Study of superdeformed bands in ^{58}Ni in the framework of VMI model

Tapan Sharma‡ and Honey Sharma*
‡Department of Physics, DAV University,
Jalandhar, Punjab, India
and
*Department of Physical Sciences,
Sant Baba Bhag Singh University,
Padhiana, Punjab, India

Introduction

Around N, Z=30-32 [1, 2] the theoretical computation of large shell gaps in the single particle energy levels have realized the existence of SD bands in A∼60 mass region [3]. Due to the experiment restraints, the confirmation for such SD bands in the A∼60 mass region has been detected around the year 1997-1999 [4, 5]. The inspection of this mass region was very crucial because it provides the contrast between the Shell model calculation and mean field Cranking model of the SD bands. Also, there was the feasibility of establishing the complete understanding on the onset of T=0 n-p pairing at large rotational frequency and associated loss of collectivity. The observation of first SD band in A∼60 mass region was revealed in N=32, Z=30, i.e., ^{62}Zn [5]. A sequence comprising of only six E transitions leads to a quadrupole moment of $2.7^{+0.7}_{0.5}eb$ and $\beta = 0.45^{+0.10}_{-0.07}$. Afterwards, the existence of new SD bands was recognized in the double magic N=Z nucleus ^{60}Zn [4]. Band head spin assignment of SD bands in A∼60-80 mass region through nuclear softness formula was calculated by Sharma and Mittal [6].

In this present paper, we have studied the SD bands in ^{58}Ni in the framework of VMI model. We have calculated the E_γ transition energies, band head moment of inertia, nuclear softness parameter and stiffness constant of ^{58}Ni by using VMI model.

*Electronic address: honeyshrma777@gmail.com

Formalism

VMI model

$$E_\gamma(I \to I-2) = \frac{[I(I+1)-(I-2)(I-1)]}{2\Im_0} + \frac{[I(I+1)]^2-[(I-2)(I-1)]^2}{8C(\Im_0)^4}, \quad (1)$$

where $\Im_0$ and C is a model parameters, which can be found by using the fitting techniques.

Results and Discussion

A VMI model has been applied on the SD bands [7] in $^{58}Ni(1,2)$. We have calculated the transition energies of $^{58}Ni(1,2)$ SD bands by using VMI model; and the result of which are compared with the experimental data (see Table I, II). The calculated results are in good agreement with the available experimental data. The band head moment of inertia, nuclear softness parameter and stiffness constant of $^{58}Ni(1,2)$ SD bands are also calculated (see Table III).

TABLE I: Comparison of the theoretical result(VMI model) and experimental results of transition energies E_γ of $^{58}Ni(2)$ SD band in (keV).

$E_\gamma(I \to I-2)$	VMI model
1688.0	1667.62
1996.0	1976.86
2276.9	2295.33
2570.9	2624.39
3002.8	2965.41

TABLE II: Comparison of the theoretical result(VMI model) and experimental results of transition energies E_γ of $^{58}Ni(1)$ SD band in (keV).

$E_\gamma(I \rightarrow I-2)$	VMI model
1664.0	1672.2
1988.7	1991.0
2349.7	2343.9
2750.5	2735.1
3157.0	3168.6

TABLE III: Parameters obtained from least-squares fit for $^{58}Ni(1,2)$ using the VMI model. $\Im_0$ is a band head moment of inertia, C is a stiffness constant and σ is a nuclear softness parameter.

SD bands	$\Im_0$	$C \times 10^8$	$\sigma \times 10^{-4}$
$^{58}Ni(2)$	0.0141	8.730	2.016
$^{58}Ni(1)$	0.0205	6.572	8.830

Conclusion

In this present work, it is observed that the VMI model very well proves its efficiency in order to explain experimentally observed $^{58}Ni(1,2)$ SD bands.

References

[1] R. K. Sheline, I. Ragnarsson and S. G. Nilsson, Phys. Lett. B, 41: 115 (1972)
[2] J. Dudek et al., Phys. Rev. Lett., 59: 1405 (1987)
[3] I. Ragnarsson, Proc. Workshop on the Sci. of Int. Radio. Ion Beams (Eds. J. B McClelland and D. J. Vieira) Los Alamos National Lab. Report No. LA-11964c: 199 (1990)
[4] C. E. Svensson et al., Phys. Rev. Lett., 82: 3400 (1999)
[5] C. E. Svensson et al., Phys. Rev. Lett., 79: 1233 (1997)
[6] H. Sharma and H. M. Mittal, Int. J. Mod. Phys E, 26: 1750074 (2017)
[7] http://www.nndc.bnl.gov/