International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 1281-1284 www.ijaem.net ISSN: 2395-5252

B(M2: $\pi g_{9/2}^{+} \rightarrow \pi f_{5/2}^{-}$) in odd $^{83-89}$Rb isomers

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Submitted: 15-05-2021 Revised: 26-05-2021 Accepted: 28-05-2021

ABSTRACT: We reportbetween $\pi(g_{9/2}^{+})$ and $\pi(f_{5/2}^{-})$ levels in odd Radium (Z=37) nuclei for the B (M2) with even neutron N = 46 to 52 . The binding energy, mean-life, and hindrance factors F_w, width of levels in odd $^{83-89}$Rb isotopes are reported. Thepresentdata of the B(M2)are matched to the earliermeasured data. The levels energy of $9/2^{+}$ versus neutron numbersof those nucleiwas systematically studied. The fragment energy are calculated and compared with available experimental data.

Keywords: Radium, B(M2), Mean-life, width levels, binding energy, Hindrance factors

I. INTRODUCTION

Single- and a few-particle excitations around magic number Z=28are important about closed shellstructure [1]. The excited states ofGa, As, Br andRb nuclei give valuable information on single particle states of nuclear configurationabout the^{78}Ni shell closure.

It is known that nuclear shell model has clarified the goodspossessionsof isomers neighboring to the magic information. The excited levels of nuclei are extensivelyspread out by severalshell model potential. A long-lived levelis called nuclear isomers, which existedaround shell closure [2,3].

Experimentally Broda et al. establish sub-shell in Nicole (A =68) for neutron 40[4]. This confirmed 2^{+} level in ^{68}Ni is very high. The M2 transitions of ^{67}Zn, ^{67}Ge and ^{69}Genuclied were recognized due to $\nu g_{(9/2)}{}^{n}$formation[4].

Anobservation of particleevolution in neutron rich isotopeswasconfirmed by shell model design [6]. It was shown that protons and neutrons motion are collective observed inE2 transition [7]. Hossain et al. studied M2 transition between single particle level $9/2^{+}$ to $5/2^{-}$ of $^{69-79}$As [8,9].

In the odd Rubidium (Rb) isotopes, proton$g_{9/2}^{-}$ isomers were found [10-13]. So that it is interesting to expand the research by calculating the properties of isomers of oddRb isotopeswith N=46-52. Moreover, in odd $^{83-89}$Rb nuclei are not reported yet the systematic hindrance factors,B(M2) data, mean lives and level of width. It is exciting to study analyticallyof those nuclei.

II. THEORETICAL CALCULATION

2.1.1 Reduce transition probabilities B(M2)

The ratio ofmeasured and theoretical data of B(M2) is a moralinquiry in order to find the construction of isomeric level in Weisskopf unit (W.U.).The B(M2) of the isomers,

$$B(M2; I_i \rightarrow I_f) = 7.381 \times 10^{-8} E_{\square}^{-5} P_{\square} (M2; I_i \rightarrow I_f)$$

in the unit of $\mu_N^2 fm^{2L-2}$

Where, I_i and If are total spin of the initial and final states in that order.

$E_{\square}$ = energy of isomeric level

$P_{\square\square\square}$ transition probability = $(\frac{0.693}{t_{1/2}})$

The Weisskopfapproximation of $B_w(M2)$:

$$B_w(M2) = 1.65\ A^{2/3}$$

$$B(M2) = \frac{B(M2)\mu_N^2 fm^6}{B^w(M2)} W.u$$

2.1.2 Mean-life time, τ

Established on the harmful decay relation, substitute $\frac{1}{2}N_o$ into N at a time t = $T_{1/2}$ that gives;

$$T_{1/2} = \frac{0.693}{\lambda} \equiv 0.693\ \tau$$

Where, $T_{1/2}$ = half-life

$$\text{So}, \tau_\gamma = \frac{T_{1/2}}{0.693}$$

3.7 Width of level, Γ_γ

Width of isomeric level

$$\frac{1}{\tau_\gamma} = \frac{\Gamma_\gamma}{\hbar}$$

Where; τ_γ = mean life

Γ_γ is Width (of the level)

$\hbar = \frac{h}{2\pi}$; h is plank constant

2.4 Hindrance Factor, F_w

Weiskopf Hindrance Factor can be determined by;

$$F_w = \frac{B^w\left(\frac{M}{E}\right)}{B\left(\frac{M}{E}\right)\text{theoretical}}$$

Where; $B^w\left(\frac{M}{E}\right) = 1.65A^{2/3}$

2.5 Binding Energy

The energy that equivalent to the mass defect is taken to find the binding energy. The binding energy can be calculated by using equation follow.

$$\text{Binding Energy} = \Delta m\left[\frac{931.4}{1\ \text{amu}}\right]$$

Δm = mass defect

$$\Delta m = [Z(m_P + m_e) + (A - Z)m_n] - m$$

With; Z = Proton number

A = Mass number

m = Mass of atom

m_P = proton mass

m_e = electron mass

m_n = neutron mass

III. RESULT AND DISCUSSION

The calculation result of M2 gamma transition between $9/2^+$ to $5/2^-$, strength of B(M2), isomeric levels, mean life,half-life, , width of levels, binding energy and hindrance factor of odd$^{83-89}$Rb are presented in Table 1.

3.1 Systematic Reduced Transition ProbabilitiesB(M2)

The calculated B(M2) of odd $^{83-89}$Rbisotopes show that M2-type has been givenfrom $9/2^+$ to $5/2^-$ created on requiredguidelines. Figure 1 shows the B(M2) values between theoretical data and measured data. The B(M2) versus A(mass number) has been drawn. It is noted that there is no experimental data of B(M2) for ^{83}Rb, ^{85}Rb and ^{87}Rb isotopes. However, for ^{89}Rb, the calculated value of B(M2) is slightly difference from experimental value. The calculated B(M2) value of ^{83}Rb is higher than ^{85}Rb and ^{87}Rb.Theextreme magnetic quadrupolecompactevolutionprobabilities is 2.5925 W.u in ^{83}Rb. The data show the B(M2) is rapidly decreasesfrom mass number A=83 to A=85 and then remain constant with increasing mass number upto89.

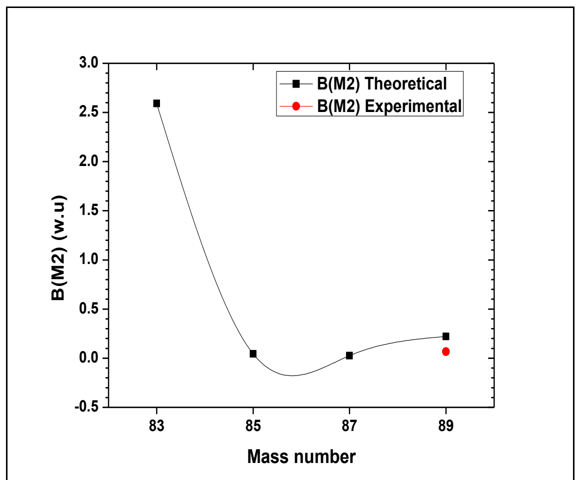

Fig. 1.B(M2) in W.u versus A of odd ^{83}Rb to ^{89}Rb

3.2 Isomeric level

Figure 2displays the isomeric levels vs odd A of ^{83}Rb to ^{89}Rb nuclei. Based on the nuclear data sheets [10-13], it is shown that at $9/2^+$ level, the isomeric energy level of nuclei from ^{83}Rb to ^{87}Rb is increasingmonotonically with the increasing of mass number and then decreases until ^{89}Rb.

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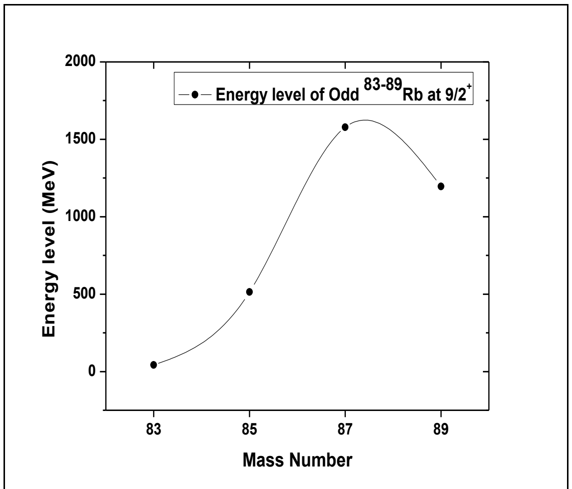

Fig.2. Energy level versus mass number of odd ^{83}Rb to ^{89}Rb

3.3 Hindrance Factor, Fw

F_w indicates the hindrance factor comparative to the single-particle Weisskopfestimation. The result shows that the hindrance factor is increasing from ^{83}Rb to ^{87}Rb and decreasing towards ^{89}Rb.

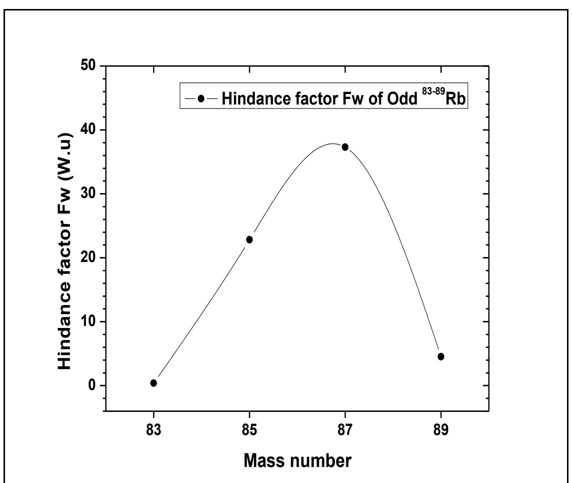

Fig. 3. Hindrance factor VsA of odd ^{83}Rb to ^{89}Rb

IV. CONCLUSION

The methodical mean life, B(M2), thickness of level, Weisskopflimitation factor and binding energy are premeditated in odd ^{83}Rb to ^{89}Rb. The calculations of B(M2) aremoralsettlement with the measured result. The regular de-excitation of meta-stable levels indicatesextremely deformation happensin^{87}Rb.

ACKNOWLEGEMENT

The author thanks to the Research Management Centre (RMC), Universiti Teknologi Malaysia and Ministry of Higher Education (MOHE) for the grant GUP vote #(Q.J130000.2526.03H28).

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Volume 3, Issue 5 May 2021, pp: 1281-1284 www.ijaem.net ISSN: 2395-5252

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Table 1: Properties of odd ^{83,85,87,89}Rb isomers

Nucl.	*E_{level} keV	*E□ ($9/2^+ \rightarrow 5/2^-$) keV	$T_{1/2}$	T□ Sec	B(M2) W.u exp	B(M2) W.u present	Γ□ (eV)	F_w	PLF energy $(MeV)_{exp}$ [14]	PLF energy $(MeV)_{present}$	BE (MeV)	*Ref
^{83}Rb	42.11	42.33	0.3 ms	4.329×10^{-4}		2.5915	1.5246×10^{-2}	0.39		362.89	719.688	10
^{85}Rb	514.00	514.00	1.015(1) µs	1.4646×10^{-9}		0.0438	4.5063×10^{3}	22.83		367.99	738.914	11
^{87}Rb	1577.90	1175.3	6 (1) ns	8.658×10^{-8}		0.0268	76.2300	37.31	324(10)	372.25	757.477	12
^{89}Rb	1195.36	974.39	8 (2) ns	1.1544×10^{-9}	0.067	0.2208	5.7173×10^{3}	4.53		371.97	770.727	13