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dictates two options,
 either $n_k = 0, 1$, for a
 gas of fermions or
 $n_k = 0, 1, \dots$, for
 bosons. QF $k = \sum$
 $n_k = 0. = 1 + e^{-\beta(\epsilon_k - \mu)}$
 while for bosons the
 right hand side is an
 infinite geometric
 series QB $k = \sum$
 $n_k = 0. e^{-\beta(\epsilon_k - \mu)} = (1 - e^{-\beta(\epsilon_k - \mu)})^{-1}$.

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are limitations to the
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need to include
quantum

mechanical effects
becomes specially
apparent at low
temperatures. In this
section we shall first
demonstrate the
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classical results in
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1.1 Probability
Amplitudes. A key
aspect of QM is that
probability enters in

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an unusual way. To stress this point let's recall that "classical" probabilities follow rules like If A,B are independent events with probabilities $P(A)$ and $P(B)$, then the probability for A and B is $P(A \text{ and } B) = P(A)P(B)$.

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The energy eigenstates of one particle are ψ_{n_x, n_y, n_z} .

$$\psi_{n_x, n_y, n_z}(x, y, z) = \sin(k_x x) \sin(k_y y) \sin(k_z z)$$

$$\text{with } k_x = \frac{n_x \pi}{L_x}, k_y = \frac{n_y \pi}{L_y}, k_z = \frac{n_z \pi}{L_z}$$

$$\text{and } n_x, n_y, n_z = 1, 2, 3, \dots$$

$$\text{with energy eigenvalues}$$

$$E_{n_x, n_y, n_z} = \frac{\hbar^2 k^2}{2m}$$

$$= \frac{\hbar^2 \pi^2}{2m} (k_x^2 + k_y^2 + k_z^2)$$

$$= \frac{\hbar^2 \pi^2}{2m} \left(\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2} + \frac{n_z^2}{L_z^2} \right)$$

y.

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particle creation
operators with
quantum number l
 $a_{j n}^\dagger a_{l n} = \delta_{j l} (n+1)$ if
 $n \neq l-1$ for fermions $a_{j n}^\dagger a_{l n} = \delta_{j l} (n+1)$
 $a_{j n}^\dagger a_{l n} = \delta_{j l} (n+1) (-1)^{j-1} \prod_{k=1}^{j-1} a_{k n}^\dagger a_{k n}$
else: (17) Here the $+(-)$ sign applies to
bosons (fermions).

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particle annihilation
operators with
quantum number l c
 $l_j n_1 n_2 \dots i = p_n l(1)$
 $P | 1 j=1 n j j n_1 n$
 $2 \dots n | 1 \dots i: (18)$ We
note that (18)
follows from (17) by
 $h m_1 m_2 \dots j c y | j n$
 $1 n_2 \dots i = h n_1 n$

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dictates two options,

either $n_k = 0, 1$, for a

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gas of fermions or
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$$n_k = 0, 1, \dots, \text{ for } \mu - \epsilon_k < 0$$

while for bosons the
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$$n_k = \frac{1}{e^{\beta(\epsilon_k - \mu)} - 1}$$

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Amplitudes. A key
aspect of QM is that
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recall that "classical"
probabilities follow
rules like If A,B are
independent events
with probabilities
 $P(A)$ and $P(B)$, then
the probability for A
and B is $P(A \text{ and } B) = P(A)P(B)$.

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eigenstates of one
particle are ψ_{n_x, n_y, n_z} .

$\psi_{n_x, n_y, n_z}(x, y, z) = \sin(k_x x) \sin(k_y y) \sin(k_z z)$ with $k_x = \frac{n_x \pi}{L_x}$, $k_y = \frac{n_y \pi}{L_y}$, $k_z = \frac{n_z \pi}{L_z}$; and $n_x, n_y, n_z = 1, 2, 3, \dots$ with energy eigenvalues $E_{n_x, n_y, n_z} = \frac{\hbar^2}{2m} (k_x^2 + k_y^2 + k_z^2)$.

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Ideal Gases

particle creation

operators with

quantum number l

$a_{l j n} = \begin{cases} 1 & n \geq 1 \\ 0 & n = 0 \end{cases}$

$n = 1$ for fermions p

$n = l + 1(1) P | 1 j = 1 n$

$a_{l j n} = \begin{cases} n & n \geq 1 \\ 0 & n = 0 \end{cases}$

else: (17) Here the +

() sign applies to

bosons (fermions).

particle annihilation

operators with

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quantum number l c

$l_j = 1, 2, \dots, l$

$P = \prod_{j=1}^n j^{2j-1}$

$2 \dots n$ (18) We

note that (18)

follows from (17) by

$h_m = 1, 2, \dots, j$

$1, 2, \dots, i = h_n$

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