4
^{46}Ti	889	0.317	8
^{48}Ti	983	0.269	4
^{50}Ti	**1553(Max.)**	**0.166(Min.)**	**0(Min.)**
^{52}Ti	1049	-	4
^{46}Cr	892	0.288	8
^{48}Cr	**752(Min.)**	**0.340**	**16(Max.)**
^{50}Cr	783	0.290	8
^{52}Cr	**1434(Max.)**	**0.210**	**0(Min.)**
^{54}Cr	834	0.020	8
^{56}Cr	1006	0.195	16
^{58}Cr	880	0.254	24
^{60}Cr	646	0.230	32
^{62}Cr	**447(Min.)**	**0.270**	**40(Max.)**
^{54}Ni	1392	0.179	2
^{56}Ni	**2700(Max.)**	**0.151(Min.)**	**0(Min.)**
^{58}Ni	1454	0.179	2
^{60}Ni	1332	0.205	4
^{62}Ni	1172	0.197	6
^{64}Ni	1345	0.162	8
^{66}Ni	1424	0.157	10
^{68}Ni	**2034(Max.)**	**0.101(Min.)**	**10(Max.)**
^{70}Ni	1259	0.179	8
^{74}Ni	1024	0.210	4
^{62}Zn	954	0.217	8
^{64}Zn	991	0.233	12
^{66}Zn	1039	0.219	16
^{68}Zn	**1077(Max.)**	**0.201(Min.)**	**20(Max.)**
^{70}Zn	884	0.229	20
^{72}Zn	652	0.234	16
^{74}Zn	605	0.247	12
^{76}Zn	598	0.206	8
^{78}Zn	730	0.147	4
^{80}Zn	**1492(Max.)**	**0.141(Min.)**	**0(Min.)**

It is inferred in the present study that at mid shell and little around it the N_pN_n product is inversely proportional to $E2_1^+$ in all cases without exception but it is directly proportional to β in cases under consideration except Ti and Cr isotopic chains. This is strange that the scheme is not being followed beyond the value of N_pN_n as 8. Thus the N_pN_n scheme which has been so successful in medium mass region chains of Mo, Ru and Pd nuclei [3] fails to be so well in light mass region of nuclear chart.

References:

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