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# The Study Of Fermi-Dirac, Bose-Einstein And Maxwell-Boltzmann Distribution With Energy At Different Temperatures With Scilab Software

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## ABSTRACT:

We study the three distributions viz. Maxwell-Boltzmann distribution, Fermi-Dirac distribution and Bose-Einstein distribution with the energy at different temperatures individually as well as the comparison for all the distributions also has been done through Scilab programming at temperature 100K. On increasing the temperature it has been observed net increment in the occupation number corresponding to a particular energy state because the particles can gain the energy and excite thermally to upper states, this happens for Maxwell-Boltzmann distribution. For Fermi-Dirac distribution all energy states are filled below a particular energy level known as Fermi energy level and above which all states are empty. But as we increase the temperature particles, here Pauli's exclusion principle is followed that means no two particles occupied the same quantum state. For Bose- Einstein distribution each energy state can contain any number of particles since the particles are identical and indistinguishable.

## INTRODUCTION:

Scilab is a open source and commercial software, numerical computation package. It has wide applications and free to all. It is available for Windows, Mac and Linux operating systems. In this paper all the plots as well as the programming is done with Scilab software.The linear equations, 2-D plotting, complex problems and some algebraic operations were done [1]. The same problems can be solved by the Matlab software which is more advanced then the present software. All the codes have been developed by the Scilab software and the commands are written in the program. Although for all the numerical problems the present software is capable.The open source softwares are mostly used in industries, research institutions and companies, etc.[2]. Xcos based model were designed and find the trajectories of an electron along 'x' and 'z' directions, traversing through a planar undulator [3].The experiment on grid computing environment is presented [4]. Now further we discuss about the statistics. The comparison of three distributions such as Maxwell-Boltzmann distribution, Fermi-Dirac distribution and Bose- Einstein distribution is very important in statistical mechanics & thermal physics. For M-B statistics the associated particles are distinguishable and spinless with constant total energy. The gas molecules at high temperature and low pressure belongs to M-B. On the other-hand for B-E statistics the particles are found in zero or integral spin which are identical and indistinguishable. Photon and mesons are its examples. But in case of F-D statistics the spin value of particles is half-integral and they are identical and indistinguishable as well as the Pauli’s principle is followed. M-Bdistribution is the well defined and a special case of B-Edistribution and F-D distribution [5].The role of quantum physics is important which able to explain the atomic phenomena and the behaviour of elementary particles [6-7].Ideal Fermi gas in a harmonic trap to partitions of given integers into distinct parts was studied by A.Kubasiaket.al.[8].Without Stirling's approximation probabilistic distributions were derived the Maxwell–Boltzmann, Bose–Einstein and Fermi–Dirac entropies [9].Experiment done by the author without Stirling's approximation it was found that the new entropy measures as explicit functions of the probability [10].The three statistics were deal with interactions of particles in a large number of a solid [11].In a study it was found that when the political heat is generated then political entropy increases with political temperature remaining constant [12].The name Swap which is a non-transitive game that was used as a toy thermodynamic model to explore temperature, heat flow, equilibrium and entropy [13]. The brief history of Fermi-Dirac statistics was discussed with necessary computing tools [14].

**Formula and symbol’s meaning:**

$n_i = (g_i/(\exp \beta(E_i-\mu)) + K)$ where the symbol having their meaning and represented as

$n_i$ = Number of states

$g_i$= Degeneracy factor

$\beta = (1/ T*K_B)$ and $K_B$ is Boltzamann constant

$E_i$ = Energy corresponding to $n_i$states

$\mu$ = Chemical Potential

K = Type of distribution,

K=-1 for B-E

= 0 for M-B

= 1 for F-D

**Algorithm:**

1. Input all the values of constants such as of β, T, $K_B$ and the type of distribution 1, 0 or -1.
2. Define a matrix of order 1*4 for defining different temperatures.
3. Define an array for energy i.e, x=linspace(1,50,100) where x = $^{Energy}/_{Boltzmann\ constant}$.
4. Use two **for loops** first for 4 different temperatures and second for making array of points of curve to be plotted.
5. Now, plot the different curves using plot command.
6. Labelling the graph using commands.

**SCILAB CODING FOR MAXWELL-BOLTZMANN (M-B) DISTRIBUTION:**

```
clf
k=0 //Maxwell-Boltzmann
T=[1,5,10,15] //Temp in K
x=linspace(1,50,100) //x=(E/K)
for j=1:4
   for i=1:100
      U(j,i)=(1/(exp(x(i)/T(j))+k)) //U(j,i)=(ni/gi)
   end
end
scf(0)
plot2d(x,U(1,:),color("red"))
plot2d(x,U(2,:),color("green"))
plot2d(x,U(3,:),color("blue"))
plot2d(x,U(4,:),color("black"))
ylabel('$\boldsymbol{Occupation Number\rightarrow}\$','fontsize',4)
xlabel('$\boldsymbol{Energy\rightarrow}\$','fontsize',4)
title("Maxwell-Boltzmann Statistics",'fontsize',4 )
legend('For T = 1 K','For T = 5 K','For T = 10 K','For T = 15 K')
```

**SCILAB CODING FOR FERMI-DIRAC (F-D) DISTRIBUTION:**

```
k=1 //Fermi-Dirac
T=[1,5,10,15] //Temp in K
x=linspace(-50,50,100) //x=(E/K)
```

```
for j=1:4
    for i=1:100
        U(j,i)=(1/(exp(x(i)/T(j))+k)) //U(j,i)=(ni/gi)
    end
end
scf(1)
plot2d(x,U(1,:),color("red"))
plot2d(x,U(2,:),color("green"))
plot2d(x,U(3,:),color("blue"))
plot2d(x,U(4,:),color("black"))
ylabel('$\boldsymbol{Occupation Number\rightarrow}\$','fontsize',4)
xlabel('$\boldsymbol{Energy\rightarrow}\$','fontsize',4)
title("Fermi-Dirac Statistics",'fontsize',4 )
legend('For T = 1 K','For T = 5 K','For T = 10 K','For T = 15 K')
```

**SCILAB CODING FOR BOSE-EINSTEIN(B-E) DISTRIBUTION:**

```
k=-1 //Bose-Einstein
T=[1,5,10,15] //Temp in K
x=linspace(1,50,100) //x=(E/K)
for j=1:4
    for i=1:100
        U(j,i)=(1/(exp(x(i)/T(j))+k)) //U(j,i)=(ni/gi)
    end
end
scf(2)
plot2d(x,U(1,:),color("red"))
plot2d(x,U(2,:),color("green"))
plot2d(x,U(3,:),color("blue"))
plot2d(x,U(4,:),color("black"))
ylabel('$\boldsymbol{Occupation Number\rightarrow}\$','fontsize',4)
xlabel('$\boldsymbol{Energy\rightarrow}\$','fontsize',4)
title("Bose-Einstein Statistics",'fontsize',4 )
legend('For T = 1 K','For T = 5 K','For T = 10 K','For T = 15 K')
```

**SCILAB CODING FOR COMPARISION OF THREE STATISTICS AT 100K:**

```
T=100 //Temp in K
K=8.617e-5 //Boltzamann constant in eV/K
m=K*T //Chemical Potential
b=(1/(K*T)) //Beta
k=[-1,0,1]
E=linspace(0.01,4.3e-2,10000) //0.001KT to 5KT
for j=1:3
   for i=1:10000
      U(j,i)=(1/(exp(b*(E(i)-m))+k(j))) //U(j,i)=(ni/gi)
   end
end
scf(3)
plot2d(E,U(1,:),color("red"))
plot2d(E,U(2,:),color("green"))
plot2d(E,U(3,:),color("blue"))
ylabel('$\boldsymbol{Occupation Number\rightarrow}\$','fontsize',4)
xlabel('$\boldsymbol{Energy\rightarrow}\$','fontsize',4)
title("Comparison of Maxwell-Boltzmann,Fermi-Dirac and Bose-Einstein
Statistics",'fontsize',4 )
legend('Bose-Einstein Statistics for T = 100 K','Maxwell-Boltzmann Statistics for T = 100
K','Fermi-Dirac Statistics for T = 100 K')
```

**Output:**

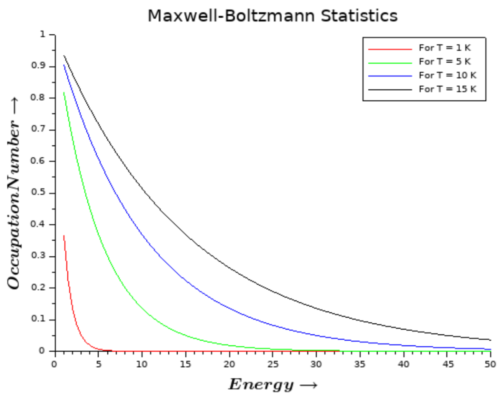


Figure (1) M-B Statistics

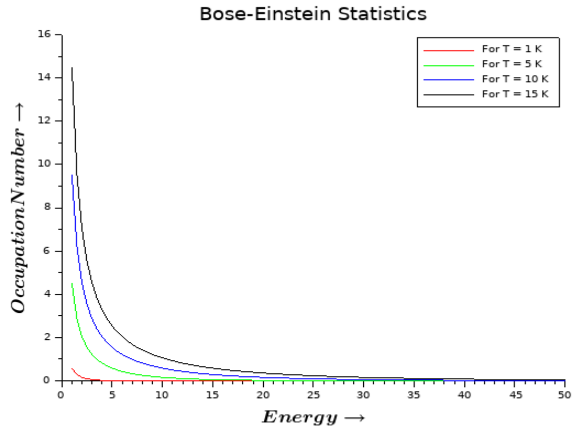


Figure (2) B-E Statistics

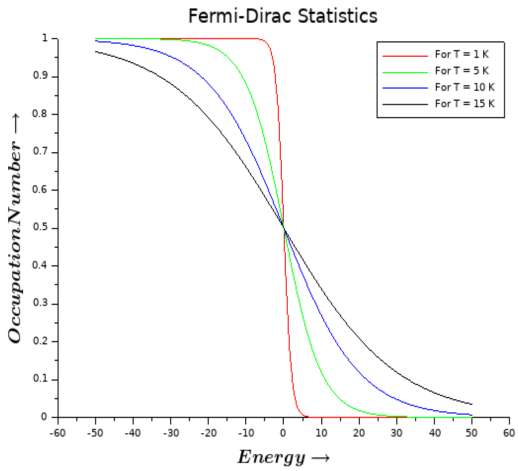


Figure (3) F-D Statistics

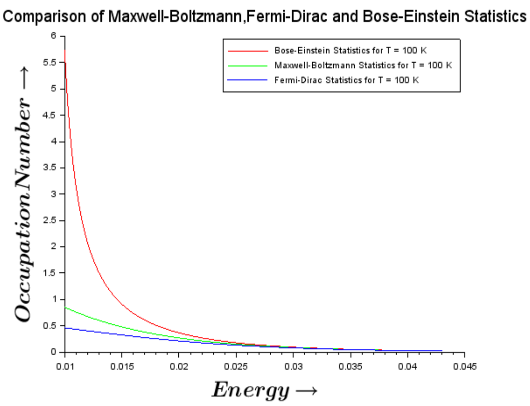


Figure (4) Comparison of three Statistics

**CONCLUSIONS:**

The study of the three statistics has been done with Scilab software with the energy at different temperatures also the comparison for all the distributions in the paper was at temperature100K. It was found for Maxwell-Boltzmann distribution that on increasing the temperature there is a net increment in the occupation number corresponding to a particular energy state because the particles can gain the energy and excite thermally to upper states. For Fermi-Dirac distribution all energy states are filled below a particular energy level. But as we increase the temperature particles, here Pauli's exclusion principle is followed that means no two particles occupied the same quantum state. For Bose- Einstein distribution each energy state can contain any number of particles since the particles are identical and indistinguishable. These plots shown in figure 1-4 match with the theoretical results for above three statistics.

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