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DEFINITION

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spin excess

QUANTUM STATISTICAL MECHANICS

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FORMULA

FORMULA

multiplicity function

Stirling's approximation

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FORMULA

ASSUMPTION

approximate multiplicity function

fundamental assumption

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DEFINITION

DEFINITION

probability of states

*expectation
average value*

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DEFINITION

EQUATION

entropy

condition for thermal equilibrium

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Assuming N is even, then we define the *spin excess* by

$$N_{\uparrow} - N_{\downarrow} = 2s$$

$$N! \approx (2\pi N)^{1/2} N^N \exp(-N + (1/12)N + \dots)$$

The fundamental assumption of statistical mechanics is that in a closed system, each of its *accessible* states is *equally likely*.

Suppose that a system has some physical property $X = X(s)$ when the system is in state s . The *expected* or *average value* of X is defined by:

$$\langle X \rangle = \sum_s X(s)P(s)$$

If two systems are in thermal contact, the condition for them to be in *thermal equilibrium* is the following:

$$\left(\frac{\partial \sigma_1}{\partial U_1} \right)_{N_1} = \left(\frac{\partial \sigma_2}{\partial U_1} \right)_{N_2}$$

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$$g(N, s) = \frac{N!}{(\frac{1}{2}N + s)!(\frac{1}{2}N - s)!} = \frac{N!}{N_{\uparrow}! N_{\downarrow}!}$$

$$G(N, s) \approx (2/\pi N)^{1/2} 2^N \exp(-2s^2/N)$$

If s is a state of a system, then the probability of that state is given by:

$$P(s) = \begin{cases} 1/g & \text{if } s \text{ is an accessible state} \\ 0 & \text{otherwise} \end{cases}$$

The sum of the probabilities over all states is unity.

$$\sum_s P(s) = 1$$

$$\sigma(N, U) \equiv \ln g(N, U)$$

DEFINITION

fundamental temperature
Kelvin temperature
Boltzmann constant

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EQUATION

multiplicity function for the Hydrogen atom

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DEFINITION

relationship between entropy
and classical thermodynamic entropy

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EQUATION

multiplicity function for 3D harmonic oscillator

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$$\frac{1}{T} = \left(\frac{\partial S}{\partial U} \right)_N$$

$$S = k_B \sigma$$

$$\frac{1}{\tau} \equiv \left(\frac{\partial \sigma}{\partial U} \right)_N$$

$$\tau = k_B T$$

$$k_B = 1.381 \times 10^{-23} \text{ J/K}$$

The multiplicity function for a simple harmonic oscillator with three degrees of freedom with energy E_n is given by

$$g(n) = \frac{1}{2}(n+1)(n+2)$$

where $n = n_x + n_y + n_z$.

The multiplicity function for a Hydrogen atom with energy E_n , is given by

$$g(n) = \sum_{l=0}^{n-1} (2l+1) = n^2$$

where n is the principal quantum number, and l is the orbital quantum number.