Journal of High Energy Physics, Gravitation and Cosmology, 2023, 9, 720-724
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

On the Origin of Gravity and the Emergence of a Black Hole

Kapil P. Chandra

Department of Theoretical Physics and Astronomy, University of Würzburg, Würzburg, Germany
Email: kapil.chandra@gov.in

How to cite this paper: Chandra, K.P. (2023) On the Origin of Gravity and the Emergence of a Black Hole. *Journal of High Energy Physics, Gravitation and Cosmology*, **9**, 720-724.
https://doi.org/10.4236/jhepgc.2023.93059

Received: March 2, 2023
Accepted: July 11, 2023
Published: July 14, 2023

Abstract

We show the theoretical origin of gravitational force and explain why it is the weakest force of nature. Further, we report that if the gravity of any object at any point is larger than a certain value, from that point on it will be a black hole-like object; this might be a new criterion to define a black hole. It might offer fresh insight into the origin of gravity and black hole.

Keywords

Gravitational Force, Nuclear Force, Thermodynamics, Black Hole

1. Introduction

Gravity is one of nature's four fundamental forces; it is weak in comparison to its counterpart forces such as nuclear force, electrostatic force, and weak force, but it governs the universe on a large scale. This force is also responsible for forming a black hole on a cosmic scale [1]. This is an inverse square law force and is tested at the millimetre length scale; beyond this, a quantum force or nuclear force comes into play. At this scale, the effect of gravity is negligible.

This force was quantified by Newton, and he proposed an empirical equation to estimate its numerical value. Therefore, there is no theoretical derivation of this force, so it's difficult to describe its nature and other properties theoretically. We have no idea how it came about. This complicates our understanding of why gravity works between masses and is always an attractive force, as well as many other related questions. It has been bothering physicists for years.

Many theories have been proposed to explain it [2] [3]; nonetheless, the problem persists. It is believed that the quantum theory of gravity may have an answer to those questions [4] [5] [6], but it is still in its development stage. However, in this paper, we take this question from another perspective and investigate the origin of gravity by using the law of thermodynamics.

2. Origins of Gravitational Force

In order to meet those questions we derive an expression for the gravitational force. To do so, we use the theory of thermodynamics, where entropic force [7] can be described as follows:

$$\nabla F \nabla R = T \nabla S = \nabla E \tag{1}$$

where F is force R is space parameter T is temperature, and S is entropy. If we take the energy $E = mc^2$ where m denotes mass and c as speed of light, and by substituting it in Equation (1), it will turn into followings,

$$F^2 = \frac{\nabla m^2 c^4}{\nabla R^2} \tag{2}$$

this shows the generalized entropic force. To find out the mathematical expression of force we use a novel scheme where we suppose that there are two categories of force and one of them is as following:

$$F \propto \frac{\nabla m^2}{\nabla R^2} \propto c^4 \tag{3}$$

and the other is,

$$F \propto \frac{1}{R^2} \propto m^2 c^4 \tag{4}$$

both categories of forces are different by nature.

From above expression we can figure out the dependency of force on variables. In order to find the exact expression of force, we need to remove proportionality by using some constants, however, let assume G is that constant. In this case, the Equation (3) will result in the following.

$$F = \frac{Gm^2}{R^2} = \frac{c^4}{G} \tag{5}$$

by dimensional analysis, we found the dimension of used constant G is same as the Newton's gravitational constant. Thus, we have recovered the mathematical expression for classical gravitational force. This shows the theoretical origin of gravitational force.

Similarly, the other category of force also needs to be removed the proportionality. For this category of forces, the used constant G is not work because the used variable are different, so by dimensional analysis, the constant that can eliminate the proportionality is hc, where h corresponds to the Planck constant and c denotes the speed of light. By substituting it in Equation (4), it yields the following:

$$F = \frac{hc}{R^2} = \frac{m^2 c^4}{hc} \tag{6}$$

these forces are different from the classical gravitational force, and they can be used to estimate the numerical value of nuclear force [8], which is a quantum form of force. We are not going into its details since it's beyond the scope of this paper.

Apart to it, from Equation (2) there is possibility of two other form of force as written below,

$$F \propto m^2 \propto \frac{c^4}{R^2}$$

This shows the dependence of force on the variables and needs to be removed from the proportionality since, to our knowledge, there is no form of force that can be described by this expression, so we leave this here for future research.

3. Why Is Gravity Such a Weak Force of Nature?

Now, we show the theoretical origin of both gravitational and quantum force. And, as we discussed earlier, out of the four fundamental forces of nature, gravity is the weakest one, but the reason behind this fact is not clear. Here we give a heuristic interpretation of this fact.

Mathematically and dimensionally, we can re-write the Equation (2) by using the Equation (5) and (6) as follows [9]:

$$\underbrace{G\frac{m^2}{R^2}\times\frac{c^4}{G}}_{\text{Gravitational force side}} = \underbrace{\frac{hc}{R^2}\times\frac{m^2c^4}{hc}}_{\text{Quantum force side}} \tag{7}$$

by substituting the mass m and R as the mass of proton and radius of nucleus, one can observe that there exists a large constant force $\left(\frac{c^4}{G}\right)$ on the gravitational side of the balance where its numerical value is nearly ~10^{43} N; thus, to retain the numerical balance, gravity remains weak.

This Equation (7) can facilitate to derive the gravitational coupling constant (relative strength) as,

$$G\frac{m^2}{R^2} = \left(\frac{Gm^2}{hc}\right)\frac{hc}{R^2}$$

it corresponds to,

$$G\frac{m^2}{R^2} = \left(\frac{1}{\alpha_G}\right)\frac{hc}{R^2}$$

where α_G is gravitational coupling constant which shows the relative strength of gravity to nuclear force (strong force). This is already known thus it shows the consistency of our derived expression with other existing theory.

This also gives the idea that why is gravity a function of both mass and space, probably due to the existence of constant force terms in the Equation (7), it retain the dimensional balance with quantum force. However, we infer there might close link between the weakness of gravity and its dependency on variables.

4. On the Relation between Mass m and Space R and the Emergence of a Black Hole

The preceding section suggests the gravitational force side is dominant by the existence of constant force terms $\left(\frac{c^4}{G}\right)$; however, an obvious question is "what will happens if the gravitational force of any physical body/object becomes larger than that constant force?" Specifically, if the condition is as following,

$$\frac{c^4}{G} \le \frac{Gm^2}{R^2}$$

simply it will reduce to,

$$R \le \frac{Gm}{c^2} \tag{8}$$

this shows the relationship between the mass and radius of any given physical body/object at the condition when gravitational attraction force is very large.

This derived relation corresponds to the half the Schwarzschild radius of a black hole [10]. However, one can say that at that condition, that physical object becomes a black hole like object, and theoretically a black hole emerged. This gives us a new interpretation of a black hole's event horizon. For any object, at any point if the gravity is $\ge \frac{c^4}{2G}$, it turn into a black hole.

5. Uncertainty Relation between the Mass and Size of a Black Hole

In this line, it would be worthy to discuss that, on the basis of the above description, one may speculate that the Equation (8) might show the gravitational uncertainty relation similar to an uncertainty relation exists in quantum physics [11]. It means to say that the mass and radius of black holes can be gravitational conjugate variables. If this is so, then:

$$\frac{\nabla R}{\nabla m} \le \frac{G}{c^2} \tag{9}$$

it denotes the gravitational uncertainty relation between ∇R and ∇m, and thus we infer that we can't measure the size and mass of a black hole at the same time.

6. Conclusions

Gravity is an entropic force. We found that there is a natural balance between gravitational and quantum forces. But there exists a constant force $\left(\frac{c^4}{G}\right)$ with a high numerical value on the side of gravitational force; thus, to strike a balance, gravity becomes weak, giving us a mathematical explanation of the weakness of gravity.

For a black hole, this constant force shows the minimum limit of gravity; it means to say that at any point of the object, for a given mass and radius, if the gravity is larger than this constant force, the object will attain the Schwarzschild radius and turn into a black hole-like object. This might be an alternative explanation of the origin of the Schwarzschild radius. It may shed light on the origin of gravity and black hole subsequently.

Acknowledgements

I would like to say thanks to anonymous referee for his critical comment to correct the manuscript. Special thanks to my coworker Shri Tej Ram Patel for this financial support to pay the APC.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Frolov, V.P. and Zelnikov, A. (2011) Introduction to Black Hole Physics. Oxford University Press, Oxford. https://cds.cern.ch/record/1418196 https://doi.org/10.1093/acprof:oso/9780199692293.001.0001

[2] Capozziello, S. and De Laurentis, M. (2011) Extended Theories of Gravity. *Physics Reports*, **509**, 167-321. https://doi.org/10.1016/j.physrep.2011.09.003 https://www.sciencedirect.com/science/article/pii/S0370157311002432

[3] Khanday, A.W., Upadhyay, S. and Ganai, P.A. (2023) Study of the Large Scale Structure through Modified Gravity Theory Using Statistical Mechanics. *Physica A: Statistical Mechanics and Its Applications*, **612**, Article ID: 128493. https://www.sciencedirect.com/science/article/pii/S0378437123000481 https://doi.org/10.1016/j.physa.2023.128493

[4] Rovelli, C. (2004) Quantum Gravity. Cambridge Monographs on Mathematical Physics. Cambridge University Press, Cambridge.

[5] Kiefer, C. (2007) Why Quantum Gravity? Springer, Berlin, Heidelberg.

[6] Carlip, S. (2008) Is Quantum Gravity Necessary? *Classical and Quantum Gravity*, **25**, Article ID: 154010. https://doi.org/10.1088/0264-9381/25/15/154010

[7] Verlinde, E. (2011) On the Origin of Gravity and the Laws of Newton. *Journal of High Energy Physics*, **2011**, Article No. 29. https://doi.org/10.1007/JHEP04(2011)029

[8] Chandra, K.P. (2023) A Thermodynamic Interpretation of Nuclear Force. https://doi.org/10.2139/ssrn.4364739

[9] Chandra, K. (2020) Why Gravity a Weak Force of Nature. *Journal of High Energy Physics, Gravitation and Cosmology*, **6**, 353-356. https://doi.org/10.4236/jhepgc.2020.63028

[10] Novikov, I. (1997) Black Holes. Springer, Berlin, Heidelberg, 237-334.

[11] Angelow, A. and Batoni, M.C. (1999) About Heisenberg Uncertainty Relation (by E. Schrodinger). https://arxiv.org/abs/quant-ph/9903100