

# Pulsar Emits a Rotating Beam

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*Researchers at the University of Southampton have cast doubt over established explanations for certain behaviours in pulsars - highly magnetised rotating neutron stars, formed from the remains of supernovae. [8]*

*Installed on the International Space Station, by mid-July it will commence its scientific work – to study the exotic astrophysical objects known as neutron stars and examine whether they could be used as deep-space navigation beacons for future generations of spacecraft. [7]*

*NASA's Chandra X-ray Observatory has discovered the first direct evidence for a superfluid, a bizarre, friction-free state of matter, at the core of a neutron star. Superfluids created in laboratories on Earth exhibit remarkable properties, such as the ability to climb upward and escape airtight containers. The finding has important implications for understanding nuclear interactions in matter at the highest known densities. [6]*

*This paper explains the Accelerating Universe, the Special and General Relativity from the observed effects of the accelerating electrons, causing naturally the experienced changes of the electric field potential along the moving electric charges. The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Relativistic Quantum Theories.*

*The Big Bang caused acceleration created the radial currents of the matter and since the matter composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces. The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.*

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## Study calls into question theories on pulsar phenomena

Researchers at the University of Southampton have cast doubt over established explanations for certain behaviours in pulsars - highly magnetised rotating neutron stars, formed from the remains of supernovae.

Mathematicians have used complex modelling to examine data for one particular pulsar which exhibits both 'glitching' and 'wobbling'. They found accepted theories which explain these phenomena conflict with one another - meaning they can't fit together to explain what is happening in the star.

Findings are published in the journal Physical Review Letters.

A pulsar emits a rotating beam of electromagnetic radiation, which can be detected by powerful telescopes as it sweeps past the Earth, rather like observing the beam of a lighthouse from a ship at sea. They rotate at extremely stable speeds, but occasionally they suddenly speed up in brief events described as 'glitches'. Pulsars can also spin at a slight angle so that their axis traces a cone shape, rather like the movement of a rugby ball which has been thrown slightly off balance - 'wobbling' at each end as it moves through the air.

Lead researcher Dr Ian Jones commented: "There are a number of different theories around what causes pulsars to glitch and wobble. Some centre on the interaction between superfluid in a star's core and its crust - others suggest gravity from an orbiting planet is pulling the star back and forth.

"By studying this unusual pulsar, which glitches and wobbles, we have found that current theories contradict each other and therefore can't explain how both anomalies are occurring in the same star. As such, our results imply we are not seeing the whole picture and that there are errors in our current theories - suggesting a need to rethink what causes the anomalies."

The researchers from Mathematical Sciences at the University of Southampton, UK and the Max Planck Institute for Gravitational Physics, Hannover, Germany, studied data on the pulsar PSR B1828-11. The star was discovered by Jodrell Bank in the UK in the in early 1990s and lies around 10,000 light-years from Earth in the constellation of Scutum. [8]

## **Neutron stars could be our GPS for deep space travel**

NASA's Neutron Star Interior Composition Explorer, or NICER, is an X-ray telescope launched on a SpaceX Falcon 9 rocket in early June 2017. Installed on the International Space Station, by mid-July it will commence its scientific work – to study the exotic astrophysical objects known as neutron stars and examine whether they could be used as deep-space navigation beacons for future generations of spacecraft.

What are neutron stars? When stars at least eight times more massive than the Sun exhaust all the fuel in their core through thermonuclear fusion reactions, the pressure of gravity causes them to collapse. The supernova explosion that results ejects most of the star's material into the far reaches of space. What remains forms either a neutron star or a black hole.

I study neutron stars because of their rich range of astrophysical phenomena and the many areas of physics to which they are connected. What makes neutron stars extremely interesting is that each star is about 1.5 times the mass of the Sun, but only about 25km in diameter – the size of a single city. When you cram that much mass into such a small volume, the matter is more densely packed than that of an atomic nucleus. So, for example, while the nucleus of a helium atom has just two neutrons and two protons, a neutron star is essentially a single nucleus made up of 1057 neutrons and 1056 protons.

## **Exotic physics impossible on Earth**

We can use neutron stars to probe properties of nuclear physics that cannot be investigated in laboratories on Earth. For example, some current theories predict that exotic particles of matter, such as hyperons and deconfined quarks, can appear at the high densities that are present in neutron stars. Theories also indicate that at temperatures of a billion degrees Celsius, protons in the neutron star become superconducting and neutrons, without charge, become superfluid.

The magnetic field of neutron stars is extreme as well, possibly the strongest in the universe, and billions of times stronger than anything created in laboratories. While the gravity at the surface of a neutron star may not be as strong as that near a black hole, neutron stars still create major distortions in spacetime and can be sources of gravitational waves, which were inferred from

research into neutron stars in the 1970s, and confirmed from black holes by the LIGO experiments recently.

The main focus of NICER is to accurately measure the mass and radius of several neutron stars – and, although the telescope will observe other types of astronomical objects, those of us studying neutron stars hope NICER will provide us with unique insights into these fascinating objects and their physics. NICER will measure how the brightness of a neutron star changes according to its energy, and how it changes as the star rotates, revealing different parts of the surface. These observations will be compared to theoretical models based on properties of the star such as mass and radius. Accurate determinations of mass and radius will provide a vital test of nuclear theory.

### **A GPS for deep space**

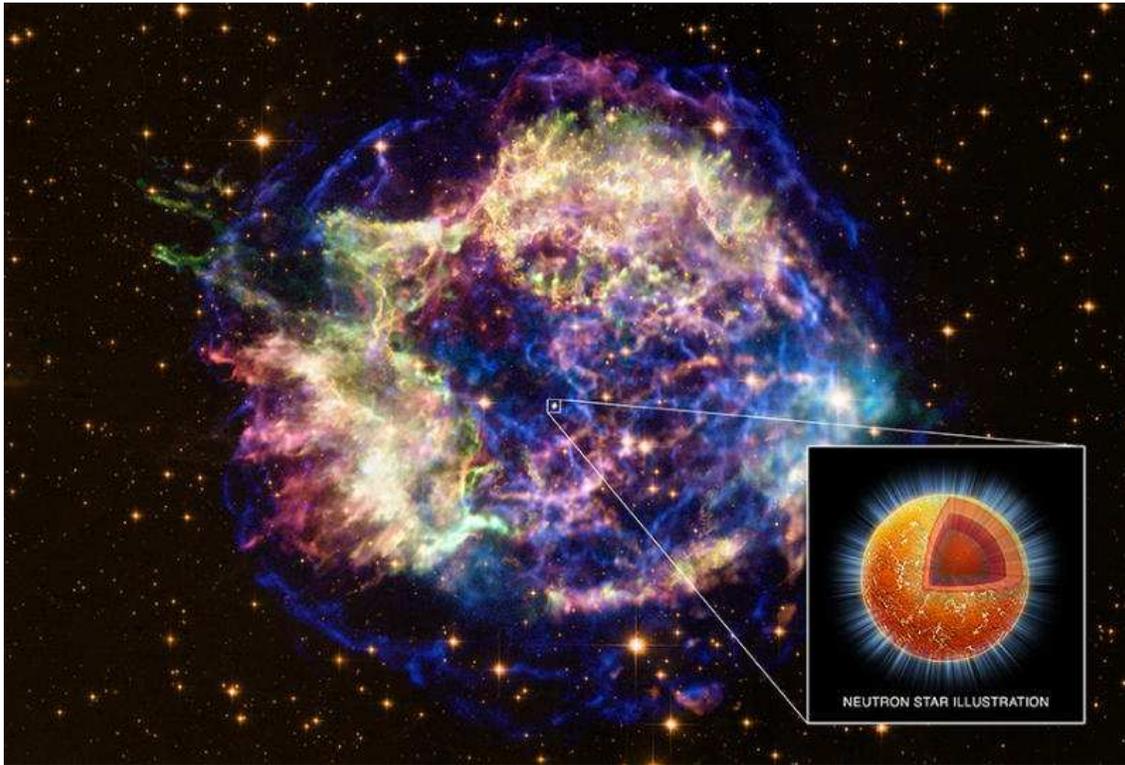
Another aspect of neutron stars that could prove important for future space travel is their rotation—and this will also be tested by NICER. Rotating neutron stars, known as pulsars, emit beams of radiation like a lighthouse and are seen to spin as fast as 716 times per second. This rotation rate in some neutron stars is more stable than the best atomic clocks we have on Earth. In fact, it is this characteristic of neutron stars that led to the discovery of the first planets outside our solar system in 1992 – three Earth-sized planets revolving around a neutron star.

The NICER mission, using a part of the telescope called SEXTANT, will test whether the extraordinary regularity and stability of neutron star rotation could be used as a network of navigation beacons in deep space. Neutron stars could thus serve as natural satellites contributing to a Galactic (rather than Global) Positioning System and could be relied upon by future manned and unmanned spacecraft to navigate among the stars.

NICER will operate for 18 months, but it is hoped that NASA will continue to support its operation afterwards, especially if it can deliver on its ambitious scientific goals. I hope so too, because NICER combines and greatly improves upon the invaluable capabilities of previous X-ray spacecraft – RXTE, Chandra, and XMM-Newton – that are used to uncover neutron stars' mysteries and reveal properties of fundamental physics.

The first neutron star, a pulsar, was discovered in 1967 by Jocelyn Bell Burnell. It would be fitting to obtain a breakthrough on neutron stars in this 50th anniversary year. [7]

## Bizarre friction-free 'superfluid' found in neutron star's core



This composite image shows a beautiful X-ray and optical view of Cassiopeia A (Cas A), a supernova remnant located in our Galaxy about 11,000 light years away.

These are the remains of a massive star that exploded about 330 years ago, as measured in Earth's time frame. X-rays from Chandra are shown in red, green and blue along with optical data from Hubble in gold. At the center of the image is a neutron star, an ultra-dense star created by the supernova. The inset shows an artist's impression of the neutron star at the center of Cas A. The different colored layers in the cutout region show the crust (orange), the core (red), where densities are much higher, and the part of the core where the neutrons are thought to be in a superfluid state (inner red ball). The blue rays emanating from the center of the star represent the copious numbers of neutrinos -- nearly massless, weakly interacting particles -- that are created as the core temperature falls below a critical level and a neutron superfluid is formed, a process that began about 100 years ago as observed from Earth. These neutrinos escape from the star, taking energy with them and causing the star to cool much more rapidly.

Neutron stars contain the densest known matter that is directly observable. One teaspoon of neutron star material weighs six billion tons. The pressure in the star's core is so high that most of the charged particles, electrons and protons, merge resulting in a star composed mostly of uncharged particles called neutrons.

Two independent research teams studied the supernova remnant Cassiopeia A, or Cas A for short, the remains of a massive star 11,000 light years away that would have appeared to explode about 330 years ago as observed from Earth. Chandra data found a rapid decline in the temperature of the ultra-dense neutron star that remained after the supernova, showing that it had cooled by about four percent over a 10-year period.

"This drop in temperature, although it sounds small, was really dramatic and surprising to see," said Dany Page of the National Autonomous University in Mexico, leader of a team with a paper published in the February 25, 2011 issue of the journal Physical Review Letters. "This means that something unusual is happening within this neutron star."

Superfluids containing charged particles are also superconductors, meaning they act as perfect electrical conductors and never lose energy. The new results strongly suggest that the remaining protons in the star's core are in a superfluid state and, because they carry a charge, also form a superconductor.

"The rapid cooling in Cas A's neutron star, seen with Chandra, is the first direct evidence that the cores of these neutron stars are, in fact, made of superfluid and superconducting material," said Peter Shternin of the Ioffe Institute in St Petersburg, Russia, leader of a team with a paper accepted in the journal Monthly Notices of the Royal Astronomical Society.

Both teams show that this rapid cooling is explained by the formation of a neutron superfluid in the core of the neutron star within about the last 100 years as seen from Earth. The rapid cooling is expected to continue for a few decades and then it should slow down.

"It turns out that Cas A may be a gift from the Universe because we would have to catch a very young neutron star at just the right point in time," said Page's co-author Madappa Prakash, from Ohio University. "Sometimes a little good fortune can go a long way in science."

The onset of superfluidity in materials on Earth occurs at extremely low temperatures near absolute zero, but in neutron stars, it can occur at temperatures near a billion degrees Celsius. Until now there was a very large uncertainty in estimates of this critical temperature. This new research constrains the critical temperature to between one half a billion to just under a billion degrees.

Cas A will allow researchers to test models of how the strong nuclear force, which binds subatomic particles, behaves in ultradense matter. These results are also important for understanding a range of behavior in neutron stars, including "glitches," neutron star precession and pulsation, magnetar outbursts and the evolution of neutron star magnetic fields.

Small sudden changes in the spin rate of rotating neutron stars, called glitches, have previously given evidence for superfluid neutrons in the crust of a neutron star, where densities are much lower than seen in the core of the star. This latest news from Cas A unveils new information about the ultradense inner region of the neutron star. [6]

## **The Big Bang**

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles.

The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

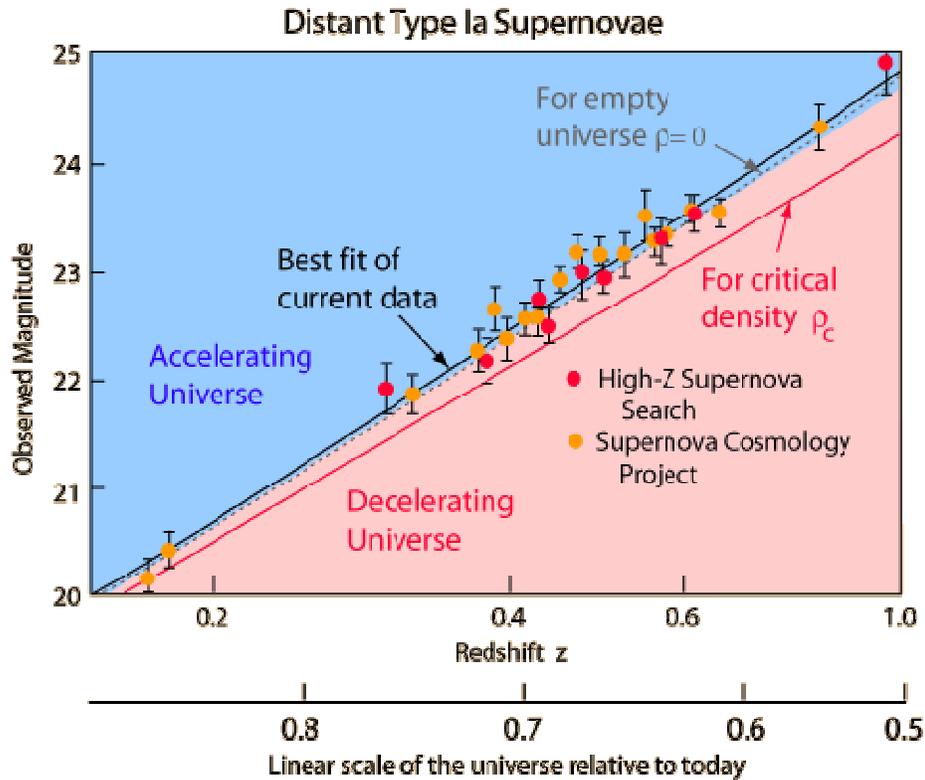
The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.

There is an asymmetry between the mass of the electric charges, for example proton and electron, can be understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

## **Evidence for an accelerating universe**

One of the observational foundations for the big bang model of cosmology was the observed expansion of the universe. [4] Measurement of the expansion rate is a critical part of the study, and it has been found that the expansion rate is very nearly "flat". That is, the universe is very close to the critical density, above which it would slow down and collapse inward toward a future "big crunch". One of the great challenges of astronomy and astrophysics is distance measurement over the vast distances of the universe. Since the 1990s it has become apparent that type Ia supernovae offer a unique opportunity for the consistent measurement of distance out to perhaps 1000 Mpc. Measurement at these great distances provided the first data to suggest that the expansion rate of the universe is actually accelerating. That acceleration implies an energy density that acts in opposition to gravity which would cause the expansion to accelerate. This is an energy density which we have not directly detected observationally and it has been given the name "dark energy".

The type Ia supernova evidence for an accelerated universe has been discussed by Perlmutter and the diagram below follows his illustration in Physics Today.



The data summarized in the illustration above involve the measurement of the redshifts of the distant supernovae. The observed magnitudes are plotted against the redshift parameter  $z$ . Note that there are a number of Type Ia supernovae around  $z=0.6$ , which with a Hubble constant of 71 km/s/mpc is a distance of about 5 billion light years.

### Equation

The cosmological constant  $\Lambda$  appears in Einstein's field equation [5] in the form of

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu},$$

where  $R$  and  $g$  describe the structure of spacetime,  $T$  pertains to matter and energy affecting that structure, and  $G$  and  $c$  are conversion factors that arise from using traditional units of measurement. When  $\Lambda$  is zero, this reduces to the original field equation of general relativity. When  $T$  is zero, the field equation describes empty space (the vacuum).

The cosmological constant has the same effect as an intrinsic energy density of the vacuum,  $\rho_{\text{vac}}$  (and an associated pressure). In this context it is commonly moved onto the right-hand side of the equation, and defined with a proportionality factor of  $8\pi$ :  $\Lambda = 8\pi\rho_{\text{vac}}$ , where unit conventions of general relativity are used (otherwise factors of  $G$  and  $c$  would also appear). It is common to quote values of energy density directly, though still using the name "cosmological constant".

A positive vacuum energy density resulting from a cosmological constant implies a negative pressure, and vice versa. If the energy density is positive, the associated negative pressure will drive an accelerated expansion of the universe, as observed. (See dark energy and cosmic inflation for details.)

## Explanatory models

Models attempting to explain accelerating expansion include some form of dark energy, dark fluid or phantom energy. The most important property of dark energy is that it has negative pressure which is distributed relatively homogeneously in space. The simplest explanation for dark energy is that it is a cosmological constant or vacuum energy; this leads to the Lambda-CDM model, which is generally known as the Standard Model of Cosmology as of 2003-2013, since it is the simplest model in good agreement with a variety of recent observations.

## Lorentz transformation of the Special Relativity

In the referential frame of the accelerating electrons the charge density lowering linearly because of the linearly growing way they takes every next time period. From the referential frame of the wire there is a parabolic charge density lowering.

The difference between these two referential frames, namely the referential frame of the wire and the referential frame of the moving electrons gives the relativistic effect. Important to say that the moving electrons presenting the time coordinate, since the electrons are taking linearly increasing way every next time period, and the wire presenting the geometric coordinate. The Lorentz transformations are based on moving light sources of the Michelson - Morley experiment giving a practical method to transform time and geometric coordinates without explaining the source of this mystery.

The real mystery is that the accelerating charges are maintaining the accelerating force with their charge distribution locally. The resolution of this mystery that the charges are simply the results of the diffraction patterns, that is the charges and the electric field are two sides of the same thing. Otherwise the charges could exceed the velocity of the electromagnetic field.

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

## The Classical Relativistic effect

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field.

In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.

## Electromagnetic inertia and Gravitational attraction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass.

It looks clear that the growing acceleration results the relativistic growing mass - limited also with the velocity of the electromagnetic wave.

Since  $E = h\nu$  and  $E = mc^2$ ,  $m = h\nu/c^2$  that is the  $m$  depends only on the  $\nu$  frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the  $m_0$  inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

If the mass is electromagnetic, then the gravitation is also electromagnetic effect caused by the accelerating Universe! The same charges would attract each other if they are moving parallel by the magnetic effect.

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force.

## Electromagnetic inertia and mass

### Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

### Relativistic change of mass

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### The frequency dependence of mass

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## Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [1]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

## Gravity from the point of view of quantum physics

### The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Big Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate  $M_p=1840 m_e$ . In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

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## The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [2]

## Conclusions

"Previously we had no idea how extended superconductivity of protons was in a neutron star," said Shternin's co-author Dmitry Yakovlev, also from the Ioffe Institute. The cooling in the Cas A neutron star was first discovered by co-author Craig Heinke, from the University of Alberta, Canada, and Wynn Ho from the University of Southampton, UK, in 2010. It was the first time that astronomers have measured the rate of cooling of a young neutron star. [6]

The accelerating Universe fits into the accelerating charges of the electric currents, because the Big Bang caused radial moving of the matter.

Needless to say that the accelerating electrons of the steady stationary current are a simple demystification of the magnetic field, by creating a decreasing charge distribution along the wire, maintaining the decreasing U potential and creating the  $\underline{A}$  vector potential experienced by the electrons moving by  $\underline{v}$  velocity relative to the wire. This way it is easier to understand also the time dependent changes of the electric current and the electromagnetic waves as the resulting fields moving by c velocity.

It could be possible something very important law of the nature behind the self maintaining  $\underline{E}$  accelerating force by the accelerated electrons. The accelerated electrons created electromagnetic fields are so natural that they occur as electromagnetic waves traveling with velocity c. It shows that the electric charges are the result of the electromagnetic waves diffraction.

One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .

The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing. Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions.

The electric currents causing self maintaining electric potential is the source of the special and general relativistic effects. The Higgs Field is the result of the electromagnetic induction. The Graviton is two photons together. [3]

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