Log Mirror Symmetry Between the Lifetime and the Excitation Energy of the $9/2^+$ Isomer in Mass ∽80

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Introduction

The transition probability for a state with J_i decaying into state J_f, by a transition of multipole order L and the energy E_γ, is given [1] by $T_{fi}(\sigma L) =$

$$\frac{8\pi(L+1)}{\hbar L((2L+1)!!)^2}\left(\frac{E_\gamma}{\hbar c}\right)^{2L+1} B(\lambda L : J_i \to J_f)(1)$$

where $B(\sigma L : J_i \to J_f)$ is called the *reduced transition probability*. The lifetime of state depends on three parameters, E_γ, L and $B(\lambda L : J_i \to J_f)$. It is very important to scale the effect on transition probability by change in any parameter, and these called as shape isomers (decay inhibited due to shape mismatch), spin isomers (spin mismatch) and K-isomers (change in spin orientation with respect to axis of symmetry).

The fox on role of these parameters in different mass region (different orbital), is crucial for the isomeric states. The unique-parity states are of special importance because in that case the state of the valence particle can be assumed to be a relatively pure single particle one. In this report, the systematically study of $9/2^+$ isomer in mass ∼80, will be explored in such a way that lead to a dependence on the number of neutrons and protons in the active shell (N_pN_n). We attempt to understand general systematics and the role of the $g_{9/2}$ orbit rather than to reproduce exact agreement between theory and experiment.

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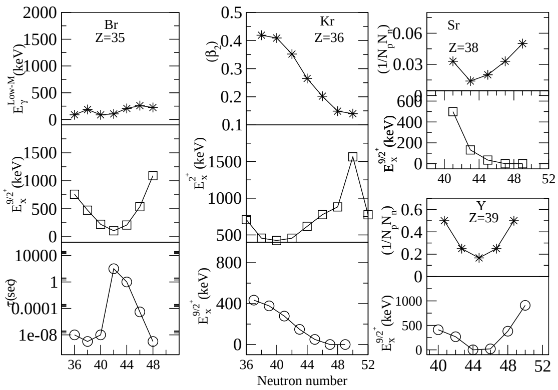

FIG. 1: Figure shows the energy of lowest multipole γ-transitions, the level energies and theirs lifetimes.

Experimental observations

From the exist experimental data (Fig.1), it is possible to observe fellowing points address below for some odd-A nuclei in the mass A∼ 80.

(i) For odd-Z nuclei, a minima in the $9/2^+$ excitation energy is observed at N=42 for As and Br, and at N=44 for Rb and Y. The excitation energy of levels, $E_x^{9/2}$, present a parabolic shape.

(ii) The excitation energies of $9/2^+$ levels in odd-N nuclei follow the same trend as the β-deformation of their even-even neighbouring nuclei.

(iii) Except when the $9/2^+$ state is ground state, the lifetime pattern and the pattern of excitation energy of $9/2^+$ level, look anti-symmetric (mirror image) in different units and scale.

Disccussion

A. Consideration of N_pN_n term

The N_pN_n scheme could be applied to interprate the energy shape of $9/2^+$states in odd mass ∼80. The $\pi g_{9/2}$ structure (Fig. 1) presents a relatively smooth evolution. It has been observed in various cases that odd-proton influence the deformation, and N_pN_n is related to collectivity (deformation), therefore, the excitation energy trends of $9/2^+$ states in odd-proton nuclei, corroborates with the N_pN_n (Fig. 1). The parabolic shape of $9/2^+$ states energy to $\pi g_{9/2}$ structure (as experimental observation (*i*)) is well understood in term of N_pN_n, as the $\frac{1}{N_pN_n}$ minima is observed at 42 (neutron number) for As and Br, and 44 (neutron number) for Rb, Y isotopes that means these nuclei have larger permanent deformations at these neutron number.

The $\nu g_{9/2}$ structure shows a different evolution (Fig. 1). The energy shape of $9/2^+$ state corroborates with the deformation (Fig. 1) of neighbouring even-even (core) nuclei rather than the N_pN_n (Fig. 1). The odd-neutron does not influence the deformation too much, that's why the energy shape of $9/2^+$ states in odd-neutron nuclei not corroborates with the N_pN_n (Fig. 1). It seems that the nature of coupling of $\nu g_{9/2}$ particle to their neighbouring even-even (core), cause the excitation energy of $9/2^+$ state.

B. Lifetime Evolution

The transition probability of state might be mostly defined by the transition probability of lowest multipolarity γ-transition. The $9/2^+$ isomer is mostly related to decay between structures based on the high-j $g_{9/2}$ intruder orbital and the f-shell configuration. It seems that the multipolarity of γ-transition is same and not affect lifetime pattern much. Fig. 1 illustrates that lifetime pattern not corroborates with the γ-transition energy (E_γ), even though corroborates with the level energy in case of odd-P nuclei. The experimental observation (*iii*) anti-symmetry behaviour between lifetime and level energy can be explained from Eq. 1. It should be remarked that the dependence of lifetime of $9/2^+$ isomer mainly on ($B(\lambda L : J_i \rightarrow J_f)$ *i.e.* on the level energy, is the signature of shape isomer in odd-Z nuclei.

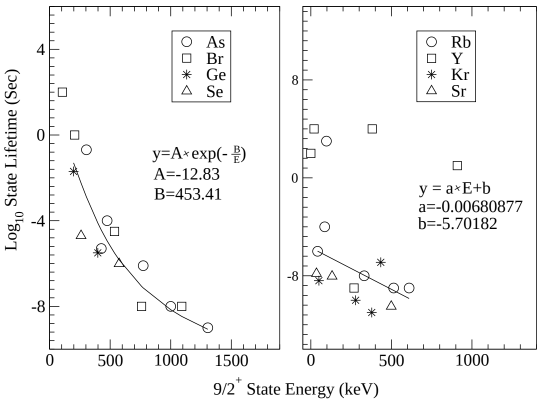

FIG. 2: Plot of decay time *versus* state energy.

It is difficult to make a clear picture between level energy and lifetime in odd-N nuclei because of the lack of lifetime data. The energy systematics of $9/2^+$state in odd-N nuclei cope with the nature of coupling of valence-neutron with neighbouring even-even (core). It is possible to view the occurrence of isomers as arising from somewhat chance couplings of particular nucleon orbits, such couplings produce unusual states, typically with well defined structure of the nucleus.

Figure 2 shows a plot of the lifetime *versus* the energy of $9/2^+$ state. It is expected some exponential correlation between logarithmic of the lifetime of ($9/2^+$ isomers) and the level energy in case of Ge, As, Se and Br isotopes while in case of Kr, Rb and Sr somewhat linear correlation, that will be resulted in some new conclusions regarding the effect of proton number on nuclear state. The data have been fitted (Fig. 2) with mathematical function ($ln(\tau) = A \times exp(-\frac{B}{E})$ and $ln(\tau) = a \times E + b$). The data points of Y-isotopes are somewhat scattered.

References

[1] A. Bohr, and B.R. Mottelson, Nuclear Structure, vol 2 (1975).