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RESEARCH ARTICLE

PHASE TRANSITION IN $^{40}_{20}\mathrm{Ca}$ AND $^{46}_{20}\mathrm{Ca}$

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Abstract

Thermodynamic properties of $^{40}_{20}\mathrm{Ca}$ and $^{46}_{20}\mathrm{Ca}$ have been calculated using an intergrated nuclear model substituted into the specific heat capacity formula. The transition temperature is obtained from the graphs of specific heat verses temperature. The transition temperature for $^{40}_{20}\mathrm{Ca}$ is $1.9\mathrm{x}10^{9}\mathrm{K}$ and $2.31\mathrm{x}10^{9}\mathrm{K}$ for $^{46}_{20}\mathrm{Ca}$.

Introduction:-

The properties and structure of an atomic nuclei are highly dependent on mass number (A) and on the ratio between the number of protons and the number of neutrons in the nucleus(kenneth *etal*,2002) since discovery of atomic nucleus, considerable efforts have been exerted to construct a general theory of the nucleus that would cover the entire range of known nuclei and have strong predictive power.

In infinetly extended nuclear systems such as neutron star matter and nuclear matter, such as neutron star matter and nuclear matter, the study of superfluidity and pairing has a long history (cooper *et al*, 1959, Emery *et al*, 1960, Migdal 1959, Khanna 1962) even predating the 1967 discovery of pulsars (Hewish *et al*, 1968) which were soon identified as rapidly rotating magnetic neutron stars.

Material and Methods:-

The intergrated nuclear model (Ghahramany *et al.*2001) predicts the binding energy based on some principles proposed by Weizsacker (Greenwood and Cottingham, 2001). It presents nuclear binding energy of all elements based on the following assumptions;

1) The nuclear binding energy is of the order of about one percent of the energy of the total rest mass of the constituent nucleons (Greenwood and Cottingham, 2001).
2) The nuclear binding energy is proportional to the volume of the nuclides $(B \propto A)$
3) The nuclear binding energy depends upon the assymmetry between the number of protons and neutrons (specially in heavy nuclides) and also depends upon the coulumb repulsion force between protons.

The binding energy is expressed as

$$B(Z,N)=\left\{\left[A-\left(\frac{\left(N^{2}-Z^{2}\right)+\delta\left(N-Z\right)}{3Z}+3\right)\right]\frac{mNC^{2}}{\alpha}, A>5, \right. \quad (1)$$

And

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$$\delta(N-Z)=\begin{cases}0 \ for \ N \neq Z. \\ 1 \ for \ N = Z.\end{cases} \quad (2)$$

Where α is defined as an adjusting coefficient, $\alpha = 90-100$, δ stands for nuclear beta-stability line condition.

The temperature dependence is introduced by use of thermal activation factor $e^{-B/KT}$. The net energy of the nuclei is written as

$$E = Be^{-B/KT} \quad (3)$$

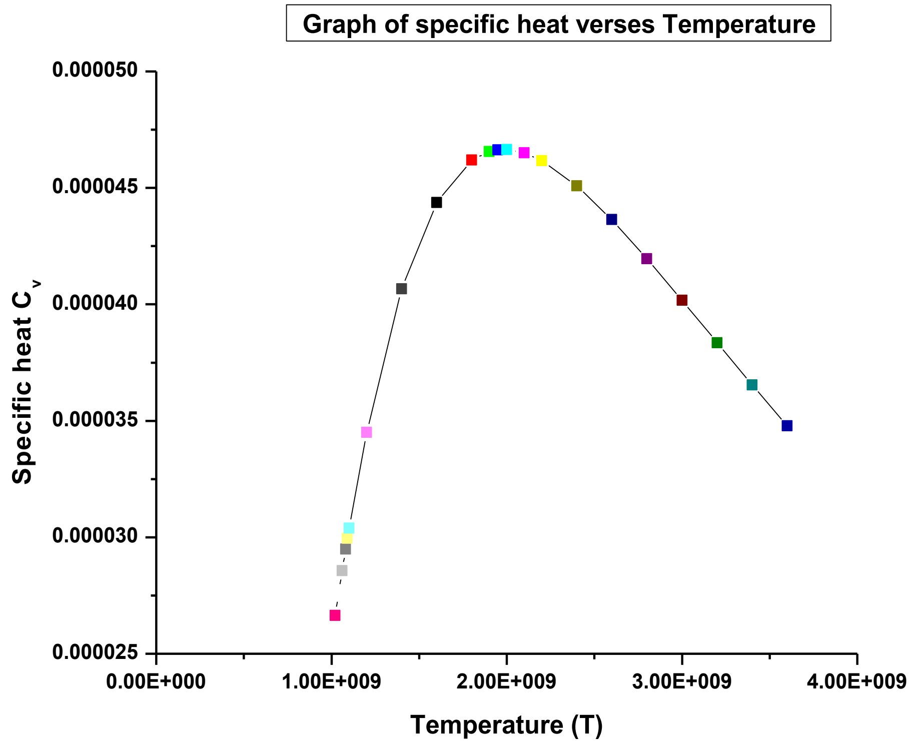
The specific heat capacity is given as $C_V = \frac{B^2}{KT^2}e^{-B/KT}$ (4)

The transition temperature is derived from equation (4) and is given as $T_c = \frac{B}{2K}$ (5)

Result and Discussion:-

i) $^{40}_{20}Ca$

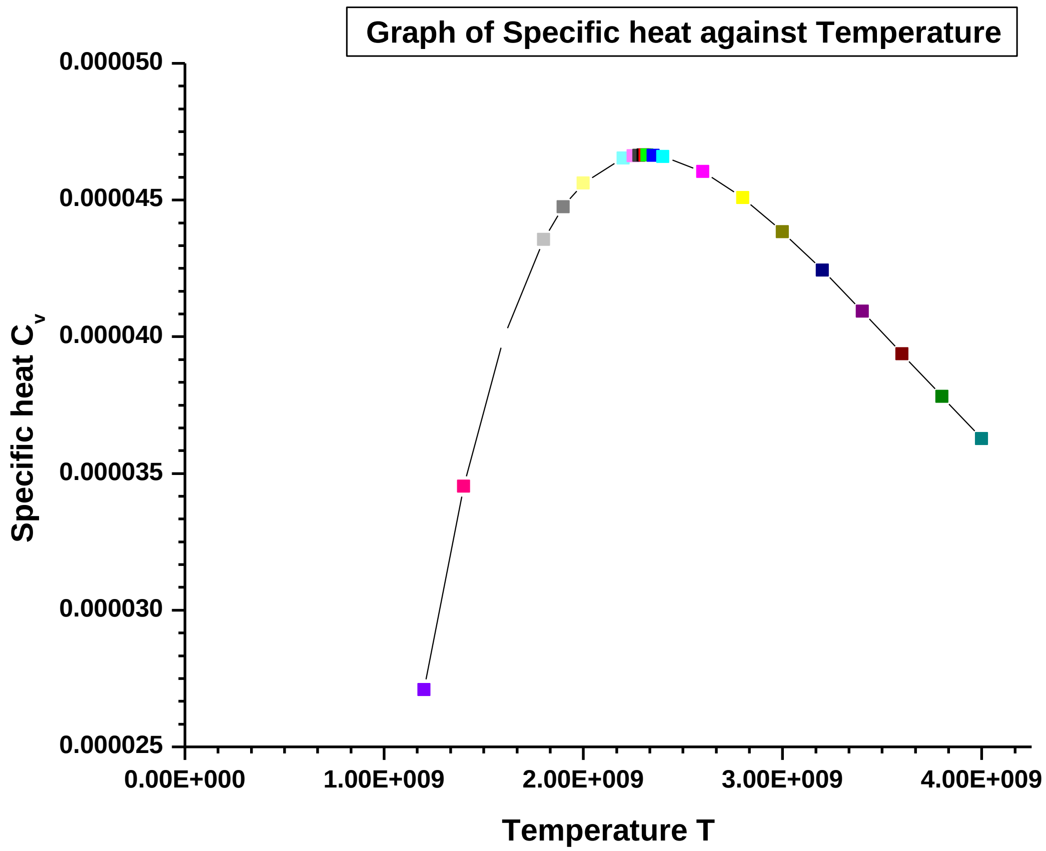
Temperature (T)	**Specific heat (C_v)**
1020000000	2.66E-05
1040000000	2.76E-05
1060000000	2.86E-05
1080000000	2.95E-05
1090000000	2.99E-05
1100000000	3.04E-05
1200000000	3.45E-05
1400000000	4.07E-05
1600000000	4.44E-05
1800000000	4.62E-05
1900000000	4.66E-05
1950000000	4.66E-05
2000000000	4.66E-05
2100000000	4.65E-05
2200000000	4.62E-05
2400000000	4.51E-05
2600000000	4.36E-05
2800000000	4.2E-05
3000000000	4.02E-05
3200000000	3.84E-05
3400000000	3.65E-05
3600000000	3.48E-05



The transition temperature is 1.9848×10^9K as depicted from the graph above, this value is the same as one found from equation (5). The shape of the graph resembles an s-shape and is non linear.

ii) $^{46}_{20}Ca$

Temperature (T)	**Specific heat (C_v)**
1200000000	2.71E-05
1400000000	3.45E-05
1600000000	4E-05
1800000000	4.36E-05
1900000000	4.48E-05
2000000000	4.56E-05
2200000000	4.65E-05
2250000000	4.66E-05
2280000000	4.66E-05
2300000000	4.66E-05
2310000000	4.66E-05
2320000000	4.66E-05
2350000000	4.66E-05
2400000000	4.66E-05
2600000000	4.6E-05
2800000000	4.51E-05
3000000000	4.38E-05
3200000000	4.24E-05
3400000000	4.09E-05
3600000000	3.94E-05
3800000000	3.78E-05
4000000000	3.63E-05



The specific heat capacity versestemperature is non linear graph as shown in figure 2. The phase transition happens at $2.31\text{x}10^9\,\text{K}$, this process is related to a liquid-gas phase transition. The transition temperature of ${}^{46}_{20}\text{Ca}$ is slighty higher than that of ${}^{40}_{20}\text{Ca}$ this may be attributted by the effect of even-even and even-odd.

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