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The publication of general relativity theory completes a hundred years

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Abstract
In March 1916, the physicist Albert Einstein published his most famous work: the General Theory of Relativity [1]. Einstein presented his theory on 25 November 1915 at the Prussian Academy of Sciences; however, the document was published only in 1916 in Annalen der Physik journal. It was after the publication that this theory had worldwide repercussions. This study focuses on some details of Einstein's life and his two scientific theories: relativity (or Special) and General Relativity. The first was published in 1905, completing previous studies of the Dutch physicist Hendrik Lorentz, while the second is the generalization of Newton's gravitation theory. It takes into account the findings ideas on relativity of space and time and proposes a generalization of the principle of relativity of motion for systems that include gravitational fields.

Keywords: Einstein, relativity, gravitational fields

1. Introduction

Einstein was born in Ulm, Germany on 14 March 1879, the first of two sons of Hermman Einstein and Pauline Koch [2]. When he was five years before starting their school life, Hermman showed Einstein a pocket compass, object that caused him a deep impression, which he described as "miracle": "the pointer, no matter the position in which the compass was placed, always returned to point to the north." He spent his youth in Munich, and from an early age showed a brilliant curiosity about nature, and an ability to understand advanced mathematical concepts. As Einstein was 15, his family moved to Milan, Italy, where he spent a year with his family and then moved to Arrau, Switzerland, where he finished high school. In 1896, he entered the Polytechnic of Zurich graduating in 1901, where he worked as a tutor and substitute teacher. In 1902, he secures a position as examiner at the Swiss Patent Office in Bern. According to MICHIO [3] in 1905, the world learned of his existence through the publication of five articles in Annalen der Physik, German scientific journal. In the same year, he received his PhD degree from the University of Zurich for a theoretical dissertation about the dimensions of molecules, and published three theoretical papers of great importance to the development of physics in the 20th century. In the first of these papers, on Brownian motion, he made significant predictions about the motion of particles randomly distributed in a fluid. Experiments later confirmed such predictions. The second work on the photoelectric effect contained a revolutionary hypothesis concerning the nature of light. The great Einstein´s third work, in 1905, "On the Electrodynamics of Moving Bodies", contained what became known as the Special Theory of Relativity. Einstein then developed a theory based on two postulates: the Relativity Principle, that physical laws are the same in all inertial frames, and the principle of invariance of light speed, where the speed of light in vacuum is a constant universal.

Some Aspects of the Theory of Relativity

In the opinion of BERTOLAMI [4] it is important to point out that the repercussions of Einstein's 1905 work was not just a genius of expression, as well as to provide key developments in physics in the nineteenth century. The basic concepts of the theory of relativity can be found in any book of Basic Physics for graduation, such as in TIPLER [6] and HALLIDAY [7]. Initially we will introduce a first postulated that concerns the fact that the laws of physics are the same in all inertial reference frames. The second assumption states that the light in vacuum propagates with a certain speed, regardless of the state of motion of the light source. In fact, these concepts are based in absolute space and absolute time that have no meaning in the theory of relativity and should therefore revise, for example, the concept of simultaneity. Every measure of time is based on a concurrency check. Finally, we can summarize that special relativity theory was based on two main assumptions: first, that the speed of light is constant for all observers; and second, that observers moving at constant speeds should be subject to the same physical laws. Following this logic, Einstein theorized that time should change according to the speed of a moving object relative to the reference frame of an observer. The essence of Einstein's work is that time and space are relative, rather than absolute, that is, the flow of time is different for different observers. The time depending on the movement received the name of time dilation [7] and says that time passes more slowly for objects moving at high speeds, as shown in Equation 1.

Equation 1

$$\Delta t = \frac{\Delta t_p}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Where Δt_p is the proper time interval, measured by a clock at rest in relation to the ship, moving with velocity v and, Δt the time interval measured by the clock moving towards the ship

(person on earth) and, c the speed of light in vacuum. Note: Δt_p is always less than Δt.
To show how it works, LASKY [5] uses the example of a fictional space travel, in a text called the twin paradox. In this supposed paradox, one twin travels almost at the speed of light to a distant star and back to Earth. According to the theory of relativity, when the traveler twin comes back, he is younger than his identical twin who remained here. The relative movement of the twins should not allow the aging of one in particular, since, for each, it seems that the other moves away with velocity v. Note that for speeds comparable to our day-to-day effects of relativity theory are insignificant.
The solution: the relative movement is not symmetrical, since the twin on the rocket undergoes accelerations, which does not happen with the twin "on Earth." To explain this fact it is said that the brother who feels the acceleration is the younger, so the brother who travels to the star is younger when returns.
Another consequence of Einstein's theory for relativity is the LORENTZ [8] contraction, where the length of a moving bar is smaller than the length of the rod at rest. We can convince ourselves of the reality of contraction of lengths from the acceptance of the postulate of the invariance of the speed of light. A closely phenomenon associated with dilation of time is the contraction of distances. It is denominated own length the length of an object in the frame in which the object is at rest, represented by the symbol L_o. In a frame in which the object is moving, the length L in the direction of movement is always less than the actual length, as shown in Equation 2.

Equation 2

$$L = L_o \cdot \sqrt{1 - \frac{v^2}{c^2}}$$

In fact, the length contraction, in special relativity, comes up as consequence of that all observers in relative uniform motion should measure the same value for the speed of light. It occurs only to an observer that measures the length of a moving bar, depending on the value of contraction of speed for the bar that moves towards him, because the contraction [7] is relative. As shown L_o will be always greater than L. This phenomenon was named the Lorentz - Fitzgerald contraction, a tribute to the physical George Francis FitzGerald (Ireland, 1851-1901) and Hendrik Antoon Lorentz (Netherlands, 1853-1928), who proposed the relationship [1] before Einstein.

Considerations on General Relativity

Einstein in 1916, ten years after the publication of Special Relativity published the general theory of relativity. Einstein presented his theory on 25 November 1915 at the Prussian Academy of Sciences, and the official document was published in March 1916 in Annalen Der Physik journal, one of the most important journals of the time. In some articles, he shows how matter and energy are intertwined, as well as space and time are unified. In March 1916, the German magazine circulated with the second part of the study of the physical, called the General Theory of Relativity. According to PEDUZZI [10] certain inconsistencies were observed, such as the famous "Mercury's orbit perihelion advance", which was not explained by the application of gravitation theory proposed by Newton. Einstein addresses the problem, starting from different assumptions than those used by the Newtonian Theory of Gravity. Without that into detail, the approach developed by Einstein, the space itself and time itself are affected by the presence of matter and energy. This theory developed by Einstein [6] is known as Theory of General Relativity. According to this theory, the presence of mass curves space (and affects the time, so that the description is made jointly, using the so-called "space-time"), and secondly the masses moving in the second space trajectories that are affected by the curvature of space. In many situations the calculations made with General Relativity lead to results that coincide quantitatively with very good approach, with results obtained using the theory of gravitation Newton. In the theory Einstein extends the description of physical phenomena not inertial systems (i.e. accelerated). The Equivalence Principle [6] posits that it is impossible to distinguish the systems uniformly accelerated gravitational fields. The two main consequences of this principle are the bending of light by gravitational field and the offset frequency (and thus changing the energy) photons in gravitational fields. Einstein introduced the general theory of relativity, according to which space is curved, distorted by the presence of bodies with huge masses like stars and planets. Both predictions were confirmed experimentally innumerous times. Another important result of general relativity was the explanation of the precession of the perihelion of Mercury. By including gravitational fields, general relativity has become a gravitation theory, perfecting Newtonian gravitation that existed 300 years ago. The generalization of Special Relativity [8], the General Theory of Relativity in 1915, is possibly one of the most elegant theories in all of physics, and replaces the concept of gravitational force of Newton by the deformation of the notion of space-time caused by the raw energy. It was necessary to generalize it, because when we speak of gravitation, we speak of accelerated bodies, if not contemplated by the theory of relativity, which deals only with inertial frames. That is, general relativity [7] is a continuation of Special Relativity, containing the generalization of Newton's gravitation theory. The new theory takes into account the ideas discovered in restricted relativity of space and time and proposes a generalization of the principle of relativity of motion for systems that include gravitational fields. Einstein's work was to obtain a set of nonlinear equations, known as Einstein's equations for the gravitational field, which related the curvature properties of space-time at each point to the amount of matter and energy present there.
The general theory of relativity (GTR) is a relativistic theory of gravitation. What Einstein understood to be able to include gravity in the theory of relativity is that gravity is equivalent to acceleration. Einstein called it the principle of equivalence. British astronomer Arthur Eddington led the first great experience that serves to confirm the assumptions of general relativity in 1919. During a solar eclipse, he noted that, as the theory predicted, the mass of the sun made the light coming from the stars behind him to bow. It has been proven that a large object could warp space-time, and even the light had to swerve to follow the new geometry.

Gravitational Waves

Scientists announced on 09.14.2015, the first detection of gravitational waves, a phenomenon predicted by physicist Albert Einstein [11] for exactly one hundred years, but had never been observed through a concussion in space and time was caused by collision black holes, which revolved around each other and collided. The discovery is important because it consolidates Einstein's theory and because astronomers can now study some phenomena that are not visible by light. The theory of general relativity gravity distorts space and time, and when there is an interaction of very massive objects, for which the force of gravity is too large, they produce waves that propagate in space. Gravitational waves are for gravity as light, an electromagnetic wave, is to magnetism and electricity. These gravitational waves, however, are tiny, with thousandths of a millimeter, requiring therefore a great and special detection system, consisting of interferometers, which are sets of mirrors and optical filters dodging laser beams to a detector. The components of each interferometer are away for another 4 km away, a tiny vibration in the mirrors makes the laser frequency is misaligned, revealing the effect of gravitational waves on these objects. Now we have the possibility to observe the sky with gravitational waves, not only electromagnetic waves, a fact that opens the phenomena discovery perspective previously invisible to astronomers.

Final Considerations

The contributions of the German Albert Einstein (1879-1955) in the various branches of physics and its repercussions in technological applications are so numerous that hinder the preparation of a text like this. If the selection criteria is very flexible, we will get virtually all areas of knowledge. There are direct applications of these theories in such things as gravitational lense [9], which are distortions in space-time caused by the presence of extremely massive bodies, such as galaxies, which distort the space around it so that less massive objects and much more distant that are behind them, from our point of view, can be observed. This is how to detect the most distant galaxies in the universe, quasars. The observation of some stars who stands behind other stars in our own galaxy from Earth's point of view, or planets that orbit can also be detected by so-called gravitational microlensing, which use the same principle derived from general relativity. In the case of relativity, one can list applications in particle physics field, as the particle accelerators (like for example the Large Hadron Collider - LHC) subatomic particles are accelerated to near the speed of light, then relativistic effects such as the dilation of time must be taken into consideration. In more everyday situations, there are in fact many applications for these theories, but interplanetary travel or even interstellar only will one day be possible by the time dilation predicted by relativity to bodies traveling at close to the speed of light. Therefore, although there are many everyday applications currently in the near future they certainly will have great influence in our lives.

The GPS [10] devices are already quite popular today and are present in most smartphones. However, did you know that the effects of relativity must be taken into account for its operation? Our GPS location is calculated with the response time between the satellites that orbit the Earth and our devices. The problem is that these satellites are at a height of 20,000 kilometers above the Earth and suffer much lower gravity effects for the ground stations and tracking devices. Add to that the movement speed of 10,000 km/h from orbiting satellites and as a result, we have about seven microseconds difference for us. It may seem little, but this time change involves a 10 km difference in the location of your GPS daily. Therefore, all devices in space have accurate chronometers that adapt to time on Earth. In particular, among its grandiose developments, the general theory of relativity led physicists [11] to discover the possibility of bodies capable of generating such intense gravitational fields, and thus bend so sharply the space around which the light emitted they describe a trajectory curve enough not be away from the body. Thus, given the impossibility of being hit by the light emitted by them and consequently of seeing them, these bodies, characterized by their extremely high densities were called black holes.

References

1. Einstein A. Die Grundlage der allgemeinen Relativitätstheorie, available in http://myweb.rz.uni-augsburg.de/~eckern/adp/history/toc/1916_49.pdf, acess in 20/12/2015
2. Brennan R. Gigantes da Física. Uma história da física moderna através de oito bibliografias. Rio de Janeiro: Jorfe Zahar Ed., 1998.
3. Kaku M. Albert Einstein German-American physicist, text available in http://www.britannica.com/biography/Albert-Einstein, acess in 20/01/2016
4. Bertolami O. Albert Einstein: o triunfo do intelecto Einstein entre nós: a recepção de Einstein em Portugal de 1905 a 1955. presented at the 2005. Coimbra, 2005. Available in <https://digitalis.uc.pt/handle/10316.2/32478> , acess in 25/01/2016
5. Lasky RC. The twin paradox, text available in http://www2.uol.com.br/sciam/artigos/o_paradoxo_dos_gemeos.html, acess in 10/12/2015
6. Tipler PA. Física Ed. Guanabara-Koogan S.A., Rio de Janeiro, 1995; 4:678-690.
7. Halliday, Resnick, Walker. Fundamentos da Física, Vol. 4, 8ª Edição, LTC, 2009.
8. Keller FG, Gettys WE, Skove Física EMJ. Ed. Makron, São Paulo, 1999, 2.
9. Serway RA, Jewett EJW. Jr. Princípios de Física, Ed. Prioneira Thomson Learning, São Paulo, 2004, 4.
10. Peduzzi Luiz OQ, A relatividade einsteiniana: uma abordagem conceitual e epistemológica, text available in http://www.if.ufrgs.br/~lang/Textos/Textos_Peduzzi, acess in 10/01/2016
11. Moskowitz C. Scientific American of Brazil, available in http://www2.uol.com.br/sciam/noticias/detectadas_ondas_gravitacionais_do_big_bang.html, acess in 20/02/2016