Discrete area spectrum and the Hawking radiation spectrum III: Maxwell-Boltzmann

Earlier, I explained that Planck's black body radiation is a phenomenon whereby every object emits light. There, I explained that in 1900 Max Planck came up with the mathematical derivation of the amount of the different kinds of emitted light present in blackbody radiation. In 1924, an Indian physicist Bose came up with another mathematical derivation of Planck's blackbody radiation. This time, he treated photons (i.e. light particles) as identical particles, specifically what is now called identical "bosons." (The term "boson" comes from Bose's name.) (If you read "Bosons, Fermions and the statistical properties of identical particles," you will understand what I mean by "identical.") Only when did he consider the photons as identical bosons, and calculated probabilities accordingly, could he get Planck's blackbody radiation spectrum.

When Hawking derived Hawking radiation spectrum, using quantum field theory, he also got Planck's blackbody radiation spectrum, even though he didn't explicitly use the fact that photons are identical bosons.

However, in 2016, I suddenly realized that Hawking radiation spectrum should not be given by Planck's blackbody radiation spectrum. Let me explain why. Recall how we counted the number of states for a black hole in loop quantum gravity. When the black hole area was 1, and the unit areas were 0.3, 0.4, 0.7 and 1, we had

$$\begin{aligned}
1 &= 1 \\
1 &= 0.7 + 0.3 \\
1 &= 0.6 + 0.4 \\
1 &= 0.4 + 0.6 \\
1 &= 0.4 + 0.3 + 0.3 \\
1 &= 0.3 + 0.7 \\
1 &= 0.3 + 0.4 + 0.3 \\
1 &= 0.3 + 0.3 + 0.4
\end{aligned}$$

Notice that $0.7+0.3$ and $0.3+0.7$ are treated differently. So are $0.4+0.3+0.3$, $0.3+0.4+0.3$, and $0.3+0.3+0.4$. So are $0.6+0.4$ and $0.4+0.6$. In other words, we considered the area quanta as distinguishable. They are distinguishable, because they have fixed locations on black hole horizon, which enables you to label the area quanta.

So, you can accordingly calculate the probabilities of certain area quanta appearing on black hole, considering that the area quanta are distinguishable. Of course, this should differ from Planck's blackbody radiation, which is based on *indistinguishability*. The statistical distribution of number of distinguishable particles in a given temperature is known as "Maxwell-Boltzmann distribution." It was first derived in the 19th century. The statistical distribution of number of identical bosons in a given temperature is known as "Bose-Einstein distribution," which coincides with Planck's blackbody radiation. Thus, I argued that the Hawking radiation spectrum is not given by Bose-Einstein distribution (i.e. Planck's blackbody radiation spectrum) but by Maxwell-Boltzmann distribution. As an aside, for identical fermions, we have "Fermi-Dirac distribution."

Summary

- Planck's blackbody radiation formula is due to the fact that photons are identical bosons. Thus, they follow Bose-Einstein distribution.
- As area quanta are not indistinguishable, but distinguishable, Hawking radiation spectrum must follow not Bose-Einstein distribution but Maxwell-Boltzmann distribution.