Pairing effect on nuclear level density parameters in ^{116}Sn

R. Razavi*
Physics Department, Faculty of Science,
Imam Hossein Comprehensive University, Tehran, Iran

Introduction

Pairing correlations have a special importance for many fermion systems [1,2]. Pairing correlations have been successfully described by the Bardeen-Cooper-Schrieffer (BCS) theory [3] of superconductivity. In this work, the pairing gap parameters as a function of nuclear temperature for ^{116}Sn have been evaluated. Then the nuclear level density and entropy have been determined using BCS Hamiltonian with inclusion of pairing effects. Also temperature dependence of level density parameters has been investigated.

Pairing Correlations and Level Density Parameters

For a complete derivation of the formulas given in this section, see our previous publications [1,2]. The state density of such an A nucleon system of energy E is related to the logarithm of grand partition function

$$\Omega(\alpha,\beta) = 2\sum_k Ln[1+exp(-\beta E_k)] - \beta\frac{\Delta^2}{G} \quad (1)$$
$$-\beta\sum_k(\epsilon_k - \lambda - E_k)$$

where $T = 1/\beta$ is the statistical temperature, $\lambda = \alpha/\beta$ is the chemical potential, E_k is the quasi particle energy where ε_k is the single particle fermion energy level, Δ is the gap parameter and it is a measure of nuclear pairing, while G is the strength of pairing interaction.

The BCS equations determine the gap parameter and the chemical potential as a function of pairing strength [4]. The entropy S can be written as

$$S = 2\sum_k Ln[1+exp(-\beta E_k)] \quad (2)$$
$$+2\beta\sum_k \frac{E_k}{1+exp(\beta E_k)}$$

The level density for a system of N neutrons and Z protons at excitation energy U is

$$\rho(N,Z,U) = \frac{\omega(N,Z,U)}{(2\pi\sigma^2)^{1/2}} \quad (3)$$

where σ^2 is the spin cut off factor related to moment of inertia [5].

We have used the following equations for level density parameters

$$a_U(T) = \frac{U(T)}{T^2} \quad (4)$$

$$a_S(T) = \frac{S(T)}{2T} \quad (5)$$

$$a_\sigma(T) = \frac{\sigma^2(T)}{T} \quad (6)$$

Summary and Results

In performing calculation of level density the energies and spins of the single particle levels were obtained from Nilsson model [6]. The values of parameters $\lambda(T)$ and $\Delta(T)$ are used to compute entropy and level density. Temperature dependence of energy gap parameter for proton system is shown in Fig. 1.It is seen from the figure that the energy gap parameter decreases rapidly with increasing temperature and it vanishes at the critical temperature.

The results of level density parameters as a function of nuclear temperature for ^{116}Sn are shown in Figs. 2 to 4.

*Electronic address: rrazavin@ihu.ac.ir

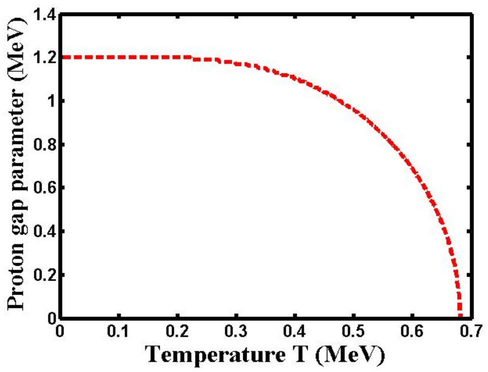

FIG. 1: Dependence of the gap parameter upon temperature for proton system.

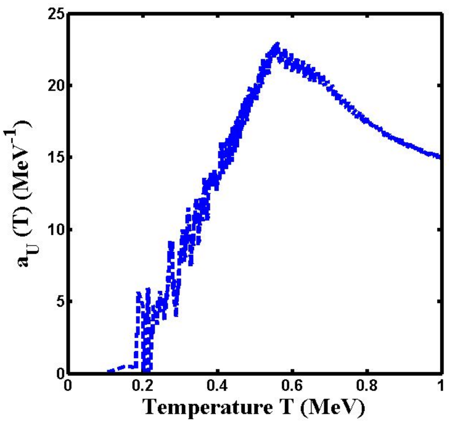

FIG. 2: Temperature dependence of level density parameter a_U.

In summary, the entropy and level density for ^{116}Sn nuclei have been investigated using superconducting theory, which includes nuclear pairing interaction based on the modified harmonic oscillator according to the Nilsson potential.Temperature dependence of the statistical quantities has been determined. Pairing correlations have a strong influence on nuclear level density parameters. The thermal breaking of cooper pairs leads to increasing entropy and level density.

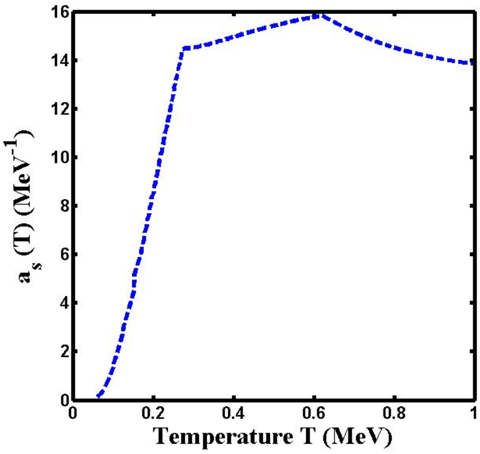

FIG. 3: Temperature dependence of level density parameter a_S.

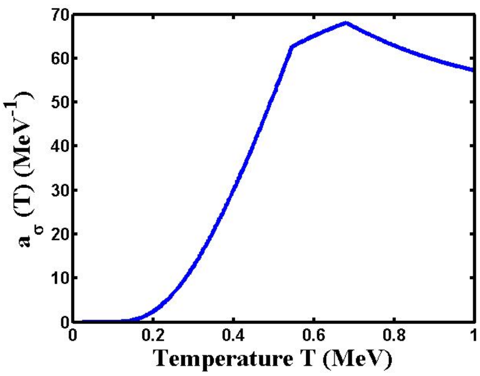

FIG. 4: Temperature dependence of level density parameter a_σ.

References

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