Nuclear level Densities In Excited Medium Mass Nuclei

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Abstract

The temperature dependent level density parameter plays an important role in the study of shape transitions in hot rotating nuclei. It can be investigated by mean field theories such as Hartree - Fock method and the Landau theory of phase transitions, but these theories ignore the statistical thermal fluctuations. For a nucleus with finite number of particles, such fluctuations on level density parameter can be large. The aim of this work is to obtain the level density parameter for ^{88}Mo and ^{90}Mo. The level density parameters for the considered nuclei are evaluated by finding the thermo dynamical functions using cranked Nilsson – Strutinsky prescription. The ensemble average of the entropy that depends on β,γ are calculated by the Landau theory of shape transitions. The thermal averaged values of β,γ then yields the required entropy. Now the value a and <a> gives the level density parameter calculated at equilibrium configuration (β_0,γ_0) without and with thermal fluctuations respectively. The results obtained for the level density parameter as a function of temperature and angular momentum for the case of ^{88}Mo and ^{90}Mo nuclei shows that the change in level density obtained as a function of temperature is more than that obtained as a function of angular momentum. The results obtained are also in conformity with the marked temperature dependence of the level density parameter observed experimentally.

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1. Introduction

The level density plays an important role in nuclear reactions such as the formation of the compound nucleus and in the γ-decay rates of highly excited nuclei. The nuclear level density is a quantity which is of considerable interest from a basic physics standpoint but also has great importance in applied physics. A substantial effort in both experiment and theory over a period of about 60 years has greatly improved our understanding of nuclear level densities, but many unanswered questions remain. Experimentally, many gaps are still present, with little information available for nuclei

off of the stability line and inadequate data as to the energy dependence of the level density at energies above 10 MeV even for nuclei on or near the stability line. Recent theoretical work has led to refinements in both Fermi gas and two-body force approaches to the level density problem, but both avenues have significant remaining problems.

Nuclear level density (LD) has been the subject of many theoretical and experimental investigations such as analyses of fusion and fission reactions for a wide range of isotopes and reactor structure designs. The theory of nuclear level density was initiated by Bethe [1] many years ago, on the basis of the Fermi gas model of the nucleus. An investigation of the problems related to nuclear LD also clarifies some basic properties of the nuclear matter such as super-fluidity, nuclear shell, pairing and collective effects. Up to date, the independent particle model of Fermi gas (FG) model after the Bethe's LD expression [3] and its various modifications [4, 5, 6] are frequently used in describing the corresponding experimental data including the LD of discrete energy levels and s-wave neutron resonance densities, as well as in the description of nuclear reaction product particle spectra [7-13]. The so-called composite Gilbert-Cameron (GC) model [4, 2, 13] unifies further FG model with the constant temperature (CT) approximation. These models however do not involve the collective excitation mechanism of the nucleus in the form of collective vibrations and rotation effects in an explicit manner, despite these effects may be described somehow by the LD parameter (a) and the concerning energy shift (Δ). The explicit collective effect contributions to LD's are well described, for instance, in the works of Refs. [5, 14] and in the LD systematic given in [2]. Apart from such effects, in these works the LD parameter (a) is supposed to be excitation energy (U) dependent. The need for the inclusion of an energy dependent LD parameter arises due to shell effects in the LD descriptions. When this term is used in the generalized super-fluid (GS) nuclear model, the related parameter a changes the shape of LD function above the critical energy Uc, characterizing transitions from super-uid to normal state. While the microscopic models of nuclear LD includes both Hartee-Fock-Bogolyubov (HFB) model of nuclear structure and combinatorial model analysis of LD's [15]. All the models mentioned above aim to describe the observed LD's accurately in a wide range of isotopes and excitation energies, which is not yet accomplished. Therefore introduction of new models and theories in describing LD's is still required in theoretical nuclear physics.

Very recently, there has been an increasing interest in the nuclear level density parameter, a, stimulated by experimental data [16] on the temperature dependence of a for nuclei with A ≈160. The temperature dependence of the level density parameter a was deduced from coincidence measurements between heavy residues and evaporated light particles. It was found that a decreases from A/8 at low temperature to A/13 for T~5 MeV. This observation stimulated a significant amount of theoretical and

experimental work. Temperature dependent Hartree-Fock [17] or semiclassical [18] calculations with various types of effective interaction fail to reproduce the trend of the data. It has been recognized that the observed temperature and spin dependence of nuclear level density can effectively be accounted for by using Landau theory of shape phase transitions.

The dependence of temperature on level density parameter plays an important role in the study of shape transitions in hot rotating nuclei. It can be investigated by mean field theories such as finite-temperature Hartree-Fock-Bogoliubov cranking (FTHFBC) theory [19, 20] or the finite temperature cranked Strutinsky calculations were being used [21]. In recent times the Landau theory of phase transitions has been applied by Alhassid et al. [22] to study the shape evolution of hot rotating nuclei. Finite temperature mean field calculations are found to yield sharp shape transitions in spite of the finite size of the nuclei. For a nucleus with finite number of particles, such fluctuations on level density parameter can be large. The aim of this work is to obtain the level density parameter for ^{88}Mo and ^{90}Mo. The level density parameters for the considered nuclei are evaluated by finding the thermodynamical functions using cranked Nilsson – Strutinsky prescription. The ensemble average of the entropy that depends on β,γ are calculated by the Landau theory of shape transitions. The thermal averaged values of (β,γ) then yields the required entropy. Now the value a and <a> gives the level density parameter calculated at equilibrium configuration (β_0,γ_0) without and with thermal fluctuations respectively.

In section II we give the method used for obtaining the equilibrium deformations, level density with and without thermal fluctuations. The results obtained are discussed in Sec. III and the conclusions drawn from the study is given in Sec. IV.

2. Level-density determination without and with thermal fluctuations

2.1 Shape parameters by mean field method

The theoretical framework for obtaining the potential energy surfaces as a function of spin and temperature for molybdenum isotopes is as follows:

The cranked Nilsson - Strutinsky method in cylindrical representation is used. In this method the nucleons move in a cranked Nilsson potential with the deformation determined by β and γ. The cranking is performed around one of the principal axes, the z- axis and the cranking frequency is given by ω. The triaxial Nilsson model in the rotating frame is used in the calculations. The shell energy calculations for non-rotating case (I=0) assumes a single particle field with a triaxial Nilsson Hamiltonian given by [23]

$$H^0 = \frac{p^2}{2m} + \frac{1}{2}m\sum_{\kappa=1}^{3}\omega^2 x^2 - \kappa^0\hbar\omega_0\left[2l.s + \mu\left(l^2 - 2\langle l^2\rangle\right)\right] \quad (1)$$

The three oscillator frequencies ω_κ are given by the Hill Wheeler parameterization as

$$\omega_y = \omega_0 exp\,[-\sqrt{\frac{5}{4\pi}}\beta\cos(\gamma - \frac{2}{3}\pi)] \qquad (2a)$$

$$\omega_y = \omega_0 exp\,[-\sqrt{\frac{5}{4\pi}}\beta\cos(\gamma - \frac{4}{3}\pi)] \qquad (2b)$$

$$\omega_z = \omega_0 exp\,[-\sqrt{\frac{5}{4\pi}}\beta\cos\gamma] \qquad (2c)$$

with the constraint of constant volume for equipotentials

$$\omega_x\omega_y\omega_z = \overset{0}{\omega_0^3} = constant\,, \qquad (3)$$

For the Nilsson parameters κ and μ, the following values are chosen [24] separately for protons and neutrons:

Protons		Neutrons	
κ	μ	κ	μ
0.070	0.390	0.073	0.290

The oscillator frequency is chosen as

$$\overset{0}{\hbar\omega_0} = \frac{45.3}{(A^{1/3}+0.77)}\,MeV \qquad (4)$$

The term $\langle l^2\rangle$ in eqn. (1) has been doubled to obtain better agreement atleast with 10% between the Strutinsky-smoothed moment of inertia and the rigid rotor value. The parameter D has been re-determined accordingly with the help of single-particle levels in the given mass region. The Hamiltonian (1) is diagonalized in cylindrical representation up to N=11 major shells.

For the rotating case $(I \neq 0)$, the Hamiltonian becomes

$$H^\omega = \sum_i h_i^\omega, \qquad (5)$$

For the rotation taking place around the Z-axis

$$h_i^\omega = h_i^0 - \omega j_z\,, \qquad (6)$$

The single particle energy e_i^ω and the wave function φ_i^ω are given by

$$h_i^\omega\varphi_i^\omega = e_i^\omega\varphi_i^\omega \qquad (7)$$

The spin projections are obtained as

$$\langle m_i\rangle = \langle\varphi_i^\omega|j_z|\varphi_i^\omega\rangle \qquad (8)$$

The total shell energy is given by

$$E_{sp} = \sum_i\langle\varphi_i^\omega|h_i^0|\varphi_i^\omega\rangle = \sum_i\langle e_i\rangle\,, \qquad (9)$$

where

$$e_i^{\omega} = \langle e_i \rangle - \hbar\omega\langle m_i \rangle \qquad (10)$$

Thus the total spin and shell energy for the unsmoothened single particle level distribution is given by

$$I = \sum_i \langle m_i \rangle \qquad (11)$$

$$E_{sp} = \sum_i e_i^{\omega} + \hbar\omega I \qquad (12)$$

Since the difficulties encountered in the evaluation of total energy for large deformations through the summation of single particle energies for I=0 case may be present for I≠0 case also [25], we use the Strutinsky shell correction method adopted to I≠0 case by suitably tuning the angular velocities to yield fixed spins.

For the Strutinsky smeared single particle level distribution [26], Eqs. (11) and (12) transform into

$$\tilde{I} = \sum_i \langle \tilde{m}_i \rangle \qquad (13)$$

and

$$\tilde{E}_{sp} = \sum_i^N \tilde{e}_i^{\omega} + \hbar\omega\tilde{I} \qquad (14)$$

In the tuning method, first the energy values are evaluated with different degrees of freedom and different angular velocities. Then the obtained spin is treated under standard interpolation with the given angular velocity to obtain the exact angular velocities for the actual spin sequence for the nuclei considered.

The energy expression [27] can have the form with specified N, Z & spin I and also deformation β as.,

$$E_{total}^{\omega(I)}(N, Z, \beta) = R_{total}^{\omega(I)} + \omega(I)I \qquad (15)$$

and the total spin,

$$\tilde{I} = \tilde{I}_Z = \sum_{v=1}^{N} \langle \tilde{j}_Z \rangle_v^{\omega} + \sum_{\pi=1}^{Z} \langle \tilde{j}_Z \rangle_{\pi}^{\omega} \qquad (16)$$

Using the above relation, we can select numerically the ω values that correspond to the chosen integer or half integer spins. Obviously, the corresponding frequency values $\omega(I)$ change from one deformation point to another and the corresponding calculations have to be repeated accordingly. The energy values are thus calculated for the exact spin sequence.

The total energy is now given by

$$E_T = E_{RLDM} - (E - \tilde{E}_{sp}) \qquad (17)$$

where the rotating liquid drop energy at constant spin

$$E_{RLDM} = E_{LDM} - \frac{1}{2} J_{rig}\,\omega^2 + \hbar\omega\tilde{I} \qquad (18)$$

the second term on the right hand side being the rotational energy. Here the liquid drop energy E_{LDM} is given by the sum of Coulomb and surface energies and J_{rig}, the rigid body moment of inertia defined by β and γ including the surface diffuseness correction.

The calculations are carried out by varying ω values in steps of $0.025\omega_0$ from $\omega = 0.0$ to $\omega = 0.3\omega_0$, ω_0 being the oscillator frequency for tuning to fixed spins. γ is varied from -180^0 to -120^0 in steps of -10^0 wherein γ=-180^0 and β values are varied from 0.0 to 1.2 in steps of 0.1.

2.2 Statistical Theory of Nuclear Level Density Parameter and Fermi-Gas model

A nucleus in the ground state is a system of fermions in the lowest possible energy state at zero temperature. If one pictures the nucleus as a liquid drop the emission of particles corresponds to an evaporation process that is temperature dependent. Viewing a high excited nucleus as a hot droplet, one may enquire into the relationship between the excitation energy E^* and the nuclear temperature. Excitation energies of the order of MeV Correspond to high absolute temperatures setting E^* equal to KT, where $K = 1.38 \times 10^{-16} erg^0 K^{-1}$ is the Boltyzman constant. By invoking a result furnished by statistical mechanics for a fully degenerate gas (at fairly low temperatures) of particles obeying Fermi-Dirac statistics. It is possible to derive a formulae linking E^* to T in the Evaporation model, which can be tested Experimentally. The energy of such a gas of n particles at the temperature T is related to its energy at zero temperature through the expression given by sommerfield

$$\mathrm{E(T) = E(0)\left(1 + \frac{3\pi^2 n^2}{20}\,\frac{KT}{E(0)^2} + \cdots\right)} \qquad (19)$$

and

$$\mathrm{E(0) = \frac{3}{5}\eta S} \qquad (20)$$

where S_0 denotes an energy limit which is now termed the fermi energy, symbolised by E_f. The excitation energy E^* corresponding to a temperature T (the nuclear ground state, being a minimum energy state, corresponds to zero temperature, T=0),

$$\mathrm{E^* = E(T) - E(0) = \frac{3\pi^2 n}{20\,E(0)}(KT)^2} \qquad (21)$$

$$\text{i.e., } \mathrm{E^* = a(KT)^2} \qquad (22)$$

where,

$$\mathrm{a = \frac{3\pi^2 n}{20\,E(0)} = \frac{\pi^2}{4}\frac{n}{E_F}} \qquad (23)$$

The collective properties of hot nuclei can be characterized by appropriate order parameters. As an example, for the spherical deformed transition, the quadrupole deformation parameters are the order parameters. The order parameters of a macroscopic system which are in an equilibrium state and which are not a critical point or undergoing a first order phase transition, are found to have specific values. These are

the equilibrium or the most probable values that are calculated by Minimizing values that are calculated by minimizing the appropriate free energy. There are statistical fluctuations in the order parameters and these are negligible in the thermodynamic limit of a large number of particles.

Peter Fong [28] has proposed a theory for fission which predicts the asymmetric nature of the process. The theory is based upon the statistical model of the compound nucleus. The probability of a fission mode is assumed to be proportional to of the density of quantum states. To calculate the density of quantum states, we approximate the nuclear configuration corresponding to mode of fission specified by mass splitting, A_1: A_2 by two spherical nuclei by mass numbers A_1, A_2 in static contact, each excited by an energy E_1 and E_2 respectively. The density of quantum states of such a two-nucleus system is proportional to the leveldensity of each component nucleus and thus proportional to their product for the level density of a nucleus of mass number A excited by energy E_1 we use the following formula

$$W_0(E) = C\exp(2\sqrt{aE}) \qquad (24)$$

The parameters a and c are of course, dependent on A from analysis of nuclei in the region of fission fragments. The density of quantum states of the two-nucleus system is given by,

$$N{\sim}C_1\exp(2\sqrt{a_1E_1}).\,C_2\exp(2\sqrt{a_2E_2}) \qquad (25)$$

Since the parameters a is proportional to the mass number we have

$$a_1 + a_2 = a_0 + a_0 \qquad (26)$$

The value of E is determined by the following equation expressing energy conservation:

$$E = M^*(A_1, Z_0) - M(A_1, Z_1) - M(A_2, Z_2) - K - D \qquad (27)$$

Where $M^*(A_1, Z_0)$ is the mass of the excited compound undergoing fission. $M(A_1, Z_1)$ and $M(A_2, Z_2)$ are masses of the primary fission fragments in their ground states, K is the total Kinetic Energy of the fragments and D is the total deformation energy of the fragments.

In the Fermi-Gas model, the neutrons and protons that make up the nucleus and are subject to Fermi Dirac statistics (including the Pauli Exclusions principle) are independently regarded as constituting a fully degenerate Fermi gas. To derive a rough estimate of the level density $\rho(E^*)$ from this primitive form of the Fermi gas model, we observe that the Bottzmann equation can be written as

$$S = K[ln(\rho(E^*))] - ln[\rho(0)] \qquad (28)$$

The energy S can be related to the nuclear excitation energy E through the thermodynamic expression,

$$S = \int_0^T \frac{dE^*}{T} \qquad (29)$$

A recent attempt to relate the nuclear level density to isospin has been undertaken by Kanestrom. The quadrupole deformation parameters β and γ were found out without and with thermal fluctuations in it.

2.3 Thermal fluctuations on level density using Landau Theory of Phase Transitions

When we consider hot nuclei, which consist of a finite number of particles, the statistical fluctuations in the order parameters can create large deviations from the most probable state [29]. Hence the shape fluctuations at finite temperature are very important. To study the shapes of hot rotating nuclei, apart from microscopic finite temperature mean field theories, macroscopic Landau theory [27,30,31] can be used. The mean field theories ignore the statistical fluctuations in the order parameters for a nuclei with finite number of particles, the fluctuations can be large. They can produce an average value for an order parameter which is qualitatively different from the equilibrium or mean field value. Shape fluctuations may also cause the damping of nuclear rotational motion at moderate temperatures.

For finite temperatures, one should also consider the thermal fluctuations which create shapes different from the most probable shape obtained by minimizing the free energy F = E - TS. These shape fluctuations can significantly alter the properties of hot rotating nuclei. According to this theory, the free energy at $\omega = 0$ can be written to fourth order in β as

$$F(T, \omega = 0, \beta, \gamma) = F_0(T) + A(T)\beta^2 - B(T)\beta^3 \cos 3\gamma + C(T)\beta^4 \quad (30)$$

where the coefficients Fo, A, B and C depend on the temperature T and β and γ are the usual intrinsic deformation parameters.

The free energy which depends on β and γ will also depend on the orientation angles relative to the rotation axis ω for the rotating case $\omega \neq 0$.

Extending Eqn. (30) to the rotating case with ω parallel to Z axis,

$$F(T, \omega; \beta, \gamma) = F(T, \omega = 0; \beta, \gamma) - \frac{1}{2} J_{ZZ}(\beta, \gamma, T)\omega^2 \quad (31)$$

For fixed spin this can be Legendre transformed [27] as

$$F(T, I; \beta, \gamma) = F(T, I = 0; \beta, \gamma) + \frac{I^2}{2J_{ZZ}(\beta, \gamma, T)} \quad (32)$$

where

$$J_{ZZ} = J_0(T) - 2R(T)\beta \cos\gamma + 2J_1(T)\beta^2 + 2D(T)\beta^2 sin^2\gamma \quad (33)$$

with J, R and D suitably defined to absorb various numerical constants. The R term has the leading shape dependence of the rigid-body moment of inertia, while the D term alone would represent the leading shape dependence of the irrotational

moment of inertia. For ω dependent terms in eqn. (30), as in reference [27], the rigid-body moment of inertia is assumed, setting

$$J_0 = \frac{2}{5} mAR_0^2 \,,$$
$$R = \left[\frac{5}{16\pi}\right]^{1/2} J_0 \qquad (34)$$
$$\text{and} \quad D = J_1 = 0$$

In this study, the Landau constants A(T), B(T) and C(T) are evaluated by least square fitting with the ω = 0 free energy surfaces obtained by Strutinsky method. This method has the advantage that the accuracy of the fitting can be checked by the resulting error bars.

In the Strutinsky prescription, the free energy is computed as,

$$F(T, I; \beta, \gamma) = E(T, I; \beta, \gamma) - TS - \bar{E} + E_{RLDM} \qquad (35)$$

Here, S is the total entropy of the fermion gas and is given by

$$S = -\sum_{i=1}^{\infty} [f_i ln f_i + (1 - f_i) ln(1 - f_i)] \qquad (36)$$

Expressed in terms of Fermi-Dirac occupation numbers

$$f_i = \frac{1}{1 + exp[-\frac{(e_i^{\omega} - \lambda)}{T}]} \qquad (37)$$

The chemical potential is λ with the constraint $\sum_{i=1}^{\infty} f_i = N$, where N is the total number of particles.

$$E_{RLDM} = E_{LDM} - \frac{1}{2} J_{rig} \omega^2 + \hbar\omega \bar{I} \qquad (38)$$

E_{LDM} is the liquid drop energy and is given by the sum of Coulomb and surface energies, J_{rig} the rigid body moment of inertia defined by β and γ including the surface diffuseness correction, and $\bar{I}$ is the Strutinsky smoothed spin.

In the study of shape parameters in hot rotating nuclei, the Landau theory offers a useful and economical parameterization of the results of macroscopic calculations and singles out a small number of combinations of parameters upon which the behavior of the equilibrium shape depends. According to this, the probability the system has to display a given shape characterized by the parameter (β, γ) is given by

$$\mathrm{P}(\beta, \gamma) = Z^{-1} e^{-\frac{F(\beta,\gamma)}{T}} \qquad (39)$$

where

$$\mathrm{Z} = \int \mathrm{d}\tau \left[e^{-\frac{F(\beta,\gamma)}{T}} \right] \qquad (40)$$

is the partition function and the volume element is taken to be

$$d\tau = \beta^4 |\sin 3\gamma|\, d\beta\, d\gamma \qquad (41)$$

One can now calculate the ensemble average of any operator that depends on β and γ. In particular the entropy is given by,

$$S = \langle S(I, T) \rangle = Z^{-1} \int d\tau\, P(\beta, \gamma) S(\beta, \gamma) \qquad (42)$$

From the standard relation

$$S = 2aT \qquad (43)$$

and using the averaged quantity equation in (14), one determines the level density parameter including shape fluctuations. i.e.,

$$\langle a \rangle = \frac{\langle S \rangle}{2T} \qquad (44)$$

Now the value

$$a = \frac{S(\beta_0, \gamma_0)}{2T} \qquad (45)$$

gives the level density parameter calculated at the equilibrium configuration (β_0,γ_0) without thermal fluctuations.

3. Results and Discussion

Recent developments in the area of nuclear level densities yields more information about level densities at high energy for nuclei which are off of the stability line. Some research in both theory and experiment promises to improve our understanding of level densities in the areas of nuclear structure, heavy ion physics and nuclear astrophysics. Despite this progress, unanswered questions remain about level densities even for lower energies and for nuclei on the stability line. Nuclear level densities have been studied since the earliest days of nuclear physics research. They remain a topic of considerable interest because of their importance in many areas of physics, including reaction model studies and nuclear astrophysics. The level density is defined as the number of excited levels in a given energy range. A closely related quantity is the state density, where a state is one of the (2J + 1) spin projections of a level of spin J. In rotating nuclei at finite temperatures both small and large amplitude shape fluctuations can influence the level density parameter. The temperature dependent level density parameter plays an important role in the study of shape transitions in hot rotating nuclei. It can be investigated by mean field theories such as Hartree - Fock method and the Landau theory of phase transitions, but these theories ignore the statistical thermal fluctuations. For a nucleus with finite number of particles, such fluctuations on level density parameter can be large. The aim of this work is to obtain the level density parameter for ^{88}Mo and ^{90}Mo. The level density parameters for the considered nuclei are evaluated by finding the thermodynamical functions using cranked Nilsson – Strutinsky prescription. The ensemble average of the entropy that depends on β, γ are calculated by the Landau theory of shape transitions. The thermal averaged values of β, γ then yields the required entropy. Fig. 1 show the inverse level

density parameter as a function of temperature for ^{88}Mo and ^{90}Mo nuclei which increases with temperature.

Now the value a and <a> gives the level density parameter calculated at equilibrium configuration (β_0,γ_0) without and with thermal fluctuations respectively. Table 1 and Table 2 shows the level density parameter as a function of temperature and angular momentum for the case of ^{88}Mo and ^{90}Mo nuclei. The results obtained for the level density parameter as a function of temperature and angular momentum for the case of ^{88}Mo and ^{90}Mo nuclei shows that the change in level density obtained as a function of temperature is more than that obtained as a function of angular momentum. The results obtained are also in conformity with the marked temperature dependence of the level density parameter observed experimentally.

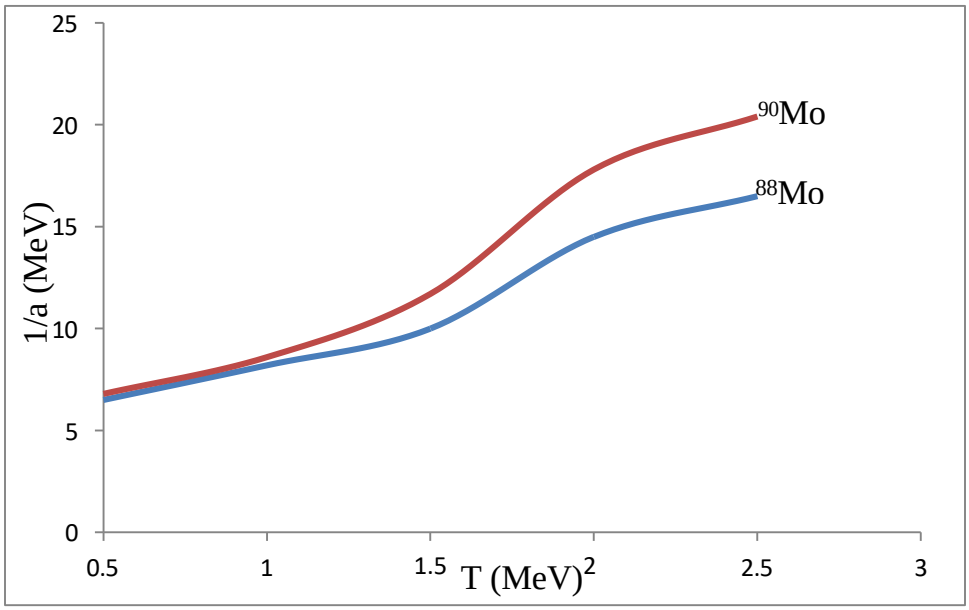

Fig. 1 Inverse level density parameter as a function of temperature

Table 1: Level density parameter as a function of temperature and angular momentum for the case of **^{88}Mo**

I/T	0.5MeV	1.0 MeV	1.5 MeV	2.0 MeV	2.5 MeV
10 ħ	6.846	7.122	8.187	9.201	10.168
20 ħ	6.863	7.145	8.236	9.278	10.198
30 ħ	6.872	7.333	8.278	9.355	10.229
40 ħ	6.887	7.463	8.360	9.465	10.331
50 ħ	6.892	7.562	8.461	9.534	10.483

60 ħ	6.932	7.702	8.493	9.612	10.568

Table 2: Level density parameter as a function of temperature and angular momentum for the case of **^{90}Mo**

I/T	0.5MeV	1.0 MeV	1.5 MeV	2.0 MeV	2.5 MeV
10 ħ	6.934	7.364	8.375	9.317	10.276
20 ħ	6.971	7.383	8.448	9.386	10.297
30 ħ	6.978	7.417	8.489	9.479	10.386
40 ħ	6.985	7.483	8.576	9.578	10.469
50 ħ	6.996	7.578	8.593	9.684	10.594
60 ħ	7.052	7.764	8.698	9.767	10.685

4. Conclusion

In the study of shape transitions of hot rotating nuclei, the temperature dependent level density parameter has an important role to play. It can be investigated by mean field theories such as Hartree - Fock method, but these theories ignore the statistical thermal fluctuations. For a nucleus with finite number of particles, such fluctuations on level density parameter can be large. In work we have calculated the level density parameter as a function of spin and temperature for ^{88}Mo and ^{90}Mo. The level density parameters for the considered nuclei are evaluated by finding the thermo dynamical functions using cranked Nilsson – Strutinsky prescription. The ensemble average of the entropy that depends on β,γ are calculated by the Landau theory of shape transitions. Now the value a and <a> gives the level density parameter calculated at equilibrium configuration (β_0,γ_0) without and with thermal fluctuations respectively. Our results show that the change in level density obtained as a function of temperature is more than that obtained as a function of angular momentum for the case of ^{88}Mo and ^{90}Mo nuclei. The results obtained are also in conformity with the marked temperature dependence of the level density parameter observed experimentally.

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