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Redefining Black Hole Entropy due to Proportionality to the Fine Structure Constant

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Abstract

In this article we propose a new definition of the entropy of black holes. For this we base ourselves on a reformulation of the Hawking-Bekenstein formula in such a way that, on the one hand, by introducing a new variable that represents the number of microstates and On the other hand, taking into account the mass of the black hole, we can conclude a new equation for the entropy of black holes.

Keywords: Black hole; Entropy; Microstates; Black hole mass

Introduction

In this paper I will present an equation which will show how the black hole entropy is proportional to the fine structure constant. Afterwards I will explain how this equation relates to black hole entropy and how we can define it in relation to the original Hawking-Bekenstein black hole entropy formula. We can see below the original formula,

$$S_{BH} = \frac{4\pi r^2}{4l_p^2}$$

The equation above tells us the amount of entropy of a black hole. Originally Bekenstein derived this formula and concluded a black hole entropy is proportional to the black hole's event horizon surface area.

The Fine Structure Constant

$$\alpha_e = \frac{1}{137} = \frac{k_e e^2}{\hbar c}$$

Above we have an equation which gives us the value of the fine structure constant. We represent the fine structure constant as "α_e". The variable "α_e" can also be given by the second expression $\frac{k_e e^2}{\hbar c}$. This expression essentially implies that the fine structure constant is a probability which shows the chance of an electromagnetic interaction between a photon and an electron within an atomic electrostatic interaction. The probability is one out of 137 atomic electrostatic interactions emitting or absorbing a photon.

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The New Micro-State Variable for Black Hole Entropy

$$\phi_M = \frac{Gm^2}{k_c e^2}$$

This is the micro-state variable we will use in our new black hole entropy equation. The variable tells us how many atomic electro-static interactions are needed within a certain surface area to result in the gravitational field of the mass "*m*". Keep in mind the surface area is derived using the Schwarzschild radius of the mass "m". Whenever the mass "*m*" equals the Planck mass, ϕ_M equals which is the maximum of the fine structure constant [1].

Multiplying the fine structure constant and the micro-state variable,

$$\alpha_e \phi_M = \alpha_e \frac{Gm^2}{k_c e^2} = \frac{m^2}{m_P^2}$$

The product of both the fine structure constant α_e and the micro-state variable ϕ_M give us the squared number of Planck masses "m_P" within an overall mass "m". Within each Planck mass there are 137 atomic electro-static interactions and each 137 electro-static interaction there are at least one of the interactions has an electro-magnetic absorption or emission of a photo.

Presenting a New Form of Black Hole Entropy

$$S_{BH} = k_B \frac{4\pi r_B^2}{4 l_P^2} = 4\pi k_B \alpha_e \phi_M$$

This is the black hole entropy equation in its original form reduced to $4\pi k_B \alpha_e \phi_M$. The original Hawking-Bekenstein equation makes the black hole entropy proportional to the surface area $4\pi r_B^2$ where "r_B" is the Schwarzschild radius of the mass "*m*". "r_B" equals $2Gm$ divided by c^2. The new form makes ϕ_M the micro-state variable proportional to the black hole entropy S_{BH}.

Keep in mind "α_e" is the fine structure constant and ϕ_M equals $\frac{Gm^2}{k_c e^2}$.

This new form of black hole entropy needs to be interpreted because of how I have defined above the variables of the fine structure constant and the micro-state [2].

I conclude black hole entropy in this new form can be interpreted as a measure of the different states in which a certain number of atomic electro-static interactions can be arranged in a Schwarzschild surface area to result in the gravitational field of mass "*m*".

List of Physical Parameters

S_B	Black hole entropy
k_B	Boltzmann constant, $1.3807 \times 10^{-23} JT^{-1}$
c	Speed of light , 299792458 ms^{-1}
G	Gravitational constant, $6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$
m	Mass of black hole
r_b	Schwarzschild radius of mass "m"

l_P	Planck length, 1.6162×10^{-35}m
ϕ_M	Micro-state variable of black hole entropy
m_P	Planck mass, 2.176×10^{-8} kg

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2. Alberto Coe. Micro Black Hole Entropy and Fine Structure Constant: A Numerological Approach. 2021