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► **To cite this version:**

Luca Roatta. Discretization of space and time: determining the values of minimum length and minimum time. 2017. hal-01498171

HAL Id: hal-01498171

<https://hal.science/hal-01498171>

Preprint submitted on 29 Mar 2017

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Discretization of space and time: determining the values of minimum length and minimum time

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Abstract

Assuming that space and time can only have discrete values, we obtain the expression of the minimum length and the minimum time interval. These values are found to be exactly coincident with the Planck's length and the Planck's time but for the presence of h instead of \hbar .

1. Introduction

Let's assume, as work hypothesis, the existence of both discrete space and discrete time, namely spatial and temporal intervals not further divisible; this assumption leads to some interesting consequences. Here we find that the values of the minimum length and of the minimum time interval are (almost) coincident with the Planck's length and the Planck's time. The only difference is that in Planck's units appears the term \hbar , while in this discrete context appears h .

So, if we suppose that neither space nor time are continuous, but that instead both are discrete, and following the terminology used in a previous document^[1], we call l_0 the fundamental length and t_0 the fundamental time.

2. Obtaining the values of l_0 and t_0

If we insert, in the graph of the figure here below, all bodies arranging them according to their mass and their radius (assuming that they are spherical), we would have a distribution rather varying because in general there is not a precise relation between the mass of a body and its size: different bodies can have very different densities so they can be distributed very widely in the below figure.

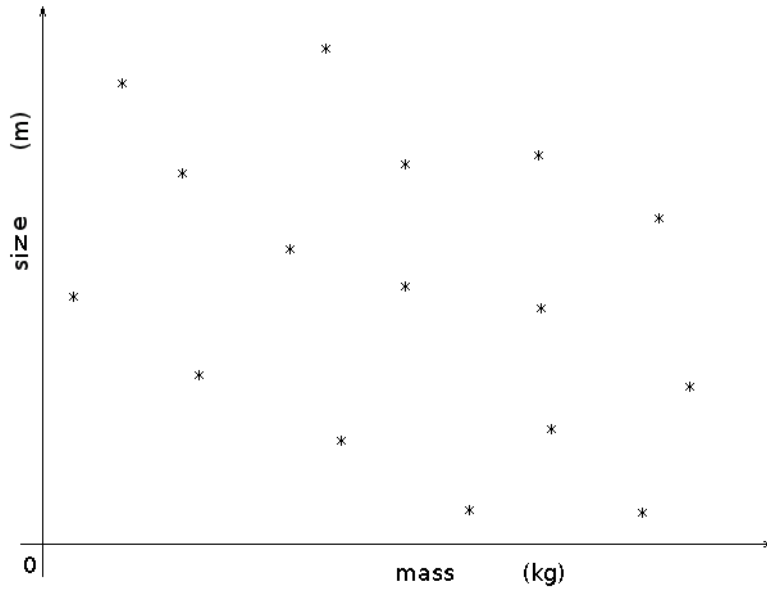


Fig. 1

However, there are bodies for which this relation is known: they are the black holes, whose relation between radius and mass, obtained in a previous document^[2], is shown here:

$$d = \frac{GM}{c^2} \quad (1)$$

where d is the radius of the black hole of mass M .

Let's insert Eq. (1) in the figure here below: it must be said that the actual inclination of the line has been greatly increased for representative reasons, because it is so small that the line itself would be visually indistinguishable from the axis of abscissas.

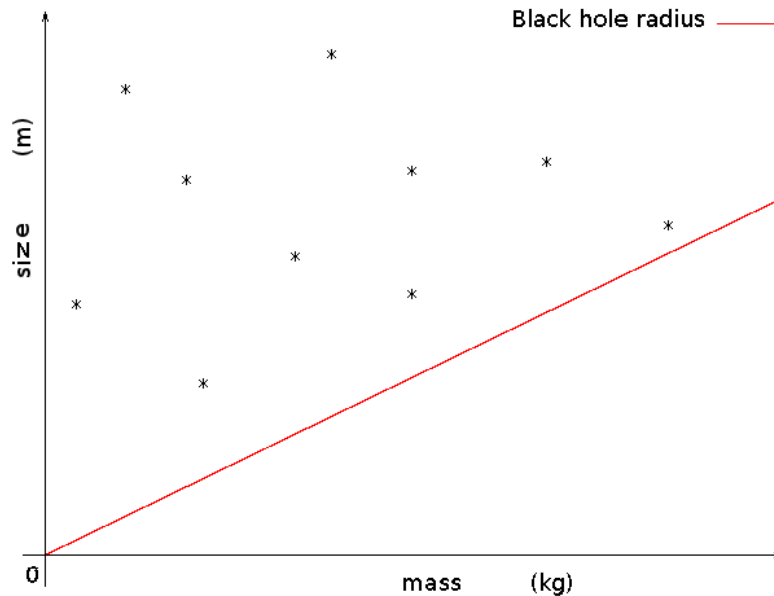


Fig. 2

The ray, that indicates the line on which are located the black holes depending on their mass, splits the quadrant into two zones. The top section contains the bodies (almost all, given the actual inclination of the line) whose size is greater than the size of the black hole of equal mass.

The lower section is empty because we have already found^[2] that the black hole is the most compact object for a given mass: so no object can have radius shorter than the radius of the black hole, and no object can be represented below the line.

There is another length related to the mass m of a body: the Compton wavelength, already met in a previous document^[1]:

$$\lambda_c = \frac{h}{mc} \quad (2)$$

If we trace this function on the same graph, we get the figure here below: also in this case, for clarity, the correct proportions have not been respected.

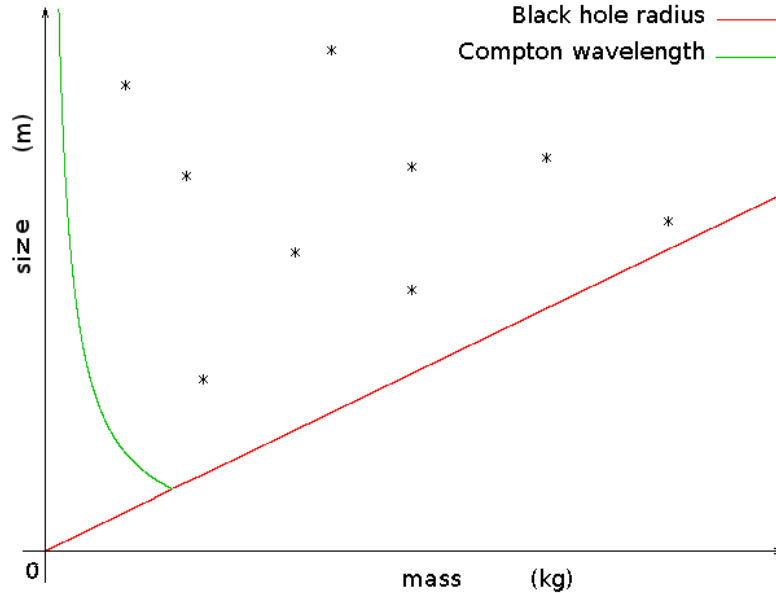


Fig. 3

The function that describes the Compton wavelength intersects the line identifying the radius of the black hole at a precise point; but, as explained above, in the area below the ray can not exist objects of any kind; then the point of intersection of the two functions is both the upper limit for the mass to which can be associated the Compton wavelength, and the lower limit for the wavelength itself.

It has already been obtained^[1] that in the equation of the Compton wavelength there is a maximum value for the mass an object can have:

$$m_{max} = \frac{h}{l_0 c} \quad (3)$$

At this mass corresponds the minimum wavelength, that is the minimum length l_0 .

But also for a black hole it has been already obtained^[4] that there is a lower limit for the mass:

$$m_{min} = \frac{l_0 c^2}{G} \quad (4)$$

At this mass corresponds the minimum radius for a black hole, that is again the minimum length l_0 .

Of course it means that the minimum mass for a black hole and the maximum mass that can be associated to a wavelength are equal.

In the figure below is represented this situation.

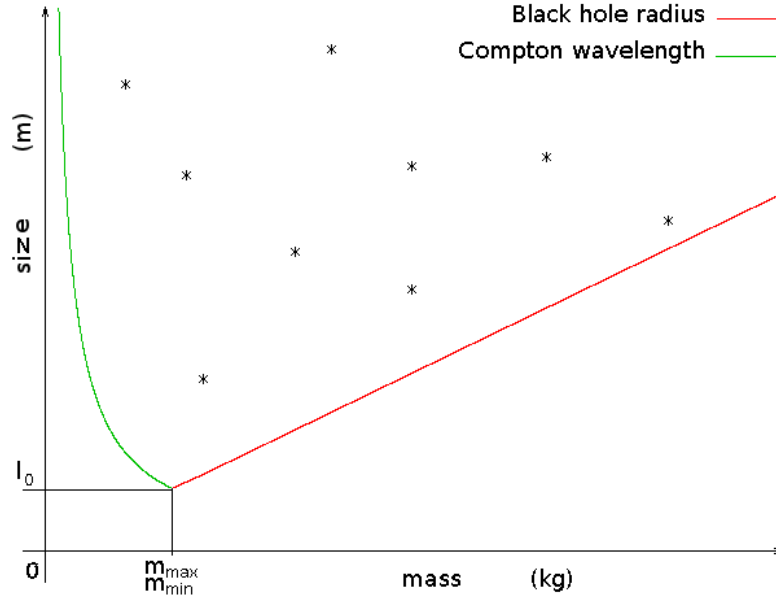


Fig. 4

Being $m_{max} = m_{min}$, from Eq. (3) and Eq. (4) we have:

$$\frac{h}{l_0 c} = \frac{l_0 c^2}{G} \quad (5)$$

from which we obtain:

$$l_0 = \sqrt{\frac{hG}{c^3}} \quad (6)$$

that coincides with the Planck's length exactly but for the presence of h instead of \hbar . Substituting the values of h , G , c , we have $l_0 \sim 4.0 \cdot 10^{-35} m$. This is a very little value. We have already obtained^[1] that $t_0 = l_0/c$, so we have also

$$t_0 = \sqrt{\frac{hG}{c^5}} \quad (7)$$

that coincides with the Planck's time exactly but for the presence of h instead of \hbar .

Substituting the values of h , G , c , we have $t_0 \sim 1.3 \cdot 10^{-43} s$. Also this is a very little value.

At this point we can also obtain the value of m_{max} , equal to the value of m_{min} ; for coherence of notation we denote it by m_0 . It is:

$$m_0 = \sqrt{\frac{hc}{G}} \quad (8)$$

that coincides with the Planck's mass exactly but for the presence of h instead of \hbar .

Substituting the values of h , G , c , we have $m_0 \sim 5.0 \cdot 10^{-8} kg$. This, instead, is not a very little value.

This is not the first time (see for instance this document^[3]) that the Compton wavelength and the black hole radius are equalized to obtain the Planck's length, but I think that this theory follows a more natural approach.

So, m_0 is the lower limit for the mass of a black hole: this discrete theory prohibits the existence of black holes with smaller mass. We have already seen^[4] that m_0 is the validity limit for General Relativity. But m_0 is also the maximum value of the mass of a body to which can be associated a wavelength: this discrete theory states that this is the upper validity limit of wave and quantum mechanics.

The fact that these two limits coincide implies that, in a discrete context, quantum physics and General Relativity operate in different domains, without any possibility of intersection: where we can apply the one, the other can not be applied; and vice versa.

This theory of discrete not only justifies the difficulties that are met trying to reconcile quantum mechanics and General Relativity, but, by establishing the same insuperable limit for both, states that it is not at all possible.

3. Conclusion

Assuming that space and time can only have discrete values, we obtained the values of l_0 , t_0 and m_0 that coincide with the correspondent Planck's units but for the presence of h instead of \hbar . We have also shown that quantum mechanics and General Relativity operate in completely separated domains.

References

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