High spin structure of ^{88}Zr

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Introduction

High spin spectroscopy of nuclei near shell closure remains a subject of current interest in nuclear physics. Due to the limited available valence space for particle excitation shell model calculation is very useful to interpret the experimental spectrum in this region. Measurements in modern large gamma ray detector array have made it possible to identify excitation up to very high spin in these nuclei. Calculation for these high spin excited states requires shell model calculations involving larger model space which are currently being developed. The experimental data at high spin will give stringent test to shell model interaction in this region. In particular, an optimum shell model interaction in $f_{5/2}pg_{9/2}$ model space is being developed to explain the excitation in nuclei close to ^{100}Sn and ^{56}Ni. According to a recent review no shell model interaction is yet optimized in this model space [1]. Nuclei around ^{90}Zr having Z=40 sub-shell closure and N=50 shell closure are good candidates to compare such interactions. In our recent work, a detailed comparison of the measured excited levels of ^{89}Zr [2] up to high spin with the results from the shell model calculations based on the JUN45[1] and jj44b[3] interactions has been done. With the same motivation here, we will present our study of high spin states in ^{88}Zr nucleus and compare our result with the same interactions. Possibility of excitation across the N=50 shell gap will also be explored.

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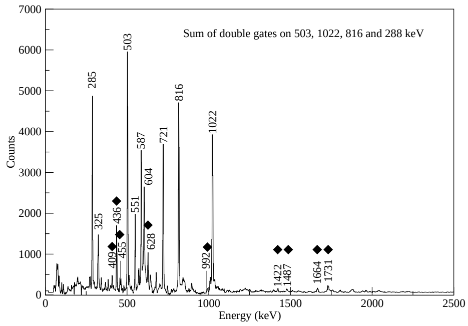

FIG. 1: Double gated γ-ray coincidence spectrum showing transition of ^{88}Zr. The newly observed transitions are marked with diamond symbol.

Experimental Technique

Excited states of ^{88}Zr was produced by bombarding ^{13}C beam from TIFR-BARC pelletron facility at 60 MeV on thin target of 500 μg/cm^2 ^{80}Se evaporated on a aluminum foil of 80 μg/cm^2 thickness. The target was mounted with the aluminum backing facing the incident beam. The target was sufficiently thin so that the recoil compound nucleus can fly through it. The γ-rays emitted in the reaction have been measured with the Indian National Gamma Array (INGA) at TIFR which is a Compton suppressed clover detector array with a provision of placing 24 clovers at angles with 3 at 23°, 40°, 65°, 115°, 140°, 157° and 6 detectors at 90° with respect to the beam direction. Two and higher fold clover coincidence events were recorded in a fast digital data acquisition system based on Pixie-16 modules of XIA LLC [4]. γ-rays from the re-

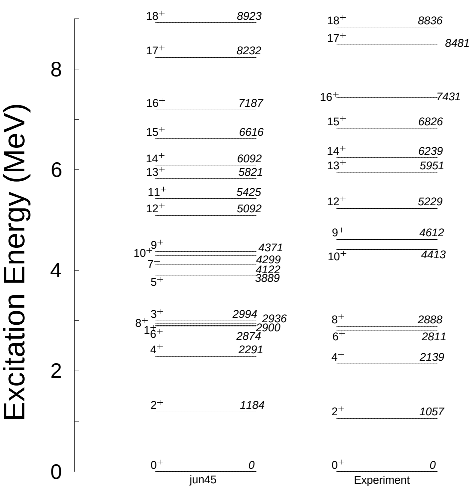

FIG. 2: Comparison between experimental and calculated positive parity states of ^{88}Zr.

coiling compound nucleus were corrected for respective Doppler shifts at different angles according to the formula:

$$E_\gamma = E_0(1 + \beta cos\theta). \quad (1)$$

where, E_0 is the Doppler shifted γ-ray emitted from a recoil moving with a velocity v incident at an angle θ with respect to the beam direction and $\beta = \frac{v}{c}$. The data sorting routine "Multi pARameter time-stamped based COincidence Search program (MARCOS) "developed at TIFR was used for gain matching and Doppler correction and to generate $E_\gamma - E_\gamma$ matrix and $E_\gamma - E_\gamma - E_\gamma$ cube which were later converted to radware format and the analysis was done using radware package [5].

Results and Discussion

Previously, high spin states in ^{88}Zr was observed up to an excitation of 7432 keV in the positive parity levels and a spin of 16$\hbar$[6]. Around 25 new transitions have been observed in the present analysis and the level scheme has been extended up to 9473 keV excitation energy and a spin of 18$\hbar$ in the positive parity side of the level scheme. While, in the negative parity we could not observe any levels with a spin more than 20$\hbar$ but several previously assigned γ-rays has been rearranged in the present level scheme and this has been supported with the newly found crossover γ-rays. A sum of double gated spectrum is shown in Fig.1. Large scale shell model calculation has been carried out with ANTOINE code taking as ^{56}Ni core and the full valence space of $f_{5/2}$, $p_{3/2}$, $p_{1/2}$ and $g_{9/2}$ orbitals. Two newly developed interactions *i.e.* JUN45[1] and jj44b[3] are used. A comparison of the calculation with experimental positive parity levels is shown in Fig.2. Good agreement of calculation up to the highest spin in the positive parity has been obtained.

Acknowledgments

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References

[1] M. Honma *et al.* Phys. Rev. C **80**, 064323 (2009).
[2] S. Saha *et al.* Phys. Rev. C **86**, 034315 (2012).
[3] B. A. Brown and A. F. Lisetskiy (unpublished).
[4] R. Palit *et al.*, Nucl. Instrum. Methods A 680 90 (2012).
[5] D. C. Radford, Nucl. Instrum. Methods A **361**, 297 (1995).
[6] E. K. Warburton *et al.*, Phys. Rev. C **31**, 1184 (1985).