Bose–Einstein statistics

In quantum statistics, ***Bose–Einstein statistics*** *(or* ***B–E statistics****)* describe one of two possible ways in which a collection of non-interacting, indistinguishable particles may occupy a set of available discrete energy states at thermodynamic equilibrium. The theory of this behavior was developed (1924–25) by Satyendra Nath Bose, who recognized that a collection of identical and indistinguishable particles can be distributed. The idea was later adopted and extended by Albert Einstein in collaboration with Bose.

The Bose–Einstein statistics apply only to those particles not limited to single occupancy of the same state—that is, particles that do not obey the Pauli Exclusion Principle restrictions. Such particles have integer values of spin and are named bosons, after the statistics that correctly describe their behavior. There must also be no significant interaction between the particles.

Bose–Einstein statistics apply when quantum effects are important and the particles are "indistinguishable". Quantum effects appear if the concentration of particles satisfies

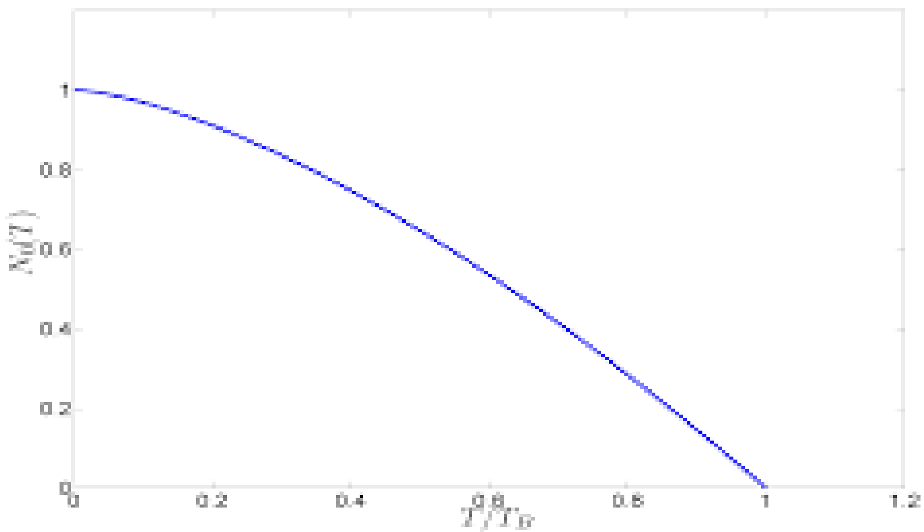
$$\frac{N}{V} \geq n_q$$

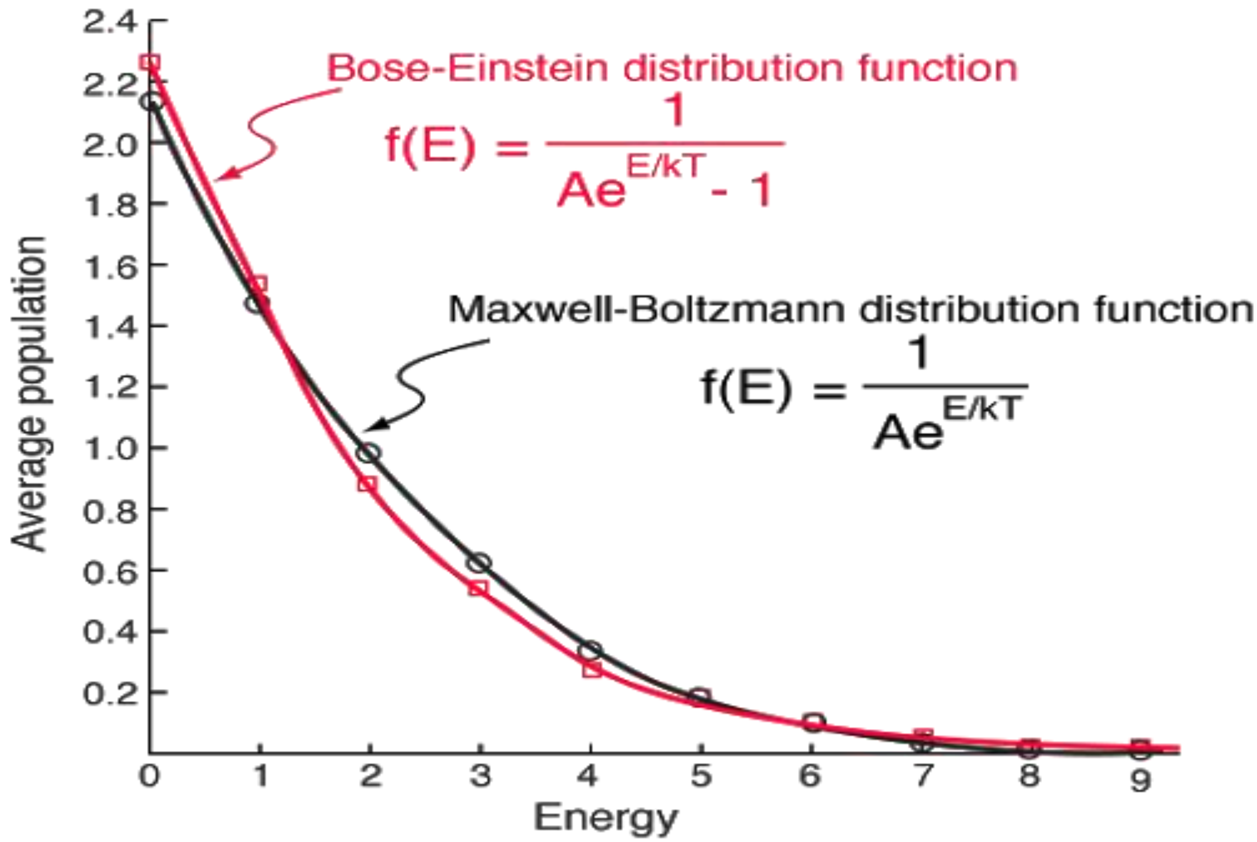
Where, N is the number of particles, V is the volume, and n_q is the quantum concentration, for which the inter-particle distance is equal to the thermal de Broglie wavelength, so that the wave functions of the particles are hardly overlapping. Bose–Einstein statistics apply to bosons. Bose–Einstein becomes Maxwell–Boltzmann statistics at high temperature or at low concentration.

B–E statistics was introduced for photons in 1924 by Bose and generalized to atoms by Einstein in 1924–25.The expected number of particles in an energy state *i* for B–E statistics is:

$$\bar{n_i} = \frac{g_i}{e^{(\varepsilon_i - \mu)/k_B T} - 1}$$

with $\varepsilon_i > \mu$ and where n_i is the number of particles in state *i*, g_i is the degeneracy of energy level *i*, ε_i is the energy of the *i-th* state, μ is the chemical potential, k_B is the Boltzmann constant, and T is absolute temperature.


$N_0(T)$
T/T_B


Bose-Einstein distribution function
$f(E) = \frac{1}{Ae^{E/kT} - 1}$
Maxwell-Boltzmann distribution function
$f(E) = \frac{1}{Ae^{E/kT}}$
Average population
Energy

Bose-Einstein Distribution

$$\langle n \rangle = \frac{1}{\exp[(\varepsilon - \mu)/k_B T] - 1}$$