Systematic for parity dependence of nuclear level density

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Introduction

Nuclear level density function (ρ) is required to determine nuclear cross-sections. From the available high resolution data on individual resonance parameters (E_o, J^π, Γ_n) for s- and p-wave neutrons [1], mass and energy dependence formulae for the parity distribution in the nuclear level density have been proposed. So far, there has been no systematic study of the parity dependence of nuclear level density near neutron binding energy based on high-resolution data on neutron resonances. Nuclear level density (ρ) can be expressed as a function of excitation energy U, angular momentum J and parity π as;

$$\rho(U,J,\pi) = F_\pi(U) F_J(U,J)\,\rho(U) \qquad \ldots (1)$$

Here,

$$\rho(U) = \frac{1}{\sqrt{2\pi\sigma^2}} \frac{\sqrt{\pi}}{12a^{1/4}} \frac{e^{2\sqrt{aU}}}{U^{5/4}}$$

$$F_J(U,J) = \frac{2J+1}{x} e^{-\frac{J(J+1)}{x}}$$

$$x = \left(\frac{4m_U AR^2}{5\hbar^2}\right)\sqrt{\frac{U}{a}}$$

U is difference between neutron separation energy and pairing energy; 'a' is level density parameter etc. Recent analysis of experimental data [2-5] and theoretical calculations [6-8] on parity dependence of nuclear level density in the compound nucleus has been pointed out.

Method and Analysis

The data used, is obtained from a huge collection of data of 'Atlas of Neutron Resonances, Z=1-100' [1]. By using the asymmetry parameter α as follows;

$$\alpha = \frac{3\rho_- - \rho_+}{3\rho_- + \rho_+} \text{ and } \frac{\rho_+}{\rho_-} = \frac{3D_1}{D_0} \qquad (I^\pi = 0^+)$$

$$\alpha = \frac{9\rho_- - 4\rho_+}{9\rho_- + 4\rho_+} \text{ and } \frac{\rho_+}{\rho_-} = \frac{9D_1}{4D_0} \qquad (I^\pi = ½^+)$$

$$\alpha = \frac{2\rho_- - \rho_+}{2\rho_- + \rho_+} \text{ and } \frac{\rho_+}{\rho_-} = \frac{2D_1}{D_0}$$

(for I^π = 3/2⁺, 5/2⁺, 7/2⁺, 9/2⁺)

$$\alpha = \frac{D_0 - D_1}{D_0 + D_1}$$

Here,
ρ_- = density of negative parity states for l = 0
ρ_+= density of positive parity states for l = 1
D_0 = s- wave level spacing
D_1= p- wave level spacing
In the present work, experimental results are presented for 86 nuclei. Asymmetry parameter ($|\alpha|/A^2$) and excitation energy (U/A^2) vs mass number (A) curves, and asymmetry parameter ($|\alpha|/A^2$) vs excitation energy (U/A^2) analysis have been considered to take into account the mass and energy dependence of nuclear level density.

Results

From the latest input data (A, Nuclei, S_n, I^π, D_0, and D_1) taken from Atlas of Neutron Resonances [1] and output parameters ($|\alpha|/A^2$, U/A^2) for 86 lower to higher mass target nuclides of positive parity as well as for the target nuclides of negative parity including the data of magic nuclides as a function of mass number is shown in fig. 1 and 2. From the fig1 it has been shown that as the mass of the target nuclei increases the parameter $|\alpha|/A^2$ decreases simultaneously but during this decay various peaks has been observed only for even mass target nuclides. It is quite clear that there is a redistribution of the positive and negative parities states equally. Likewise in fig2 parameter U/A^2 decreases with mass number and few peaks have been observed only for odd mass target nuclides. In both the cases, higher mass nuclides attain almost a constant value. Present results are found to be in general agreement with the values reported in literature [9].

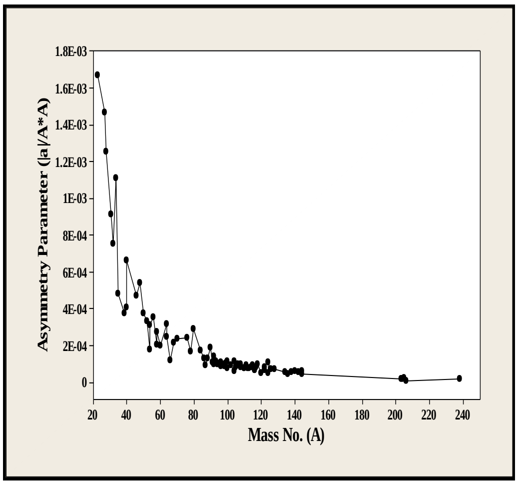

Fig. 1 Asymmetry parameter (α/A^2) vs. Mass number (A).

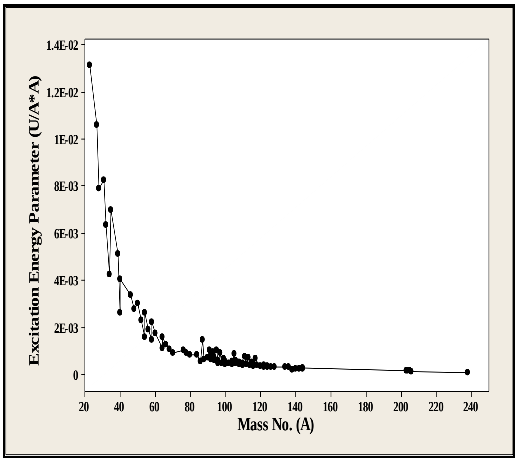

Fig. 2 Excitation energy parameter (U/A^2) vs. Mass number (A).

In fig3, we also analyzed the two output parameters with respect to each other and it has been shown that as the excitation energy parameter (U/A^2) increases asymmetry parameter (α/A^2) also increases. From the analyzed parameters it has been proved that parity is an essential property of nuclear levels and its statistical distribution as projected by us will go a long way in determining neutron cross-section calculations.

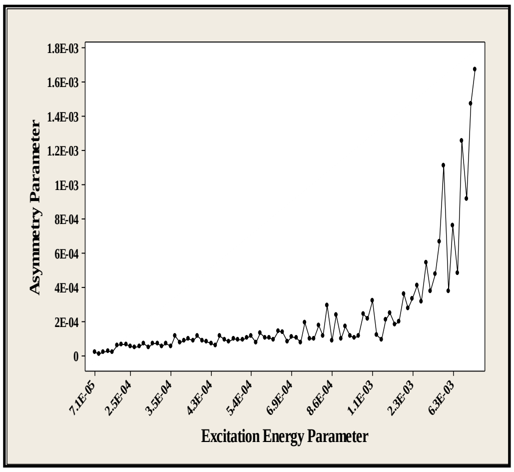

Fig. 3 Asymmetry Parameter (α/A^2) vs. Excitation Energy Parameter (U/A^2)

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