Study of Alignment phenomenon effect on electromagnetic properties for ^{185,187,189}Os isotopes

Maryam Moonesi[1, *], Saeed Mohammadi[1], Mehran Shahriari[1]

[1]Department of Physics, Payame Noor University, PO BOX 19395-3697 Tehran, Iran

*Corresponding author: E-mail: moonesimaryam@gmail.com

Abstract. In this paper the energy levels of $^{185\text{-}187\text{-}189}$Os isotopes using projected shell model (PSM) has been calculated. Yrast Spectrum, nucleus rotation frequency and the ratio of reduced electromagnetic transition probabilities, B(E2)/B(M1) plots versus spin for understand the structure of multi-quasiparticle band up to the spins $47/2^+$, $33/2^+$ and $31/2^+$ for these isotopes, are plotted, respectively. It was founded that in spins $35/2^+$, $31/2^+$ and $27/2^+$ due to 3-quasiparticle band-crossing, simultaneously by increasing rotational inertia of the nucleus, nucleus rotation frequency decreases greatly and as an important result, B(E2)/B(M1) ratio in these spin increases. Indeed, in these spins, nucleons align with nucleus, electrical properties of nucleus increases.

Keywords. Yrast Spectrum, Alignment Phenomenon, Electromagnetic Transition Probability, Projected Shell Model.

PACS Nos: 21.60.-n

1. Introduction

The electromagnetic spectrum of the gamma rays resulting for the excited nucleus in high-spin always for studying of nuclear structure was important. Especially, for neutron-rich heavy deformed nuclei in the rare-earth region with 180 < A < 200, in the past few years, was caused that using nuclear spectroscopic techniques change and these nuclei show new band structures [1-3]. Very few theoretical and experimental studies have been reported by the aim of understanding the osmium isotopes. Some of the important research on these isotopes are reported, which among them the experimental works was carried out by S. mohammadi *et al.* [4-7], high-spin states in the neutron-rich nuclei of $^{184\text{-}186\text{-}188\text{-}190}$Os [4-6] and $^{185\text{-}187\text{-}191}$Os [7] have been populated using the ^{85}Se+^{192}Os deep-inelastic reaction.
The theoretical work was carried out by the projected shell model that for the first time by the Nilsson in 1955 [8] for considering the deformed shape of the nucleus was presented. Forty-five years later, this model was formulated as shell model projected on the nuclear symmetry axis known as PSM model by Hara and Sun [9]. Finally, in 1997, FORTRAN code of the psm for PCs was written and published [10] and has been quietly successful and is still used today.

By the PSM code many articles have been published, including for Osmium and Erbium, back-bending and nucleon-rich phenomenon due to the reduced electromagnetic transition probabilities, B(M1)/B(E2), by Shahriari *et al* [11] and Moonesi *et al* [12], calculated and compared with the experimental values.
In the present work, systematic study of high spin states of $^{185\text{-}187\text{-}189}$Os isotopes have been investigated using the PSM model. In section 2, the PSM model, section 3 results and discussion, and section 4, the conclusions are summarized.

2. Projected Shell Model

In fact, the PSM is a truncated spherical shell model projected on axial symmetry of deformed nuclei and most commonly is used to study medium and heavy-rare-earth mass nuclei. The most important of PSM model is formation of a quasi-particle structure by combining the single-particle deformed states from the Nilsson model with the BCS calculations based on the vacuum quasi-particle, |0> [13]. The configuration space of the PSM model generally consists of three major shells for protons and neutrons. In this model, Computations are done with three major shells N= 3, 4, 5 (N=4, 5, 6) with active shell N=5 (N=6) for protons (neutrons). Nilsson parameters ε_2 (Quadrupole deformation) and ε_4 (Hexadecupole deformation) are chosen from reference [14] and are listed in table 1. By projecting a set of multi-quasiparticle states $|\Phi_k>$ that includes single and three particle states for the odd-even nuclei in the form of the relation 1 on a suitable angular momentum such as I, quasi particle states of deformed shell model are constructed.

$$\{|\Phi_k>\} = \{a_\nu^+ \ |0>. a_\upsilon^+ \ a_{\pi_1}^+ a_{\pi_2}^+ |0>\} \quad (1)$$

Where |0> the vacuum state and a^+ are the quasi particle (qp) creation operators and the index υ (π) stands for neutrons (protons). Then by defining the angular momentum image operator $\widehat{P}_{MK}^{I}$ as [3]:

$$\widehat{P}_{MK}^{I} = \frac{2I+1}{8\pi^2} \int d\Omega \, D_{MK}^{I}(\Omega)\widehat{R}(\Omega) \quad (2)$$

So that $\widehat{R}(\Omega)$ is the rotational operator , Ω the Euler angle and $D_{MK}^{I}(\Omega)$ the function –D, which forms complete set of functions in the parametric space Ω and by affecting the nucleon-like pairs. $|\Phi_k>$, function wave form of the PSM model is obtained.

$$|\Psi_{IM}> = \sum_K F_K^I \widehat{P}_{MK}^I \, |\Phi_k> \quad (3)$$

Coefficients F_K^I by solving the Schrodinger equation $\widehat{H}\,|\Psi_{IM}> = E\,|\Psi_{IM}>$ and simultaneous Hamiltonian diagonalization are determined at the bases $\{\widehat{P}_{MK}^I|\Phi_k>\}$. As a result, Eigen-value equation of the PSM model is obtained as:

$$\sum_{k'}\left(H_{kk'}^I - E\,N_{kk'}^I\right)F_{k'}^I = 0 \quad (4)$$

So that the elements of the Hamiltonian and normal matrixes are defined as 5 relations,

$$N_{kk'}^I = \left\langle \Phi_k \middle| \widehat{P}_{kk'}^I \middle| \Phi_{k'} \right\rangle \quad , \quad H_{kk'}^I = \left\langle \Phi_k \middle| \widehat{H}\widehat{P}_{kk'}^I \middle| \Phi_{k'} \right\rangle \quad (5)$$

Finally, the amount of energy required for the Hamiltonian model of Nilsson is obtained as a function of spin I which is used for spin (band diagram energy) as:

$$E(I) = \frac{\left\langle \Phi_k \middle| \widehat{H}\widehat{P}_{kk'}^I \middle| \Phi_{k'} \right\rangle}{\left\langle \Phi_k \middle| \widehat{P}_{kk'}^I \middle| \Phi_{k'} \right\rangle} = \frac{H_{kk'}^I}{N_{kk'}^I} \quad (6)$$