Energy dependence of the effective moment of inertia in light nuclei A=20-39

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Introduction

The nuclear levels density parameters are the essential tools for investigating nuclear structure. The level densities are important for many aspects of fundamental and applied nuclear physics. The level densities represent a very important ingredient in statistical model calculations of nuclear reaction cross sections, which are needed in many applications from astrophysical calculations (determining thermonuclear rates for nucleosynthesis) to fission or fusion reactor designs.

Since Bethes pioneering work [1], many studies have been devoted to evaluation of the nuclear level density (NLD). The so-called partition function method is by far the most widely used technique for calculating level densities, particularly in view of its ability to provide simple analytical formulae.

In its simplest form, the NLD is evaluated for noninteracting gas fermions which confined to the nuclear volume and having equally spaced energy levels. Such a model corresponds to the zeroth-order approximation of Fermi gas model and leads to very simple analytical though unreliable expressions for the NLD.

The purpose of this article is to determine the energy dependence of the effective moment of inertia at low excitation energies. A number of nuclei from ^{20}F to ^{39}Ca have been investigated. The level density parameter a and the back shifted fermi gas model E_1 from Bethe formula have been used to determine the spin cut off factor and effective moment of inertia.

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Statistical Formulas

The dependence of the nuclear level density ρ, on angular momentum J, can be written as[2-4]

$$\rho(U,J) = \rho(U)(\frac{2J+1}{2\sigma^2})exp(\frac{-J(J+1)}{2\sigma^2}) \quad (1)$$

where U is the excitation energy and σ^2 is the spin cut-off factor describing the width of the spin distribution. σ^2 is related to an effective moment of inertia I_{eff} and to the nuclear temperature T[5]

$$\sigma^2_{eff} = \frac{I_{eff}T}{\hbar^2} \quad (2)$$

The nuclear moment of inertia for a rigid body is $I_{Rigid} = (2/5)MR^2$(where M=A, the amu nuclear mass; $R = 1.25A^{1/3}$ fm, the nuclear radius) resulting in [5]

$$\sigma^2_{Rigid} = 0.015A^{5/3}T \quad (3)$$

The values of the spin cut-off parameter using the solid sphere approximation are computed for comparison.

Results and Discussions

The effective spin cut-off parameters for nuclei from ^{20}F to ^{39}Ca are calculated from level density parameters determined in our previous Publication[6]. The rigid body values of spin cut-off parameter are also determined for comparison.

The values of the effective and rigid moment of inertia are obtained from equations (2) and (3), Respectively.

The ratio of I_{eff}/I_{Rigid} are calculated at various excitation energy for nuclei. The values of the I_{eff}/I_{Rigid} versus mass number is

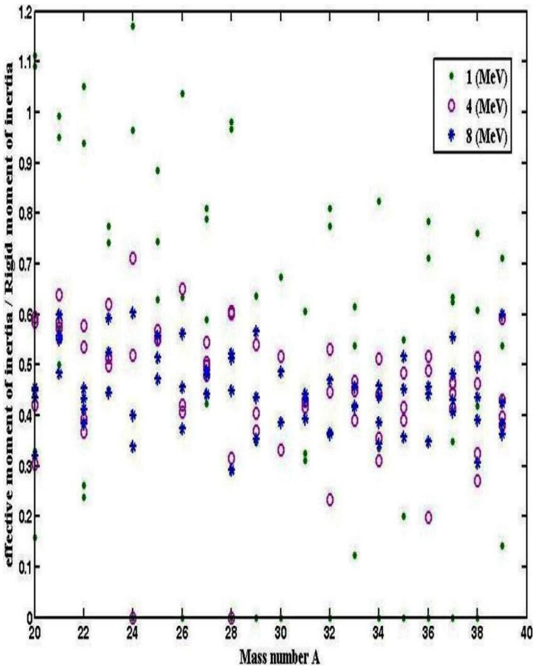

FIG. 1: The ratio of I_{eff}/I_{Rigid} versus mass number at 1(MeV), 4(MeV) and 8(MeV) excitation energy for nuclei from ^{20}F to ^{39}Ca.

plotted in Fig. 1. at 1(MeV), 4(MeV) and 8(MeV) excitation energy.

conclusions

It is clear from this figure that the rigid body values of the moment of inertia differs substantially as compared to their effective values.

The ratio of I_{eff}/I_{Rigid} is found at ~ 0.5 for nuclei from ^{20}F to ^{39}Ca at higher excitation energy.

References

[1] H.A. Bethe, Phys. Rev. 50, 332(1936).
[2] A. N. Behkami, R. Razavi and T. Kakavand, Nuclear Technology and Radiation Protection, 24, 2, 82 (2009).
[3] A. Gilbert and A.G.W. Cameron, J. Phys. 43, 1446(1965).
[4] T. von Egidy and D. Bucurescu, Phys. Rev. C 72, 044311(2005).
[5] R. Razavi, N. Sharifzadeh and M. R. Farahmand, DAE Symp. on Nucl. Phys. **56**, 282 (2011).
[6] R. Razavi, DAE Symp. on Nucl. Phys. **55**, 144 (2010).