g-Factor in High Spin States of ^{84}Zr

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Introduction

The study of the proton-rich mass-80 nuclei is not only interesting from the structure point of view, but it also has important implications in the nuclear astrophysical study [1]. In this mass region ^{84}Zr has been studied up to very high spin [2, 3]. A systematic shell model study of this nuclei in this region has been carried out in ref. [4]. We have carried out study of g-factor for high spin states ^{84}Zr within the framework of cranked Hartree-Fock-Bogoliubov (CHFB) using the pairing + quadrupole + hexadecapole model interaction Hamiltonian [5–7].

Theoretical Formulation and Model

We employ a quadrupole-plus-hexadecapole-plus-pairing model interaction hamiltonian,

$$H = H_0 - \frac{1}{2}\sum_{\lambda=2,4}\chi_\lambda \sum_{\mu} \hat{Q}_{\lambda\mu}(-1)^\mu \hat{Q}_{\lambda-\mu} - \frac{1}{4}\sum_{\tau=p,n} G_\tau \hat{P}^\dagger_\tau \hat{P}_\tau \ , \quad (1)$$

where, H_0 stands for the one-body spherical part, χ_λ term represents the quadrupole and hexadecapole parts with $\lambda = 2, 4$ and the G_τ term represents the proton and neutron monopole pairing interaction. Explicitly we have

$$\hat{Q}_{\lambda\mu} = (\frac{r^2}{b^2})Y_{\lambda\mu}(\theta,\phi)\,, \quad (2)$$

$$\hat{P}^\dagger_\tau = \sum_{\alpha_\tau,\bar{\alpha_\tau}} c^\dagger_{\alpha_\tau} c^\dagger_{\bar{\alpha_\tau}}\,. \quad (3)$$

In the above $c^\dagger$ are the creation operators with $\alpha \equiv (n_\alpha l_\alpha j_\alpha m_\alpha)$ as the spherical basis states quantum numbers with $\bar{\alpha}$ denoting the conjugate time-reversed orbital. The standard mean field CHFB equations [8] are solved self-consistently for the quadrupole, hexadecapole and pairing gap parameters. The deformation parameters, and pairing gaps are defined in terms of the following expectation values:

$$D_{2\mu} = \chi_2 < \hat{Q}_{2\mu} >,\ D_{4\mu} = \chi_4 < \hat{Q}_{4\mu} > \quad (4)$$

$$\hbar\omega\beta\cos\gamma = D_{20}\ , \hbar\omega\beta\sin\gamma = \sqrt{2}D_{22}\ , \hbar\omega\beta_{40} = D_{40}\ ,$$

$$\Delta_\tau = \frac{1}{2}G_\tau < \hat{P}_\tau > \ . \quad (5)$$

The oscillator frequency $\hbar\omega = 41.0A^{-1/3}$ (MeV), and β,γ and β_{40} are the usual deformation parameters, while Δ_p and Δ_n are the pairing gap parameters for protons and neutrons, respectively.

Results and Discussions

The study of g-factor has been extensively employed in the past as a sensitive probe for a better understanding of the structure of ground state as well as excited states up to very high angular momentum in stable nuclei in different mass regions. Therefore, direct and definite information on nuclear structure can be obtained through measuring g-factors. Nuclear structure at high spins in a mid-weight mass region of A = 80 possesses many interesting features. Among them the quasi-particle alignment (QPA) is a significant feature. The g-factor measurement of intraband states can provide unique information on

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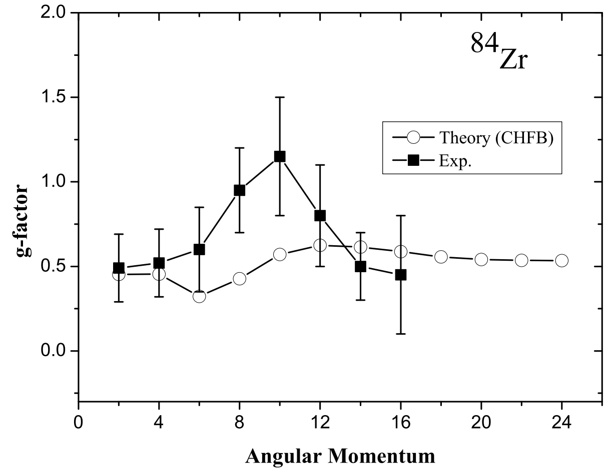

FIG. 1: Theoretical (g-factor) gyromagnetic factors are compared with experimental values for ^{84}Zr [9].

QPA since g-factors of $g_{9/2}$ protons are positive and large (g_p = 1.38) and g-factors of $g_{9/2}$ neutrons are negative and small (g_n = -0.24). The neutron and/or proton alignments govern the value and variation of g-factors with spin. The experiment that measured g-factors has been performed recently for ^{84}Zr [9]. In Fig. 1, we have shown comparison of calculated g-factor and experimental g-factor value as a function of angular momentum. The proton alignment causes the increasing of g-factor, while the neutron alignment the decreasing of g-factor. A little increment in g-factors can be seen around spin I = 12. This is interpreted by the alignment response of the quasi-protons and neutrons to the collective rotation of the nucleus. The competition of the proton and neutron alignments can result in such a structure of the g-factors. The observed large g-factors result from the $g_{9/2}$ proton alignment followed by the $g_{9/2}$ neutron alignment at higher spins. The present g-factors strongly confirm the mixed configuration of proton and neutron alignments and support the predictions of proton and neutron interaction. However, the calculated g-factors are lower in the peak region while compared with experimental data [9].

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