for the apparent stabilization of a large population of particles in the ground orbital. We consider a system composed of a large number N of noninteracting bosons. When the system is at absolute zero all particles occupy the lowest-energy orbital and the system is in the state of minimum energy. It is certainly not surprising that at $\tau = 0$ all particles should be in the orbital of lowest energy. We can show that a substantial fraction remains in the ground orbital at low, although experimentally obtainable, temperatures.

If we put the energy of the ground orbital at zero on our energy scale, then from the Bose-Einstein distribution function

$$f(\varepsilon,\tau) = \frac{1}{\exp[(\varepsilon - \mu)/\tau] - 1} \qquad (53)$$

we obtain the occupancy of the ground orbital at $\varepsilon = 0$ as

$$f(0,\tau) = \frac{1}{\exp(-\mu/\tau) - 1}. \qquad (54)$$

When $\tau \to 0$ the occupancy of the ground orbital becomes equal to the total number of particles in the system, so that

$$\lim_{\tau \to 0} f(0,\tau) = N \approx \lim_{\tau \to 0} \frac{1}{\exp(-\mu/\tau) - 1} \approx \frac{1}{1 - (\mu/\tau) - 1} = -\frac{\tau}{\mu}.$$

$e^{-x} \cong 1 - x + \cdots$

$x \equiv \frac{\mu}{\tau}$

$x \lll 1$

Here we have made use of the series expansion $\exp(-x) = 1 - x + \cdots$. We know that x, which is μ/τ, must be small in comparison with unity, for otherwise the total number of particles N could not be large. From this result we find

$$\boxed{N = -\tau/\mu; \qquad \mu = -\tau/N\,,} \qquad (55)$$

$N = 10^{22}$ *

$T = 1\,\mathrm{K}$

as $\tau \to 0$. For $N = 10^{22}$ at $T = 1\,\mathrm{K}$, we have $\mu \cong -1.4 \times 10^{-38}$ erg. We note from (55) that

$\tau = k_B \cdot T$

$T = 1\,\mathrm{K}$ *

$\tau = k_B = 1.38 \cdot 10^{-16}\ \frac{\mathrm{erg}}{\mathrm{K}}$

$$\lambda \equiv \exp(\mu/\tau) \cong 1 - \frac{1}{N}\,, \qquad (56)$$

as $\tau \to 0$. The chemical potential in a boson system must always be lower in energy than the ground state orbital, in order that the occupancy of every orbital be non-negative.

$\mu = -\frac{\tau}{N} \Rightarrow \frac{\mu}{\tau} = -\frac{1}{N}$

$\underset{\lambda}{e} \quad e \qquad \frac{1}{N} \equiv x$ ostatka