# Lifetime measurements of $g_{9/2}$ positive parity band in $^{57}$Fe

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## Introduction

The lifetime measurements of nuclear state act as a microscopic tool for detailed nuclear structure study. From the lifetime ($\tau$) of a state, transition probability B(E2) and transition quadrupole moment $Q_t$ are determined which give direct information on the amount of collectivity in the system [1]. Sub picosecond lifetimes are measured using Doppler Shift Attenuation Method (DSAM) where, the stopping times of the recoiled nuclei in the target and backing medium are comparable with the nuclear lifetime.

In this work, the lifetimes of the states of the $g_{9/2}$ band in $^{57}$Fe have been measured. Band crossing in this band was identified in our earlier work [2]. The B(E2) values, obtained from the lifetimes, will provide the information on collectivity of this band.

## Experiment and Results

The $^4$He + $^{55}$Mn reaction was used to produce the excited states in $^{57}$Fe [2]. 34 MeV $\alpha$ beam was delivered from K-130 cyclotron at VECC. A $\sim$ 6 mg/cm$^2$ $MnO_2$ target on a Myler backing ($\sim$ 0.6 mg/cm$^2$) was used. The lifetimes of the states were measured by fitting the lineshapes of the $\gamma$ rays at different angles. 3 angle dependent matrices were made and gated spectra were used. The LINESHAPE [3] package, along with the developments reported in [4] were used to fit the lineshapes to extract lifetimes. FIG.1 shows an example

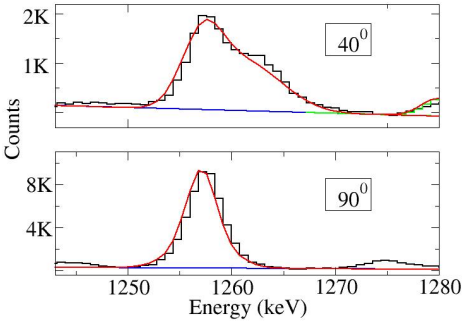


FIG. 1: Experimental spectra with fitted lineshapes of 1256 keV at 90$^0$ and 40$^0$.

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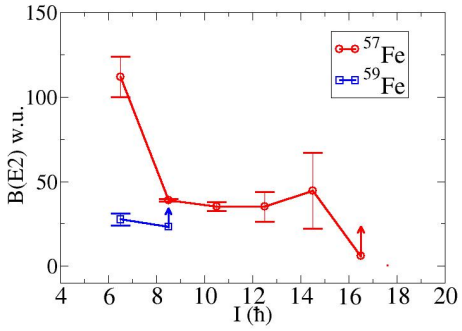


FIG. 2: Plot of B(E2) vs. spin (I) of the $g_{9/2}$ band in $^{57}$Fe and its neighbouring isotpoe $^{59}$Fe

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of lineshape fitting for the 1256 keV $\gamma$ at 2 angles, 90° and 40°. All the $\gamma$s in $g_{9/2}$ band show lineshapes from which lifetime of all the states was determined. The effective lifetime of the highest observed level was determined first and subsequently the lifetime ($\tau$) of the lower states were determined by fitting the lineshapes of the corresponding $\gamma$ rays, taking in to account the top and side feeding. The B(E2) and $Q_t$ values were determined from $\tau$ using the well known equations [1].

## Discussion

The B(E2) values in Weisskopf unit (w.u) are plotted as a function of spin for the $g_{9/2}$ band in $^{57}$Fe in FIG.2, which is found to remain almost constant up to band crossing, except for the $13/2^+$ state, and seems to drop at the band crossing. The measured B(E2) value of the $17/2^+$ in $^{57}$Fe is found to be slightly higher than $^{59}$Fe. These could not be compared with other neighboring nuclei due to the lack of lifetime data. The excitation energies of the $9/2^+$ state, i.e the $\nu g_{9/2}$ band head are plotted as a function of neutron number for the odd-N nuclei from Ti ($Z = 22$) to Ni ($Z = 28$) in FIG.3. It shows a monotonic decrease of $E_{9/2^+}$, suggestive of larger occupancy probability (op) of $g_{9/2}$, with N. The $g_{9/2}$ op of $^{59}$Fe is found to be larger than $^{57}$Fe, but less B(E2) values. This indicates that larger $g_{9/2}$

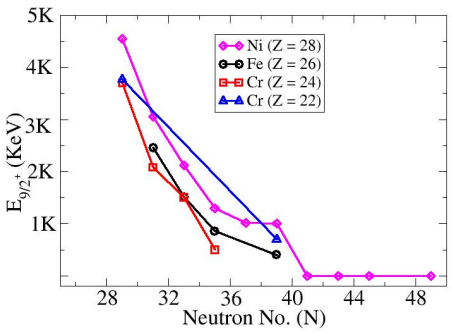


FIG. 3: Plot of $9/2^+$ excitation energy ($E_{9/2^+}$) vs. neutron no. N in different odd A isotopes.

op may not be necessarily generating larger collectivity. More theoretical and experimental investigation are needed in this direction.

## Conclusion

The lifetime of all the members of the $g_{9/2}$ band in 57Fe are measured using DSAM. The B(E2) values show almost constant collectivity, except at the start of the band, until band crossing. Variation of collectivity with $g_{9/2}$ occupation probability has been discussed.

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