INTRODUCTION

It is interesting to analyze the decay of a compound nucleus formed after fusion of projectile and target nucleus. After the compound nucleus is formed , an equilibration process distributes the energy over all nucleons,as a result some of which can be emitted. In the discrete energy region, the level density is low enough to enable observation of electromagnetic transition between resolved lines in γ-ray spectrum.

Deformed nuclei; those characterized by a non-spherical spatial distribution of nuclear density are known to exhibit rotational bands in their spectra[1], microscopic descriptions of the rotational motion involves coherent contributions from many nucleons and is thus referred to as a collective motion. That results in a rotation of the nucleus as a whole around an axis different from the nuclear symmetry axis. A schematic example of a collective rotation is a prolate-nucleus that rotates around an axis perpendicular to the nuclear symmetry axis. It was found, from experimental spectra, that the relation between the excitation energy **E** and spin **I** is often a smooth one while for spins that are not too high, it can be approximated by $\mathbf{E \sim I(I+1)}$.

The corresponding series of states with consecutively increasing angular momentum is called a rotational band. The lowest state of a band is referred to as bandhead. Many states of different intrinsic structure can in principle become bandheads ; the band built on the ground state of the nucleus is referred to as the ground state band (GRB). All others bands are called excited bands (or side bands). The lowest energy state of a given angular momentum is called the Yrast state ,the first crossing of different bands in **(E,I)** plane between the GRB and the first excited rotational band in nuclei is often called Stokohlm band (S B)[1].

Near the crossing point between the two bands several physical quantities related to the Yrast line E(ω),I(ω),$\Im$ (ω) often show characteristic multi-valued behavior in the form of an **S** shape, this fact is referred to as a backbending effect .

Typical examples of nuclei exhibiting such a collective rotation with crossing bands are provided in the regions of mass number $150 \leq A \leq 190$ in rare earth region and $A \geq 220$ in actinide region. In addition these nuclei are characterized by the existence of super-fluid type (pairing) nucleon-nucleon correlation, which result in an appreciable reduction of rotational moment of inertia and the quasiparticle (rather than particle -hole)excitation.

Another mechanism is likely to exist in spherical or weakly deformed nuclei , here the alignment in the individual nucleonic orbitals along the nuclear symmetry axis appears to be the only possible mechanism of building up the high angular momentum. This type of nuclear motion is often referred to as a non collective rotation. In this case, a few valence nucleons move in an oblate average potential and populate orbitals with positive angular momentum project on nuclear symmetry axis. It has been discovered that the alignment of the angular moments of only a few nucleons may be sufficient for producing relatively high nuclear spin, this is the case when the alignment is nearly complete and high spin orbitals contribute to this phenomena.

The Hamiltonian for such deformed nuclei can be taken to be that of a rotating and vibrating motion. The solution of the associated Schrödinger equation will yield energy eigenvalue and state functions. Considering the adiabatic approximation here $\omega_{vib} >> \omega_{rot}$ (2), the Schrodinger equation can be separated into rotational and vibrational parts(3).

It was shown by Mallman(4) that for even-even nuclei with widely differing **N,Z** (where **N** and **Z** are the neutron and proton numbers in nuclei respectively), the energy ratios E(6)/E(2) and E(8)/E(2) plotted against E(4)/E(2) lie on two universal curves where E(I) is the energy level of the angular momentum **I**. This finding suggests that these ground state bands may indicate features of nuclear dynamics which are common to nuclei both in the deformed and in near-harmonic region.

In all cases the energy spacing at higher I are smaller than required by **I(I+1)** rule, since for rotational bands this decrease in energy spacing may be attributed to an increase in the moment of inertia $\Im$.

Three different explanations for the increase of the moment of inertia with increasing **I** have been proposed(5):

a) At higher angular momentum the deformation increases.

b) The pairing energy for neutrons and protons decreases with increasing I.

c) An extension of the cranking model to higher-order terms in the nuclear angular velocity ω leads to an increase of $\Im$ with I.

On the basis of the symmetry consideration (A. Bohr and B. R. Mottelson)[2], it was pointed out that for the axially symmetric nucleus, the rotational energy **E** can be expanded in powers of **I(I+1)** for small values of **I**. Especially, for ground state bands of an even-even deformed nucleus

$$E = AI(I+1) + BI^2(I+1)^2 + C\,I^3(I+1)^3 + DI^4(I+1)^4 + \ldots \qquad (1)$$

However , the analysis of the experimental data shows that the convergence of the above equation is not satisfactory [6].

Another model built on the assumption that the deformation (β) changes the moment of inertia $\Im$ leads to the semiclassical model[7-8]

$$E(\beta) = \frac{\hbar^2}{2\Im(\beta)} I(I+1) + \frac{1}{2} C(\beta_I - \beta_o)^2 \qquad (2)$$

with the equilibrium condition $\frac{dE(\beta)}{d\beta_I} = 0$ applied to obtain the values of β_I. With this models a good fit may be obtained for bands of strongly deformed nuclei. However, bands outside the deformed region cannot be fitted by this method with reasonable accuracy. Another difficulty for this model is that the increase in β is not large enough to explain the deviation from the **I(I+1)** rule.

The decrease of the effective pairing force has an even greater affect on the increase of the moment of inertia with increasing **I** than the increase of deformation. These findings suggest that a more realistic treatment of ground-state bands should include more degrees of freedom than just β.

The following approach replaced the deformed parameter by a general variable **x**, and assumed that moment of inertia can be expressed by χ^n, where **n** is an integer.

The best fits for all ground state bands of the strongly deformed nuclei obtained for **n=1**. Thus one, arrives at the variable moment of inertia model VMI)[5], which gives the energy levels as

$$E(\Im) = \frac{\hbar^2}{2\Im(I)} I(I+1) + \frac{1}{2} C(\Im(I) - \Im_o)^2 \qquad (3)$$

nd the equilibrium condition

$$\left.\frac{dE(\Im)}{d\Im(I)}\right|_I = 0 \qquad (4)$$

etermined the moment of inertia for each state with spin **I**. $\Im_o$ is a parameter efined as the ground state moment of inertia and **C** is the restoring force nstant. The range of validation of the VMI model is $2.23 \le R(4) \le 3.33$[5].

A crossing of two bands in the **(E,I)** plane means that at certain $\mathbf{I}=\mathbf{I}_{cross}$ the energies of the corresponding two states belonging to different bands are approximately equal. In particular, a crossing of two bands which form a partition of the Yrast line leads apparently to a rearrangement of intrinsic structure in the de-exciting nucleus.

In recent years, several semi-empirical and semi-classical models have been introduced for correlating the large amount of experimental data available for the energy levels of the ground-state bands in even-even nuclei. In particular, the variable moment of inertia VMI model which is equivalent to the Harris model[6]. Marriscotti et al.[5] have worked out a two parameters VMI model under two limiting conditions :

i) Empirically the moment of inertia was taken proportional to the deformation parameter and

ii) The potential energy was assumed to be of the harmonic type. Using :he minimum condition of the total energy with respect to the moment of nertia, the ground state rotational energy was obtained in terms of two ›arameters, the ground state moment of inertia $\Im_0$ and the restoring force onstant **C** .

The Harris model is highly successful up to about $10^+ \sim 12^+$ for nuclei in ıe rare earth region and up to $10^+ \sim 16^+$ in actinide region. In the framework of the Harris model, a simple linear dependence of the moment of inertia on the square of the angular velocity is given.

The aim of this work is to study the rotational spectra for some nuclei in rare earth and actinide regions.

This thesis consists of three chapters, two appendices, and the Arabic summary.

In chapter I, an introduction and summary of the previous work.

In chapter II, using the Harris model[6-9], the Sood model[10] and the two parameters expression[11] $E(I) = a\left[\sqrt{1 + bI(I+1)} - 1\right]$. The rotational spectra are presented for $Yb^{168}, Er^{166}, Dy^{164}$ up to $I^{\pi} = 10^{+}$ in earth region and for $U^{232,234,236,238}$ isotopes up to $I^{\pi} = 16^{+}$ in actinide region. Using the iterative method in solving the cubic equation, which is given by Harris model, an analytical formula for the moment of inertia is given, and also, by expanding he two parameter expression[11-12] a similar expression for the moment of nertia is obtained. The predicted values of rotational spectra and the moment f inertia are compared with the corresponding experimental values.

In chapter III, the collective Hamiltonian[2] of the nucleus is derived, ıken into consideration the rotational motion of the nucleus besides the bration of its surface.