Concerning gravitational waves

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Abstract

A mathematical result opens the way to a unified theory of gravitational forces and electromagnetic forces, a pre-quantum physics accompanied by a return to determinism in physics. This approach is based on the idea that the neutrinos present more or less everywhere in space, constitute the ether, a discrete medium of propagation of electromagnetic waves and gravitational waves. Gravitational waves were observed for the first time in 2016. That observation supports these propositions.

1 Space-time and waves

Theoretical physics research aims to unify in a single theory the main aspects of both general relativity and quantum mechanics. The approach generally regarded as the most promising is that initiated by G. Veneziano, of string theory. The recent detection of gravitational waves seems likely to alter the current orientation of this research.

Why?

Because quantum mechanics is based partly on the theory of special relativity: in short, on the relativity principle put forward by Poincaré, [1], in 1904 and because general relativity, a misleading term, departs from that principle, basing itself on the principle of equivalence between gravitation and acceleration and constituting a gravitation theory that is not relativistic in Poincaré's sense. It is not invariant by a Lorentz's transformation. The detection of gravitational waves strengthens the credibility of general relativity as a theory of gravitation, suggesting a need to call into question the theory of special relativity and revise quantum mechanics accordingly.

There are two principles of relativity. According to the first of them, physical phenomena are not modified by a Galilean transformation and it is on this principle that rational mechanics, that of Newton, Lagrange and Jacobi, is based.

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According to the second principle, physical phenomena are not modified by a Lorentz transformation, and it is on this principle that the relativistic mechanics put forward by Poincaré, [2], as "new mechanics" and skilfully disseminated in Germany by Einstein in 1905 is based.

This second principle of relativity, which has replaced the first, arose from observation of electromagnetic phenomena. Poincaré, [1], proposed, as of 1904, to extend its validity to all physical phenomena including gravitational ones. In fact, these latter seem to be in line with general relativity, a validation that suggests abandoning this second principle of relativity and revising quantum mechanics accordingly.

Theoretical physics research today is not oriented in this direction but inspired by the idea that it is possible to use string theory to make the effects of gravitational interactions seem identical to those modelled by general relativity, over an extensive domain, say a domain outside Planck's length. The second principle of relativity is not abandoned, it is actually maintained. No-one today knows what the laws of physics are like in the immediate vicinity of a black hole, i.e. the singularity arising from the description of gravitational phenomena according to general relativity. Each black hole has an associated Schwartzschild radius, say a ball of light, but a light which, despite its speed, cannot escape from the ball, as if the ball marked the boundary of a finite space- time. A black hole is thus described as a ball of light that emits no light, like a runner who remains stationary when running on a treadmill that is travelling in the opposite direction.

Note: Hawking has since shown that a black hole does emit radiation by tunnel effect, but this radiation is so weak that the life of a black hole, through depletion of its mass by such emission, may be much longer than the age of 13 or 14 billion years currently attributed to the universe.

Sound waves are transmitted by a quasi- continuous medium, air. Electromagnetic waves have been supposed to be transmitted by a continuous medium called the ether, a hypothesis now generally dismissed for want of experimental evidence of such a medium.

Are gravitational waves transmitted by a continuous medium?

On the basis of a mathematical result, [3], we have proposed, [4], the existence of a universal cloud of tenuous particles that might take the place of the,ether to serve as a propagation medium for both electromagnetic waves and gravitational waves. The former would be "transverse" waves, the latter "pressure" waves.

Some indications about this appear below.

2 Existence of gravitational waves

A gravitational wave has been observed and this observation strengthens the validity of any theory of gravitation that takes the form of a set of partial differential equations allowing undulatory solutions, a set of equations associating a gravitational wave with an accelerated massive body, just as Maxwell's set of equations describing electromagnetic effects associate an electromagnetic wave with an accelerated electrical charge.

General relativity, today's reference theory of gravitation, is one such theory. In light of the history of science, it should be noted that Poincaré suggested as of 1905 various gravitation theories that involve the concept of "gravific wave". An extract from Poincaré's communication in Comptes rendus de l'Académie des Sciences, session of 5 June 1905, reads: "Thus when we talk of the position or speed of an attracting body, that position or speed will be at the moment where the gravific wave leaves that body;....". Thus, the concept of gravitational wave did not appear for the first time in 1915 with the publications of Hilbert and Einstein, but in or even before 1905. The effects of a gravitational wave, except in the case of a wave induced by a body of "great mass very greatly accelerated", are so weak as to be practically undetectable.

NOTE 1: This point may be illustrated by some figures.

Any two accelerated massive bodies, orbiting for example about one another, will emit gravitational waves. A player of the French bowls game pétanque moving his arms while holding a ball in each hand will emit a gravitational wave. The propagation of these waves weakens with distance and they induce, at a few metres, an oscillation of any relative measurement of length, of about ϵ.

The gravitational wave that has been detected arose from two masses far larger than a pétanque ball, each of them about 30 times the mass of the sun. Moreover, these two masses, each of high density, were orbiting one another at a short distance, a few tens of kilometres, at a considerable speed (nearly comparable to the speed of light). The two masses were therefore greatly accelerated. However, the wave was detected on earth, far away from the emission site, with the result that the detectable relative length measurement deviation ϵ was of the order of 10^{-20} or 10^{-21}. If the astronomical phenomenon that gave rise to this gravitational wave had occurred nearer to the earth, say at the confines of the solar system, it would have been easy to detect.

The gravitational wave emitted by a pétanque player induces at a few metres from him such a small relative deviation ϵ , of the order of 10^{-40}, as to be impossible today to prove its existence. ($\epsilon \approx a.b.c^2.d.e \approx 10^{-40}$,
with $a \approx 10^{-21}$, the relative deviation of length on earth induced by the gravitational wave observed, emitted a billion years ago by two black holes in close orbit;
with $b \approx 10^{-32}$, the ratio between the mass of a pétanque ball (0.7 kg) and 30 solar masses ($30.(2.10^{30})$ kg);
with $c \approx 10^{-7}$, the ratio between the orbital speed of a pétanque ball (5 metres per second) and the orbital speed of the two black holes;
with $d \approx 10^4$, the ratio between the orbital radius of the black holes and the height of a pétanque player;

with $e \approx 10^{23}$, the ratio between the distances from wave emitter to detectors, a billion light years relative to a distance of the order of a few metres.)

Electromagnetic waves are at human scale and therefore have innumerable applications. Such is probably not the case with gravitational waves.

NOTE 2: A distance that seems well defined is that between two parallel planar mirrors. However, a mirror consists of atoms and the distance thus defined seems to lose its significance at the level of a fraction of atomic radius. To improve accuracy, it is necessary to introduce an average distance that eliminates the atomic asperities. The mirrors of the most accurate interferometers are large enough to introduce Avogadro's number.

The experimentally observed gravitational wave, as modelled by general relativity, is a continuous phenomenon in terms of solving partial differential equations. On the contrary, we think that this wave is only the statistical appearance at the scale of observations, of an underlying discrete phenomenon.

3 Existence of waves Sound waves

The propagation of sound waves in air is likewise modelled by a set of partial differential equations. Observing these waves is easy because humans have an organ, the eardrum, that is specifically sensitive to waves from an emitter such as the diaphragm of a loudspeaker. A wave is an air pressure oscillation that propagates progressively from the emitter, in the respective "continuous" medium, the air, air modelled by an equation of state, Mariotte's law.

This modelling of sound waves is very precise and makes it possible to analyse sounds by breaking them down into elementary sounds, each characterised by a frequency.

However, no-one today still contests the atomistic hypothesis that air is not a continuous medium but a discrete medium consisting mainly of atoms of nitrogen and oxygen. Thus, the eardrum is not impinged upon by a wave but by collisions of atoms. The diaphragm of a loudspeaker does not move in a continuous medium but in a discrete medium, and its alternating movements modify the distribution of the speeds of different atoms. Avogadro's number is necessarily involved in the analysis of their distribution.

In the absence of any noise such as sounds, the speeds of the atoms will be disorderly and the eardrum is insensitive to disorderly collisions. The internal movements of a diaphragm induce, in the motions of atoms in contact, a degree of orderliness that is transmitted progressively by contacts between neighbouring atoms; thus the approximate description of these motions of atoms is most conveniently expressed by grouping into waves so as to eliminate the atomic disparities. A wave will retain an overall motion and eliminate the specificities of individual collisions; it has no physical existence but is an excellent means of approximate description. The eardrum is an integrating organ that picks up the signal carried by the wave and disregards disorderly atomic collisions.

Electromagnetic waves and gravitational waves

Assuming that waves are propagated in a continuous medium means having to look for their medium of propagation, like air in the case of sound waves. The medium for electromagnetic waves, in particular for light, is called the "ether" but its existence has not been experimentally proved. This leads to contesting its existence and the need for it by a certain revision of the concepts of time and space.

More precisely, this revision is as follows:

before revision, the physical principle adopted is that of relativity on which rational mechanics is based and, according to which, no physical phenomenon is modified by a Galilean transformation. After revision, the physical principle adopted is that of relativity on which the new (so-called relativistic) mechanics is based and according to which no physical phenomenon is modified by a Lorentz transformation.

This Lorentz transformation entails the existence of a speed, denoted c, which physics interprets as the speed of propagation of electromagnetic waves. This revised principle of relativity thus makes it pointless to seek a speed of propagation of electromagnetic waves via the properties of a propagation medium, an ether.

Quantum mechanics today is based partly on this revised principle of relativity which, structurally, has nothing to do with gravitational effects.

If a gravitation theory is firstly, based on the revised principle of relativity, secondly, allows gravitational waves as a solution and thirdly, dismisses any specific medium of propagation of those waves, then their propagation speed will be c, but, by what miracle can the revised principle of relativity, which is independent of any mass, provide a description of gravitational effects between masses?

The gravitation theory, known as general relativity, is not based on the revised principle of relativity but on the structure of a Riemann space whose geodetics would be the trajectories of any test body in free fall. General relativity, as has been shown by A. Friedmann, is not based on a transformation constituting a group, such as the Lorentz transformation.

As quantum mechanics is based on the revised principle of relativity, from which general relativity departs, these two theories are mutually incompatible. They are also incompatible for a second reason which is still more important and more commonly cited, namely quantification itself.

4 Gravitational waves

A gravitational wave has been observed but there has been no proof of a specific propagation medium for such waves.

General relativity is a model based on differential equations that involves the concept of the continuous, the concept of a real number. In fact, the discovery of the quantum by Planck and the success of quantum mechanics suggest that the continuous does not exist in physics. The concept of a real number would be a mathematical concept with no physical existence. This suggests the existence of a discrete medium of propagation of gravitational waves, a universal cloud of tenuous particles, denoted U, each of them being of very small mass. The gravitational attraction between two electrically uncharged massive bodies would be due to a screen effect in that cloud.

The electromagnetic interaction between two charged bodies would likewise be due to a screen effect in the cloud.

It is this "statistical ether", common to both electromagnetic waves and gravitational waves, that would explain the propagation speed of these waves being the same, c. Electromagnetic waves would in a certain respect be "transverse" waves, gravitational waves would be "pressure" waves. The mass of any particle other than a U particle, other than an interaction particle, would be related to a train of U particles forming part of its structure. This train would depend on the speed of the particle's transit through the cloud, and hence the mass of a particle would depend on its speed. Any principle of relativity is thus nullified; more precisely there is, for any relativity principle, a realm of invalidity.

Note: the train might also depend on the numerical density per unit volume of U particles in its vicinity, which might itself depend on the universe zone concerned (galactic, intergalactic etc.). The far universe, distant in time and space, still remains partly mysterious. In this respect there is nothing universal, neither universal time nor invariant physical constants, whatever their nature. The realm of physics cannot reach boundlessly beyond the realm of observations. Attributing both gravitational and electromagnetic interactions to a screen effect results in their non-existence in that their status is that of a temperature, i.e. a statistical property (not scalar like a temperature but vectorial) acquired by moving from fine description to statistical description. Thus, the photon would not exist but the U particle would. The eye would be a detector not of U particles but of orderly groups of U particles, groups described by the properties of a photon or a light wave. Other orderly, but practically undetectable, groups would be gravitational waves.

NOTE: Let there be a location where it is proposed to detect, at a particular moment, either electromagnetic waves or gravitational waves. Let us specify the location as a small sphere and the moment as a brief interval of time. At pre-quantum scale we shall observe that the location has a large number of U particles passing through it in that interval of time. If the distribution of these transits, in position and direction, is perfectly disorderly, no wave will exist in that location at that moment. If the transits exhibit, within the respective interval of time, a certain orderliness, a periodicity, in their positions on a particular meridian section of the sphere, this reduction of disorderliness will be characteristic of a wave. A reduction of disorderliness affecting the positions of transits in substantially the same directions will indicate a "transverse" wave.

A reduction of disorderliness affecting a certain weighted sum of transits from one side to the other of a meridian plane, from one interval of time to the next, will indicate a "pressure" wave. The distribution of the U particles is partly ordered by waves, and the orderliness induced by electromagnetic waves may be revealed at each moment, whereas the orderliness induced by gravitational waves involves integration over successive intervals of time. The frequencies of electromagnetic waves may be high, those of gravitational waves are necessarily limited to a few tens of hertz.

For example, the photon becomes a vectorial statistical indicator, with a status comparable to that of a temperature, i.e. with no physical existence at very fine scales of observation. (The photon has a physical existence somewhat comparable to the existence of a monochromatic sound wave.)

The existence of a universal cloud of U particles constituting a new ether in no way conflicts with the theories of quantum mechanics and general relativity, it makes them look like approximate statistical theories.

Relativistic mechanics (also called special relativity) also looks like approximate statistical mechanics.

The differences between predictions based on fine theories and those based on statistical theories may only show up at the level of measurements covering very short intervals of time, well below a nanosecond.

The hypothesis of a universal cloud of U particles induces a "pre-quantum" physics that makes all the physical theories, rational mechanics, relativistic mechanics, quantum mechanics and general relativity, look like statistical theories.

We have already noted that, at the level of this pre-quantum physics, the two relativity principles are both invalidated because the inertial mass of a particle depends on its speed relative to the surrounding universal cloud of U particles. This induces a new version of Langevin's twins that we will discuss below, see Chapter IV.

5 Concerning black holes

The gravitational wave that has been observed arose from two black holes in rapid rotation about one another, a "great" mass in "great" acceleration. The description of a black hole involves two numbers, its mass and its kinetic momentum. (We rule out the existence of charged black holes).

The mass of a black hole controls its horizon, and the fine nature of the black hole within the sphere bounded by that horizon is unknown. The mean density of the black hole within that sphere is inversely proportioned to its mass, with the result that, in the case of black holes of great mass, this density is less than that of a neutron. A neutron star is not a black hole but is indistinguishable from a black hole as regards gravitational effects beyond its horizon. According to Hawking and Bekenstein, each black hole has an entropy proportional to the surface area of its horizon, and a temperature, that of the black hole's radiation, a radiation that is conventionally ruled out but is possible by tunnel effect. Moreover, this entropy would be maximal. The hypothetical universal cloud of U particles is heterogeneous in that the particles are either dispersed in space or grouped in trains that are each associated with a fermion. If a number of fermions are themselves grouped, e.g. in any star, the numerical density per unit volume of the U particles in that star and its vicinity will be much greater than the average numerical density of the universe's U particles.

If the entropy is maximal, being that of a black hole, the distribution of the U particles within its horizon will be as disorderly as possible, since the entropy is the measure of the disorderliness, it should not be possible to distinguish any train associated with a fermion. Such according to our propositions is the physical approach that explains the entropy of a black hole. (The numerical density per unit volume of the U particles will obey a Poisson law and therefore not depend only on a single parameter, the black hole's mass.) The relationship between the entropy of a black hole and the surface area of its horizon is the basis of Gerard't Hooft's propositions about a "holographic principle", supported also by Francis Sanchez and amplified by Leonard Susskind and Juan Maldacena. (The name of this principle refers to the term qualifying the relief image obtained by transferring the information contained in a volume to a surface area called a hologram.)

According to the holographic principle, the information contained in a spatial volume within a surface area is smaller than that surface area. (measured in Planck units), with the result that the elementary particles in any spatial volume will be finite in number. The holographic principle is incompatible with the hypothesis of the continuous, which does not induce any limit to the number of cells that may be distinguished in a finite volume.

In this respect, this principle is in line with the hypothesis suggested by us of a universal cloud of U particles. However, in no way does our hypothesis arise from the gravitational phenomena deemed best described by general relativity, but from the search for a propagation medium for electromagnetic waves. It happens that it might also constitute a medium for propagation of gravitational waves.

R. Charreton, Paris, 19 May 2016, revised 6 November 2016 and 18 July 2018.

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