LISA Pathfinder for gravitational waves

The European Space Agency (ESA) has launched a concept mission to test the technology required for a space-based gravitational-wave observatory. Sent into space today at 04:15 GMT (05:15 CET) on a Vega rocket from Kourou in French Guiana, LISA Pathfinder will now make its way to "Lagrange Point 1". Lying about 1.5 million kilometers from Earth in the direction of the Sun, this point in space provides a very stable environment to control the precision of the instruments on the satellite. The launch of LISA Pathfinder marks the 100th anniversary of Albert Einstein's general theory of relativity. [6]

We are more than ready to hear the plucked strings of space-time. Last Friday, the revamped LIGO took its first observations – a step towards picking up the ripples that Einstein predicted should come from exotic cosmic collisions. [5]

Scientists at the National Institute for Space Research in Brazil say an undiscovered type of matter could be found in neutron stars (illustration shown). Here matter is so dense that it could be 'squashed' into strange matter. This would create an entire 'strange star' - unlike anything we have seen. [4]

The changing acceleration of the electrons explains the created negative electric field of the magnetic induction, the electromagnetic inertia, the changing relativistic mass and the Gravitational Force, giving a Unified Theory of the physical forces. Taking into account the Planck Distribution Law of the electromagnetic oscillators also, we can explain the electron/proton mass rate and the Weak and Strong Interactions.

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Author: George Rajna

Preface

Today the most popular enigma is the gravitational force after founding the Higgs boson experimentally. Although the graviton until now is a theoretical particle, its existence is a necessary basis of the Quantum Gravitation and the Theory of Everything.

The electromagnetic origin of mass gives an explanation of the inertia, the relativistic change of mass and also the gravitational force.

Launch of LISA Pathfinder probe heralds new era in search for gravitational waves

Gravitational waves are distortions of space–time that occur when massive bodies, such as black holes, are accelerated. Ground-based detectors – such as the Advanced Laser Interferometer Gravitational-Wave Observatory located in Hanford, Washington and Livingston, Louisiana – are already trying to identify high-frequency gravitational waves in the 100–500 Hz range, but they have so far turned up empty-handed. As for finding lower-frequency waves, these are inaccessible on Earth because ground-based interferometers would be required to have impossibly long arms. A space-based mission, however, could pick up gravitational-waves with frequencies between 10–4–10–1 Hz from, for example, the coalescence of supermassive black holes.

Trillionth of a meter

LISA Pathfinder will use two 2 kg test masses made of gold and platinum that will float freely inside the craft and be separated by 38 cm. It will have a 20 × 20 cm optical bench – containing 22 mirrors and beamsplitters – to measure with a laser the deviations in their movements to an accuracy of a trillionth of a meter.

LISA Pathfinder will not be able to detect gravitational waves directly because their impact is so tiny that the test masses would need to be millions of kilometres apart. The experiment will, however, demonstrate that the two independent masses can be monitored as they free fall through space. The goal is to minimize external and internal disturbances to the point where the position of the test masses would be more stable than the expected change caused by a passing gravitational wave – a change in distance equal to much less than the size of an atom.

We will learn a huge amount about operating such instrumentation in space says Martin Hewitson, Max Planck Institute for Gravitational Physics.

"As well as testing the technologies needed for future space-based observatories, LISA Pathfinder will also allow us to characterize most of the sources of disturbance that we expect to face with such an instrument, allowing us to optimize the design of any future observatory," says Martin Hewitson of the Max Planck Institute for Gravitational Physics in Hannover, Germany, which is a leading partner in the mission. "We will learn a huge amount about operating such instrumentation in space, so that we expect to have demonstrated the ability to place test masses in free fall at the level needed to routinely observe gravitational waves in a full-scale space-based observatory."

If the mission succeeds, it could pave the way for a future space-based gravitational-wave observatory. One such proposal is eLISA, which would measure gravitational waves using laser beams bounced off test masses inside three identical spacecraft placed at the vertices of a virtual equilateral triangle with sides a million kilometers long. A passing wave would change the distance between the masses by just a few trillionths of a meter, causing the beams' interference pattern to vary. Such a mission is unlikely to be launched before the early 2030s at the earliest.

Exciting time

"It is an exciting time in gravitational-wave astronomy. The flight of LISA Pathfinder will be a major milestone in the endeavour to observe gravitational waves from space by testing much of the critical technology needed to build a full-scale observatory, such as eLISA," adds Hewitson. "The team has waited for this moment for a long time, and we can't wait to begin the experimental campaign and get our hands on the data."

Physicist Monica Colpi of the University of Milano Bicocca, Italy, who is also a member of the eLISA consortium board, says the launch of LISA Pathfinder will "mark the beginning of a new era for astrophysics, cosmology and fundamental physics". "The gravitational-wave sky is clearly an unexplored frontier, and for this reason it holds great potential for discovery and, equally important, the promise for understanding one of the most mysterious interactions of nature: gravity," she adds.

The main scientific mission for LISA Pathfinder will begin on 1 March 2016 and last for at least six months.

Nergis Mavalvala of the Massachusetts Institute of Technology explains how we can detect gravitational waves in the 100 Second Science video below. [6]

Gravitational-wave detector rebooted to sense clashing stars

During its original run from 2002 to 2010, the Laser Interferometer Gravitational-Wave Observatory listened for gravitational waves in a range that included about 100 galaxies. It didn’t find any, probably because the main event it was searching for – the death spiral of two neutron stars – might only happen in a single galaxy once every 30,000 years.

The new experiment, Advanced LIGO, uses stronger lasers and better mirrors in two detectors – one in Hanford, Washington, and the other in Livingston, Louisiana.

It will hopefully reach a volume of space that includes roughly 300,000 galaxies, and will be able to hear one neutron-star clashes per month, on average.

But it will take some ramping up before Advanced LIGO is that sensitive.

“You don’t turn on these things like a light and have them just work,” says Matthew Evans of the Massachusetts Institute of Technology.

Passing waves

The detector works by bouncing laser light between mirrors inside twin perpendicular tunnels, each 4 kilometers long. It then waits for a passing gravitational wave to slightly change the length of one tunnel relative to the other.

But that means it feels the ground’s every tremor. Delayed aftershocks from Chile’s recent earthquake have already drowned out parts of the data. However, it looks like Advanced LIGO will hear signals as far away as 230 million light years in this first run. This is the first of three scheduled observation runs that should become progressively more sensitive.

If found, long-awaited gravitational waves could allow us to test Einstein’s theory of general relativity, pinpoint the sources of gamma-ray bursts, and understand the extreme physics with which black holes merge. But for now we’re still waiting.

“Every generation has told their grad students: ‘Hey, you’re going to be the ones to detect gravitational waves!'” Evans says. “Well, I tell my grad students this, and I think it’s really true.” [5]

Probing Strange Stars with Advanced Gravitational Wave

The only known way to find strange matter at the moment would be to confirm its existence within neutron stars. On Earth, it is currently impossible to directly observe strange matter, even in places like the Large Hadron Collider at Cern in Switzerland. Pictured is the Large Hadron Collider Beauty experiment (LHCb).

‘As its name says, a neutron star is a star made up of neutrons - which are made up of two down and one up quarks,’ Dr Moraes continued.

‘It is a star of very high density and rapid rotation rate. Most of them have masses close to 1.3-1.4 solar masses.’

Most matter we see comes in two ‘flavours’, made up of just two types of fundamental particles - up and down quarks.

WHAT IS A NEUTRON STAR?

When the core of a massive star undergoes gravitational collapse at the end of its life, protons and electrons are literally scrunched together, leaving behind one of nature's most wondrous creations: a neutron star.

Neutron stars cram roughly 1.3 to 2.5 solar masses into a city-sized sphere perhaps 12 miles (20 kilometers) across.

Matter is packed so tightly that a sugar-cube-sized amount of material would weigh more than 1 billion tons, about the same as Mount Everest.

But in these extreme conditions a rare type of three-flavour matter, made of up, down and strange quarks, could be being created.

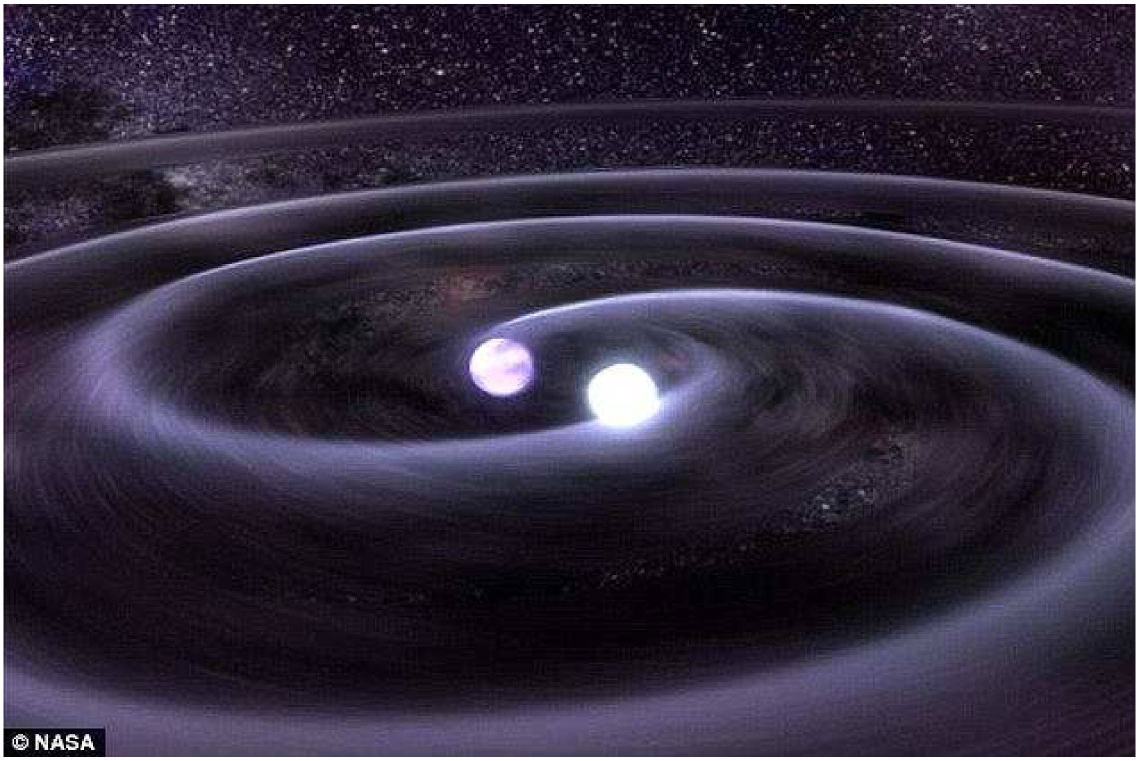
This is what strange matter would be. And Dr Moraes says, if the neutron star is massive enough and rotating at a fast enough speed, the entire star could be made of this matter.

The star would be much smaller and lighter than a neutron star. For example, a neutron star with a mass 0.2 times that of the sun would have a radius greater than nine miles (15km), but a strange star of the same mass would be less than a third the size.

One of the implications of the theory, if true, would be that there might be more types of matter in the universe than we know of.

Dr Moraes says, as we cannot observe individual fundamental particles like quarks on Earth, the only way to prove strange matter’s existence would be to spot it in a neutron star.

Interestingly, though, proving that strange stars exist could also provide a detection for one of the ‘holy grails’ of astronomy - gravitational waves.



Dr Moraes says the interaction of a neutron star and a strange star (illustration shown) could create ripples in space-times, resulting in gravitational waves. These are one of the 'holy grails' of astronomy that have been impossible to detect in other experiments so far. [4]

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

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 frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv /c^2$ that is the m depends only on the v 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_o 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.

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. [2]

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 Bing 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 Mp=1840 Me. 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!?

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 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.

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. [3]

The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

In my opinion, the best explanation of the Higgs mechanism for a lay audience is the one invented by David Miller. You can find it here: http://www.strings.ph.qmul.ac.uk/~jmc/epp/higgs3.html .
The field must come first. The boson is an excitation of the field. So no field, no excitation. On the other hand in quantum field theory it is difficult to separate the field and the excitations.
The Higgs field is what gives particles their mass.
There is a video that gives an idea as to the Higgs field and the boson. It is here: http://www.youtube.com/watch?v=RIg1Vh7uPyw . Note that this analogy isn't as good as the Miller one, but as is usually the case, if you look at all the analogies you'll get the best understanding of the situation.

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the T_{max} change and the diffraction patterns change. [2]

Higgs mechanism

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

Conclusions

The latest theory was proposed by Dr Pedro Moraes and Dr Oswaldo Miranda, both of the National Institute for Space Research in Brazil. They say that some types of neutron stars might be made of a new type of matter called strange matter. What the properties of this matter would be, though, are unknown - but it would likely be a ‘liquid’ of several types of sub-atomic particles. [4]

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