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# **A property of the space-time: space-time occupied by a particle is an inverse function of its mass**

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## **Abstract**

There are two great theories in physics: the theory of relativity which studies large scale phenomena (planets, stars, galaxies...). And quantum theory which studies the behavior of elementary particles and atoms, i.e. very small scale phenomena. These two great theories contradict each other in the space-time description. However, these two great theories and some theories that are trying to merge them are concordant that space-time no longer constitutes a simple inert screen on which natural phenomena are projected. This unanimity should encourage to explore more advantage the fundamental properties of space-time. Also, on the basis on the observations that quantum mechanics shows that the electron seems to follow several trajectories simultaneously and the theory of relativity which shows that the trajectory of a planet is very well defined, we postulate the following principle: *In a space-time, the smaller the mass of a particle is, the bigger the space-time occupied by the particle is.*

Example if we consider three particles without internal structure of sizes of an electron, a tennis ball and the planet earth, respectively. With this principle, one can say that the electron particle occupies more space-time than the tennis ball, which itself occupies more space-time than the planet earth particle.

This occupied space-time principle raises a number of questions. Most significantly is it compatible with the inertial mass and gravitational mass and how do interactions (weak, strong, electromagnetism and gravitational) influence this principle. An initial analysis indicates the compatibility between the principle and the inertial or gravitational masses and de Broglie's

hypothesis. The question of the influence of interactions (weak, strong, electromagnetism and gravitational) on this principle remains central. If these influences are proven and of the same order of magnitude, then they can constitute a fundamental basis for a merger of these interactions.

## Introduction

Space-time is the fundamental basis of Science. That they were the humanities and social sciences (history, sociology, psychology ...) or the exact sciences (mathematics, physics, chemistry ...). The phenomena or laws that locate or predict these sciences are projected in space-time. The latter is no doubt fundamental in physics that studies the external world and the laws of its variation and evolution in space and time. Specifically, there are two great theories in physics: quantum theory and the theory of relativity.

Quantum theory studies the behavior of elementary particles and atoms, i.e. very small scale phenomena [1] (Mehra & Rechenberg, 2002). The theory of relativity studies large scale phenomena (planets, stars, galaxies...) [2] (Hobson et al. 2010).

Although these two great theories have each been confirmed by experimental studies, nevertheless, they are not compatible. They contradict each other in the space-time description. The theory of relativity considers a space-time continuum, i.e. continuous, smooth but deformable while quantum theory predicts a space-time foam. This glaringly contradiction or incompatibility may legitimately lead to think that these two theories cannot both be just. However, great theories as relativity and quantum mechanics that on the one hand have repeatedly been verified by many measurements and observations: [3-8] (Bohr 1913; Bohr 1913; Compton 1923; Aad et al. 2012; Chatrchyan et al. 2012; Bevan et al. 2014) for quantum theory and [9-12] (Dyson et al. 1920; Pound & Rebka 1959; Hulse & Taylor 1974; Abbott et al. 2016) for theory of relativity. On the other hand, these theories are at the base of the significant progress of science (for quantum theory: nuclear energy, Magnetic Resonance Imaging, integrated circuit, laser... and for theory of relativity: Global Positioning System, CRT screen, electricity generators...). Therefore, these theories can by no means be false, at worst, they can only be insufficient as Rutherford-Bohr model, Galileo-Newton's mechanics and special relativity have been before.

Nevertheless, the incompatibility between the theory of relativity and quantum mechanics must lead to question on the conception of space-time of these two theories. Also, our understanding of space-

time deserves to be better investigated. Thus, this is logically that some theories, Loop Quantum Gravity and String Theory that are trying to merge quantum mechanics and the theory of relativity, explore the conception of space-time. These theories explore particularly the structure of space-time: with Loop Quantum Gravity who tries to get rid of the time and, most importantly, that space presents a discrete structure [13, 14] (Rovelli 1998; Rovelli 2015). String Theory assumes the existence of the multiple universes and included especially more than 4 dimensions [15, 16] (Tong 2009; Greene 2000).

Almost all the theories (theory of relativity, quantum mechanics, loop quantum gravity, string theory) are concordant that space-time no longer constitutes a simple inert screen on which natural phenomena are projected. The unanimity shown by these models, on this property of space-time, is experimentally highlighted within the scope of validation of the general relativity [9, 12] (Dyson et al. 1920; Abbott et al. 2016). This evidence should encourage to explore more advantage the fundamental properties of space-time.

One of the primary questions, raised by the absorption and emission of light by matter, is to understand the process that gives a color to objects. It is a fact that if an object appears of green color, it is because the whole spectrum of visible light is absorbed by the matter except for the green part which is reflected. So the colour perception of objects is strictly virtual. And if the space perception occupied by objects is also strictly virtual: i.e. between three particles without internal structure of sizes of an electron, a tennis ball and the planet earth, which actually occupies more space ?

The main objective of this present paper and to postulate a principle which defines the space-time occupied by a particle as a function to its mass. This principle may appear as a property of space-time.

## Occupied space-time principle

On the basis on the observations that quantum mechanics shows that the electron seems to follow several trajectories simultaneously and the theory of relativity which shows that the trajectory of a planet is very well defined, we postulate the following principle:

*« In a space-time, the smaller the mass of a particle is, the bigger the space-time occupied by the particle is »*

Example if we consider three particles without internal structure of sizes of an electron, a tennis ball and the planet earth, respectively. With this occupied space-time principle, one can say that the electron particle occupies more space-time than the tennis ball, which itself occupies more space-time than the planet earth particle.

This principle raises a number of questions:

- ✓ The inverse function is of what type: proportional, polynomial, exponential...?
- ✓ How is the structure of this space-time occupied: is it a space-time with more than 4 dimensions, a space without time, a time without space, a zone without space-time...?
- ✓ By which process the mass occupies the space-time, is it by the support of a field...?
- ✓ Is it the inertial mass, gravitational mass or another form of mass?
- ✓ This principle, is it compatible with the inertial mass and gravitational mass?
- ✓ How do interactions (weak, strong, electromagnetism and gravitational) influence this principle?

The question of the influence of interactions (weak, strong, electromagnetism and gravitational) on this principle remains central. If these influences are proven and of the same order of magnitude, then they can constitute a fundamental basis for a merger of these interactions. But the compatibility

between this principle and the inertial and gravitational masses remains the primary question to be explored.

The occupied space-time principle affirms that the smaller the mass of a particle, the bigger the space-time occupied by the particle is. As a result, the particles of very small size, especially at the atomic and subatomic scale (elementary particles, atoms...), occupy more space-time than particles comparable to a material point (cartridge, tennis ball, star...).

It can be stated that, the space-time in which the atomic and subatomic particles manifests itself, is bigger than that in which the particles described by a material point manifests itself. So, it takes more space-time to properly identify the atomic and subatomic particles that it is necessary to properly identify the particles described by a material point.

After all, as the space-time occupied by a particle is an inverse function to its mass, on the one hand, it is possible for a particle, with a very small mass, to occupy sufficient space-time for an investigation on the particle depends, in whole or in part, on the space-time occupied. On the other hand, a particle can have enough mass to occupy a sufficiently small space-time and be very well localized. Thus, it can be assumed that an investigation on the particle is independent, in whole or in part, of the space-time occupied.

### **Compatibility with the inertial mass**

The inertial mass is a property of matter which manifests itself by the bodies's inertia. In an inertial movement of a particle case, if an investigation on the particle depends, in whole or in part, on the space-time occupied, only a wave approach will allow to properly identify the space-time occupied by the particle. This conclusion that some particles behave as a wave, is in perfect agreement with the experimental observations and the theoretical models which show that, in an experiment where the energy of the particles is conserved, the atomic and subatomic particles (atoms, elementary particles ...) behave like waves.

In the case where the particle can have enough mass to occupy a space-time sufficiently small and to be very well localized. Thus, at any moment, the position of the particle can be determined in an inertial movement case. Also, this conclusion is in perfect agreement with the experimental observations and the theoretical models which show that particles described by a material point have a trajectory well determined.

If we consider a particle of mass  $m$  which moves at nearly the speed of light, the special relativity shows that an increase of the particle energy leads to an increase of its relative mass. The theory shows above all that the space of the particle contracts. Thus, we have the mass of the particle that increases and the space occupied by the particle contracts which is in agreement with the principle.

### **Compatibility with the gravitational mass**

The gravitational mass is a property of matter which manifests itself by the universal attraction of bodies.

General relativity states that the gravitation is not a force but the manifestation of the curvature of space-time. This curvature is due to the distribution of energy, in the form of mass or kinetic energy. The occupied space-time principle states that the space-time occupied by a particle is an inverse function to its mass. As a result, the atomic and subatomic particles manifests itself in a large space-time and an investigation on these particles depends on this space-time. As a consequence, the distribution of the atomic and subatomic particles energy is more spatial, i.e. a very low energy density, and therefore a lower curvature. However, the material point particles manifest itself in a very small space-time and are well localized. So, the distribution of the material point particles energy is more concentric, i.e. a very high energy density, and therefore a higher curvature.

If we consider two particles of mass  $m_1$  and  $m_2$ , with  $m_1$  greater than  $m_2$  ( $m_1 > m_2$ ). The principle says that the mass particle  $m_2$  occupies more space-time than  $m_1$ . Assuming an interaction



between  $m_1$  and  $m_2$  leading  $m_1$  to acquire an energy from the  $m_2$  mass. And that the interaction process occurs through an exchange of a mediator or interaction vector. This exchange of energy results in a variation of masses  $m_1$  and  $m_2$ . And appear as an interaction between two new particles of masses  $m_1 + dm_2$  and  $m_2 - dm_2$ . With the principle, the particle of mass  $m_1 + dm_2$  will occupy a space-time smaller than that of  $m_1$ . And the particle of mass  $m_2 - dm_2$  occupies a space-time greater than that of  $m_2$ . Also, the curvature of the space-time due to the mass  $m_1 + dm_2$  is stronger than that due to  $m_1$ . This variation of the curvature, i.e. an increase in curvature around  $m_1 + dm_2$  and a decrease in curvature around  $m_2 - dm_2$ , can accelerate the interaction between  $m_1 + dm_2$  and  $m_2 - dm_2$ . And if the interaction between the particles continues at the end there will remain only a particle of mass  $m_1 + m_2$ , which will occupy a space-time smaller than occupied both masses at the beginning. In addition, a much stronger space-time curvature around  $m_1 + m_2$ .

### **Compatibility with the de Broglie hypothesis**

By identifying the velocity of the particle at the group velocity of the wave, as well as their energy, de Broglie proposes to associate to material particles a wavelength. This hypothesis leads to a relation of proportionality between the momentum and the wave vector for a particle. The equation shows that the wavelength will be greater if the mass is smaller. That is the smaller the mass of the particle is, the larger the space in which the associated wave manifests itself is. Thus, the occupied space-time principle, which predicts that: the smaller the mass of a particle is, the bigger the space-time occupied by the particle is, is in perfect agreement with de Broglie's hypothesis.

## Conclusion

A principle which defines the space-time occupied by a particle as an inverse function to its mass is postulated.

The predictions derived from this principle concerning the behavior of inertial or gravitational masses are in agreement with the experimental observations and the theoretical models. They show above all the compatibility between the principle and the inertial or gravitational masses.

It can be concluded that, the principle that the space-time occupied by a particle is an inverse function to its mass is an intrinsic properties of the space-time.

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