Study of Systematic of Mass dependent Spin Cut-off Parameter

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Introduction

Spin cut-off parameter σ^2 represents the width of the angular momentum distribution of the level density. It is a crucial parameter in all level density expressions as

$$\rho(E) = \frac{\exp[2\sqrt{aU}]}{12\sqrt{2}\sigma a^{1/4}U^{5/4}} \qquad (1)$$

Spin cut-off parameter is very useful to calculate nuclear level density in Fermi Gas model [1]. In the Back-shifted Fermi gas model [2], the pairing energy is treated as an adjustable parameter and the Fermi gas expression is used to describe the level density at all energies. At present, the level density for practical applications is calculated mainly on the basis of the Fermi-gas [3] and Gilbert-Cameron [4] formulas with adjustable parameters which are found from experimental data on neutron resonance spacing and the density of low lying discrete levels. Gilbert and Cameron [4] proposed a formula, composed of four parameters, which combines the shifted Fermi gas formula at high excitation energies with a constant temperature formula [5] for lower energies. By fitting the four constants in both regions, experimental data may be well reproduced.

Methodology

In this paper we present the calculated spin cut-off parameter for all the nuclei from lower to higher mass region using the statistical theory. In Fermi-gas model the spin cut-off parameter is determined according to the formula $\sigma^2 = m^2gt = IT/h^2$, where m^2 is the average of the square of the single particle spin projections, $T = \sqrt{(U/a)}$ is the thermodynamic temperature, $g = 6a/\pi^2$ is the single particle level density, I is the rigid body moment of inertia expressed as $I = (2/5)\mu AR^2$, where μ is the nucleon mass, A is the mass number and $R = 1.25A^{1/3}$ is the nuclear radius.

The spin cut-off parameter used in rigid body model is

$$\sigma^2\,(RB) = 0.0146A^{5/3}T \qquad (2)$$

On the other hand the Gilbert and Cameron [4] used $m^2 = 0.146A^{2/3}$. and the corresponding formula is

$$\sigma^2\,(GC) = 0.089aA^{2/3}T \qquad (3)$$

S. Iljima [6] and many others [7, 8] modify the Gilbert and Cameron spin cut-off formula as

$$\sigma^2\,(MGC) = 0.146aA^{2/3}T \qquad (4)$$

In the present work, the spin cut-off parameter σ^2 for 350 nuclei have been obtained from the Gilbert and Cameron expression, its modified expression as well as from rigid body calculations by using eq. (1), (2) and (3) respectively.

Results and Discussions

Systematic of spin cut-off parameters was presented for about 350 nuclei ranging from lower to higher masses. The value of spin cut-off parameter moves from σ^2=0.1-16.7 for GC, σ^2=0.2-22.08 for MGC and σ^2=0.1-27.6 for RB approach. Some values are in good agreement with GC approach while some for

MGC and RB approach but we find that approach which does not use discrete levels, gives better results for nuclear level density calculations. Therefore rigid body values give best results by using statistical theory. We also conclude that the three given approaches are in the ratio 1(GC):1.3(RB):1.6(MGC).

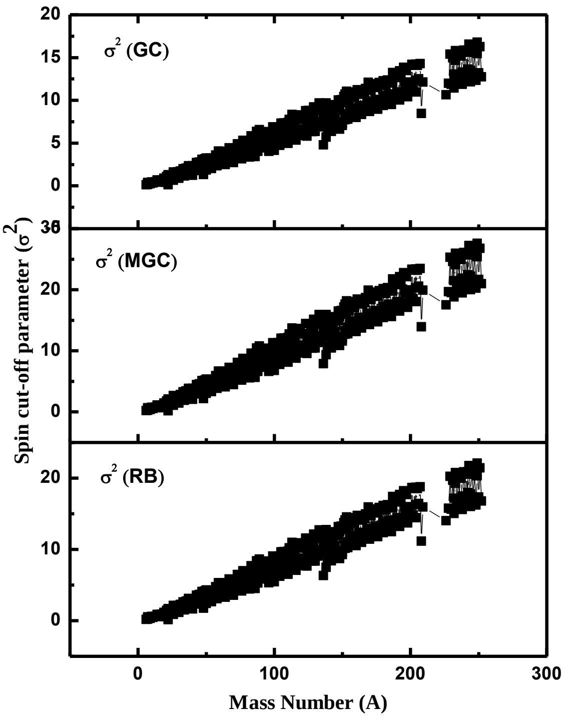

Fig1. Spin cut-off parameter values (σ^2) vs. Mass Number (A) where GC, MGC and RB represent Gilbert and Cameron, Modified Gilbert and Cameron & Rigid body model.

Conclusion

The spin cut-off parameter, which is an important parameter for all statistical model codes, has been calculated with three different approaches to obtain a comparable result and concludes that approach which does not use discrete levels, gives best agreement. The calculations are performed by considering the calculated statistical temperature, and hence the methodology may be more suitable to till higher mass region. No systematic investigations have been performed yet. Though, a problem actually connected to the spin cut-off parameters is still present and opened for theorists for further investigations.

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