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Chapter 1 : ICTP - Ousting Alternative Gravity Theories

For any alternative theory of gravity to work, it has to not only do away with dark matter and dark energy, but also reproduce the predictions of general relativity in all the standard contexts. "The business of alternative gravity theories is a messy one," Archibald said.

When Albert Einstein developed his general theory of relativity in , this was used as a mathematical starting point for most cosmological theories. The assumptions that the current standard model of cosmology, Lambda-CDM, relies upon are: The FRW metric allows for a universe that is either expanding or contracting as well as stationary but unstable universes. This implies the universe was smaller in the past, and therefore led to the following conclusions: These features were derived by numerous individuals over a period of years; indeed it was not until the middle of the twentieth century that accurate predictions of the last feature and observations confirming its existence were made. Non-standard theories developed either by starting from different assumptions or by contradicting the features predicted by Lambda-CDM. Theorists who successfully developed cosmologies applicable to the larger-scale universe are remembered today as the founders of modern cosmology. Since the discovery of the Cosmic microwave background radiation CMB by Arno Penzias and Robert Wilson in , most cosmologists concluded that observations were best explained by the big bang model. Steady State theorists and other non-standard cosmologies were then tasked with providing an explanation for the phenomenon if they were to remain plausible. This led to original approaches including integrated starlight and cosmic iron whiskers , which were meant to provide a source for a pervasive, all-sky microwave background that was not due to an early universe phase transition. Data gathered by this spacecraft has been successfully used to parametrize the features of standard cosmology, but complete analysis of the data in the context of any non-standard cosmology has not yet been achieved. The first occurred was the late s when there were a number of unsolved problems, such as the horizon problem , the flatness problem , and the lack of magnetic monopoles , which challenged the big bang model. These issues were eventually resolved by cosmic inflation in the s. This idea subsequently became part of the understanding of the big bang, although alternatives have been proposed from time to time. The second occurred in the mids when observations of the ages of globular clusters and the primordial helium abundance, apparently disagreed with the big bang. However, by the late s, most astronomers had concluded that these observations did not challenge the big bang and additional data from COBE and the WMAP , provided detailed quantitative measures which were consistent with standard cosmology. In the s, a dawning of a "golden age of cosmology" was accompanied by a startling discovery that the expansion of the universe was, in fact, accelerating. Previous to this, it had been assumed that matter either in its visible or invisible dark matter form was the dominant energy density in the universe. Today, it is more common to find in the scientific literature proposals for "non-standard cosmologies" that actually accept the basic tenets of the big bang cosmology, while modifying parts of the concordance model. Such theories include alternative models of dark energy, such as quintessence, phantom energy and some ideas in brane cosmology ; alternative models of dark matter, such as modified Newtonian dynamics; alternatives or extensions to inflation such as chaotic inflation and the ekpyrotic model ; and proposals to supplement the universe with a first cause, such as the Hartleâ€"Hawking boundary condition , the cyclic model , and the string landscape. There is no consensus about these ideas amongst cosmologists, but they are nonetheless active fields of academic inquiry. Today, heterodox non-standard cosmologies are generally considered unworthy of consideration by cosmologists while many of the historically significant nonstandard cosmologies are considered to have been falsified. The essentials of the big bang theory have been confirmed by a wide range of complementary and detailed observations, and no non-standard cosmologies have reproduced the range of successes of the big bang model. Speculations about alternatives are not normally part of research or pedagogical discussions, except as object lessons or for their historical importance. An open letter started by some remaining advocates of non-standard cosmology has affirmed that: Alternatives to general relativity General relativity, upon which the FRW metric is based, is an extremely successful theory which has met every observational test so far. However, at a fundamental level it is incompatible with quantum mechanics , and by predicting singularities , it also predicts its own breakdown. Any alternative theory of gravity would imply immediately an alternative cosmological theory since current modeling is dependent on general relativity as a framework assumption. There are many different motivations to modify general relativity, such as to eliminate the need for dark matter or dark energy, or to avoid such paradoxes as the firewall. This led naturally to speculation about the cosmological implications for such a proposal. While almost all astrophysicists today reject MOND in favor of dark matter, a small number of researchers continue to enhance it, recently incorporating Bransâ€”Dicke theories into treatments that attempt to account for cosmological observations. Tensorâ€”vectorâ€”scalar gravity Tensorâ€”vectorâ€”scalar gravity TeVeS is a proposed relativistic theory that is equivalent to Modified Newtonian dynamics MOND in the non-relativistic limit, which purports to explain the galaxy rotation problem without invoking dark matter. Originated by Jacob Bekenstein in , it incorporates various dynamical and non-dynamical tensor fields , vector fields and scalar fields. The break-through of TeVeS over MOND is that it can explain the phenomenon of gravitational lensing , a cosmic optical illusion in which matter bends light, which has been confirmed many times. The simplest case is just the function being equal to the scalar; this is general relativity. As a consequence of introducing an arbitrary function, there may be freedom to explain the accelerated expansion and structure formation of the Universe without adding unknown forms of dark energy or dark matter. Some functional forms may be inspired by corrections arising from a quantum theory of gravity. It has become an active field of research following work by Starobinsky on cosmic inflation. Steady State theories[edit] Main article: Steady State theory The Steady State theory extends the homogeneity assumption of the cosmological principle to reflect a homogeneity in time as well as in space. This "perfect cosmological principle" as it would come to be called asserted that the universe looks the same everywhere on the large scale , the same as it always has and always will. This is in contrast to Lambda-CDM, in which the universe looked very different in the past and will look very different in the future. In order to maintain the perfect cosmological principle in an expanding universe, steady state cosmology had to posit a "matter-creation field" the so-called C-field that would insert matter into the universe in order to maintain a constant density. This radiation is a natural feature of the Big Bang model which demands a "time of last scattering" where photons decouple with baryonic matter. In order to account for the uniformity of the background, steady state proponents posited a fog effect associated with microscopic iron particles that would scatter radio waves in such a manner as to produce an isotropic CMB. The proposed phenomena was whimsically named "cosmic iron whiskers" and served as the thermalization mechanism. The Steady State theory did not have the horizon problem of the Big Bang because it assumed an infinite amount of time was available for thermalizing the background. What was a coincidental ratio of hydrogen to deuterium and helium in the steady state model was a feature of the Big Bang model. After this dramatic discovery, the majority of cosmologists became convinced that the steady state theory could not explain the observed CMB properties. Although the original steady state model is now considered to be contrary to observations particularly the CMB even by its one-time supporters, modifications of the steady state model has been proposed, including a model that envisions the universe as originating through many little bangs rather than one big bang the so-called "quasi-steady state cosmology". It supposes that the universe goes through periodic expansion and contraction phases, with a soft "rebound" in place of the Big Bang. Thus the Hubble Law is explained by the fact that the universe is currently in an expansion phase. Work continues on this model most notably by Jayant V. Narlikar , although it has yet to gain widespread mainstream acceptance. Dark flow Isotropicity â€” the idea that the universe looks the same in all directions â€" is one of the core assumptions that enters into the FRW equations. The detection is controversial, and other scientists have found that the universe is isotropic to a great degree. Dark matter and Dark energy In Lambda-CDM, dark matter is an extremely inert form of matter that does not interact with both ordinary matter baryons and light, but still exerts gravitational effects. Dark energy is an unknown form of energy that tends to accelerate the expansion of the universe. Both dark matter and dark energy have not been conclusively identified, and their exact nature is the subject of intense study. For example, scientists have hypothesized that dark matter could decay into dark energy, or that both dark matter and dark energy are different facets of the same underlying fluid see dark fluid. Other theories that aim to explain one or the other, such as warm dark matter and quintessence, also fall into this category. Proposals based on observational skepticism[edit] As the observational cosmology began to develop, certain astronomers began to offer alternative speculations regarding the interpretation of various phenomena that occasionally became parts of non-standard cosmologies. It was proposed by Fritz Zwicky in The basic proposal amounted to light losing energy "getting tired" due to the distance it traveled rather than any metric expansion or physical recession of sources from observers. Other proposals for explaining how photons could lose energy included the scattering of light by intervening material in a process similar to observed interstellar reddening. However, all these processes would also tend to blur images of distant objects, and no such blurring has been detected. Dirac large numbers hypothesis[edit] Main article: Dirac large numbers hypothesis The Dirac large numbers hypothesis uses the ratio of the size of the visible universe to the radius of quantum particle to predict the age of the universe. The coincidence of various ratios being close in order of magnitude may ultimately prove meaningless or the indication of a deeper connection between concepts in a future theory of everything. Nevertheless, attempts to use such ideas have been criticized as numerology. Redshift periodicity and intrinsic redshifts[edit] See also: Redshift quantization Some astrophysicists were unconvinced that the cosmological redshifts are caused by universal cosmological expansion. In particular, Geoffrey Burbidge , William Tifft and Halton Arp were all observational astrophysicists who proposed that there were inconsistencies in the redshift observations of galaxies and quasars. The first two were famous for suggesting that there were periodicities in the redshift distributions of galaxies and quasars. Subsequent statistical analyses of redshift surveys , however, have not confirmed the existence of these periodicities. Astronomers who believed quasars were not at cosmological distances argued that the Eddington luminosity set limits on how distant the quasars could be since the energy output required to explain the apparent brightness of cosmologically-distant quasars was far too high to be explainable by nuclear fusion alone. This objection was made moot by the improved models of gravity-powered accretion disks which for sufficiently dense material such as black holes can be more efficient at energy production than nuclear reactions. The controversy was laid to rest by the s when evidence became available that observed quasars were actually the ultra-luminous cores of distant active galactic nuclei and that the major components of their redshift were in fact due to the Hubble flow. He claimed that clusters of quasars were in alignment around AGN cores and that quasars, rather than being the cores of distant AGN, were actually much closer and were starlike-objects ejected from the centers of nearby AGN with high intrinsic redshifts. Arp also contended that they gradually lost their non-cosmological redshift component and eventually evolved into full-fledged galaxies. The vast majority of these quasars are not correlated in any way with nearby AGN. Indeed, with improved observing techniques, a number of host galaxies have been observed around quasars which indicates that those quasars at least really are at cosmological distances and are not the kind of objects Arp proposes. It is also unclear how nearby quasars would explain some features in the spectrum of quasars which the standard model easily explains. In the standard cosmology, clouds of neutral hydrogen between the quasar and the earth create Lyman alpha absorption lines having different redshifts up to that of the quasar itself; this feature is called the Lyman-alpha forest. Moreover, in extreme quasars one can observe the absorption of neutral hydrogen which has not yet been reionized in a feature known as the Gunnâ€”Peterson trough. Most cosmologists see this missing theoretical work as sufficient reason to explain the observations as either chance or error. With the passing of Halton Arp, this cosmology has been relegated to a dismissed theory. The difficulties with this model were apparent almost immediately. Matterâ€”antimatter annihilation results in the production of high energy photons which were not observed. While it was possible that the local "matter-dominated" cell was simply larger than the observable universe , this proposition did not lend itself to observational tests. Like the steady state theory , plasma cosmology includes a Strong Cosmological Principle which assumes that the universe is isotropic in time as well as in space. While plasma cosmology has never had the support of most astronomers or physicists , a small number of plasma researchers have continued to promote and develop the approach, and publish in the special issues of the IEEE Transactions on Plasma Science. Additionally, in , Eric J. Lerner , an independent researcher in plasma physics and nuclear fusion, wrote a popular-level book supporting plasma cosmology called The Big Bang Never Happened. At that time there was renewed interest in the subject among the cosmological community along with other non-standard cosmologies. This was due to anomalous results reported in by Andrew Lange and Paul Richardson of UC Berkeley and Toshio Matsumoto of Nagoya University that indicated the cosmic microwave background might not have a blackbody spectrum. Nucleosynthesis objections[edit] One of the major successes of the Big Bang theory has been to provide a prediction that corresponds to the observations of the abundance of light elements in the universe. Theories which assert that the universe has an infinite age, including many of the theories described above, fail to account for the abundance of deuterium in the cosmos, because deuterium easily undergoes nuclear fusion in stars and there are no known astrophysical processes other than the Big Bang itself that can produce it in large quantities. Hence the fact that deuterium is not an extremely rare component of the universe suggests that the universe has a finite age.

Chapter 2 : Non-standard cosmology - Wikipedia

In the standard theory of gravityâ€"general relativityâ€"dark matter plays a vital role, explaining many observations that the standard theory cannot explain by itself. But for 70 years.

Sign up or login to join the discussions! Oct 25, 1: Data is the thing that allows them to test their theories and prove that they are right. May I have another? Further Reading Neutron stars collide, solve major astronomical mysteries Illuminating dark matter Dark matter is a particle that is posited to exist in large quantities in the Universe. Physicists did not dream it up because they were bored, but because the internal gravitational structure of galaxies could not be explained by the distribution of visible matter. After the existence of dark matter was first proposed, it got some critical supporting evidence. The cosmic microwave backgroundâ€"the radiation emitted during the Big Bang that permeates the Universeâ€"has features that, at the moment, we can only explain with dark matter. The difference between dark matter and ordinary matter is how the two respond to light. It invites light over for dinner, welcomes it, then throws light unceremoniously out the window for dissing its electrons. As a result, that ordinary matter is visible because of the way it absorbs and scatters light. Dark matter, on the other hand, completely ignores light and ordinary matter. If the Universe were your local neighborhood, dark matter is the family that communicates with everyone, even other family members, only by changing the name of their WiFi network. The only way they exert forces on other particles is via gravity. You can, for instance, modify the law of gravity. The stumbling block has been to figure out the underlying physical reason for the new law. This is actually a big ask. These laws are a consequence of the nature of the Universe, so changes to the laws also have to be down to the fundamental nature of the Universe. Ad hoc add-ons are not appreciated. Instead space-time warps and flows around massive objects, which provides a sliver of hope for alternative theories of gravity. One metric is coupled to ordinary matter. Light and ordinary matter dance together on this stage and provide us with a spectacular show. So there is no dark matterâ€"instead the space-time is naturally warped in the absence of dark matter. These two seemingly independent metrics can explain the structures of galaxies and of collisions between galaxy clusters, but the idea has consequences. For instance, if a something should emit both gravitational waves and light, the two waves will travel by different paths depending on the masses they encounter. When two neutron stars spiraled into each other and merged, they released a huge amount of energy as both light and gravitational waves. Three gravitational wave detectors picked up the gravitational waves emitted during the in-spiral and merger, while the Fermi telescope caught the gamma ray burst released as the stars merged. Over the course of the next few days, many telescopes observed the light emission from the cooling debris that was hurtling outwards from the merger. It was, in short, a data bonanza the likes of which we may never see again. The light and the gravitational waves travel along the direct line of sight to us, curling around the gravity wells of intervening galaxies along the way. Yes, that was the recorded delay between the two signals. That would be premature cheering. Remember, dark matter makes up most of the mass in a galaxy, so the galaxies between us and the neutron stars including our own Milky Way should provide two very different paths for the gravitational and light waves. The delay should have been longer if MOND were correct. There is, in their view, simply no way to include the intervening galaxies and exclude dark matter. This is a dead MOND theory. In other news, Einstein is still right Along the way, the researchers took a look at a related subject, called the weak equivalence principle. The idea is simple: Gravitational waves and electromagnetic waves are both carried by particles: The near simultaneous arrival of the two show that they also experienced the same gravitational field and were influenced in exactly the same way. Or more precisely, the maximum difference is less than four parts in million. Essentially, this analysis shows that photons and gravitons travel on nearly identical metrics. And, even on the same metric, they experience pretty much the same gravitational fieldsâ€"that is the coupling between the particle and the gravitational field is the same for both. This also means that any new theory of gravity has to respect the weak equivalence principle. Without a reason, they cannot be eliminated. These are also not, at first sight, eliminated. Unusually, I will be a bit cautious here. It is not clear that the remaining MOND theories do not have their success or failure hidden in the neutron star merger data. Human nature plays a role too. No theoretician lets a good idea die without a fight. You can be sure that several of them are already working to see if there is some wriggle room that might allow their theory to escape, scarred but alive.

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Chapter 3 : New Evidence Claims To Support Alternative Theory Of Gravity | IFLScience

Amongst those Brans Dicke theory [17] and Hoyle Narlikar theory [18] are most notable. However, these theories requires extra dark matter candidates to explain the galactic velocity pro les. There are several other theories such as induced matter theory [19{21], tired light hypothesis [22] etc. proposed by researchers.

Wikipedia A new theory of gravity might explain the curious motions of stars in galaxies. Emergent gravity, as the new theory is called, predicts the exact same deviation of motions that is usually explained by invoking dark matter. Erik Verlinde, renowned expert in string theory at the University of Amsterdam and the Delta Institute for Theoretical Physics, published a new research paper today in which he expands his groundbreaking views on the nature of gravity. In , Erik Verlinde surprised the world with a completely new theory of gravity. According to Verlinde, gravity is not a fundamental force of nature, but an emergent phenomenon. In the same way that temperature arises from the movement of microscopic particles, gravity emerges from the changes of fundamental bits of information, stored in the very structure of spacetime. Extending his previous work and work done by others, Verlinde now shows how to understand the curious behaviour of stars in galaxies without adding the puzzling dark matter. The outer regions of galaxies, like our own Milky Way, rotate much faster around the centre than can be accounted for by the quantity of ordinary matter like stars, planets and interstellar gasses. Something else has to produce the required amount of gravitational force, so physicists proposed the existence of dark matter. Dark matter seems to dominate our universe, comprising more than 80 percent of all matter. Hitherto, the alleged dark matter particles have never been observed, despite many efforts to detect them. No need for dark matter According to Erik Verlinde, there is no need to add a mysterious dark matter particle to the theory. In a new paper, which appeared today on the ArXiv preprint server, Verlinde shows how his theory of gravity accurately predicts the velocities by which the stars rotate around the center of the Milky Way, as well as the motion of stars inside other galaxies. According to the holographic principle , all the information in the entire universe can be described on a giant imaginary sphere around it. Verlinde now shows that this idea is not quite correctâ€"part of the information in our universe is contained in space itself. This extra information is required to describe that other dark component of the universe: Dark energy, which is believed to be responsible for the accelerated expansion of the universe. Investigating the effects of this additional information on ordinary matter , Verlinde comes to a stunning conclusion. Whereas ordinary gravity can be encoded using the information on the imaginary sphere around the universe, as he showed in his work, the result of the additional information in the bulk of space is a force that nicely matches that attributed to dark matter. Both theories, crown jewels of 20th century physics, cannot be true at the same time. The problems arise in extreme conditions: Verlinde says, "Many theoretical physicists like me are working on a revision of the theory, and some major advancements have been made. We might be standing on the brink of a new scientific revolution that will radically change our views on the very nature of space, time and gravity.

Chapter 4 : Gravitational Theories

The measurement of the speed of gravity with the gravitational wave event GW ruled out many alternative theories of gravity as explanation for the accelerated expansion. [17] [18] [19] Another observation that sparked recent interest in alternatives to General Relativity is the Pioneer anomaly.

Highly successful in everyday applications, newtonian gravitation has also proved accurate in describing motions in the solar system except for tiny relativistic effects , the internal structure of planets, the sun and other stars, orbits in binary and multiple stellar systems, the structure of molecular clouds, and, in a rough way, the structure of galaxies and clusters of galaxies but see below. There can be no instantaneous propagation. After a decade of search for new concepts to make gravitational theory compatible with the spirit of special relativity, Einstein came up with the theory of general relativity , the prototype of all modern gravitational theories. Its crucial ingredient, involving a colossal intellectual jump, is the concept of gravitation, not as a force, but as a manifestation of the curvature of space-time, an idea first mentioned in rudimentary form by the mathematician Ceorg Bernhard Riemann in Why talk of curvature? As any wave, such as light, propagates away from a gravitating mass, all frequencies in it are reduced by an amount proportional to the change in gravitational potential experienced by the wave. This redshift has been measured in the laboratory, in solar observations, and by means of high precision clocks flown in airplanes. However, imagine for a moment that general relativity had not yet been invented, but the redshift has already been measured. According to a simple argument owing to Alfred Schild, wave propagation under stationary circumstances can display a redshift only if the usual geometric relations implicit in Minkowski space-time are violated: The space-time must be curved. The observations of the redshift thus show that space-time must be curved in the vicinity of masses, regardless of the precise form of the gravitational theory. Einstein provided 10 equations relating the metric a tensor with 10 independent components describing the geometry of space-time to the material energy momentum tensor also composed of 10 components, one of which corresponds to our previous. Einstein also replaced the newtonian law of motion by the statement that free test particles move along geodesics, the shortest curves in the space-time geometry. Despite the great contrast between General Relativity and Newtonian theory, predictions of the former approach the latter for systems in which velocities are small compared to c and gravitational potentials are weak enough that they cannot cause larger velocities. This is why we can discuss with newtonian theory the structure of the earth and planets, stars and stellar clusters, and the gross features of motions in the solar system without fear of error. Einstein noted two other predictions of General Relativity. The second effect is the precession of the periastron of a binary system. According to newtonian gravitation, the orbit of each member of a binary is a coplanar ellipse with orientation fixed in space. Originally verified in the motion of Mercury, the precession has of late also been detected in the orbits of binary pulsars. All three effects mentioned depend on features of General Relativity beyond the weak equivalence principle. In practice this implies that within any region in a gravitational field, sufficiently small that space-time curvature may be ignored, all physical laws, when expressed in terms of the space-time metric, have the same forms as required by special relativity in terms of the metric of Minkowski space-time. Thus in a small region in the neighborhood of a black hole the source of a strong gravitational field we would describe electromagnetism and optics with the same Maxwell equations used in earthly laboratories where the gravitational field is weak, and we would employ the laboratory values of the electrical permittivity and magnetic susceptibility of the vacuum. Stressing that there is very little experimental evidence bearing on this assertion, Dicke and his student Carl Brans proposed in a modification of general relativity akin to a theory considered earlier by Pascual Jordan. In the Brans-Dicke theory the reciprocal of the gravitational constant is itself a one-component field, the scalar field , that is generated by matter in accordance with an additional equation. Because it involves both metric and scalar fields, the Brans-Dicke theory is dubbed scalar-tensor. Although not complying with the strong equivalence principle, the theory does respect a milder version of it, the Einstein equivalence principle, which asserts that only nongravitational laws and dimensionless constants have their special relativistic forms and values everywhere. Gravitation theorists call theories obeying the Einstein equivalence principle metric theories. The Brans-Dicke theory also reduces to Newtonian theory for systems with small velocities and weak potentials: It has a newtonian limit. In fact, Brans-Dicke theory is distinguishable from general relativity only by the value of its single dimensionless parameter which determines the effectiveness of matter in producing. The larger , the closer the Brans-Dicke theory predictions are to general relativity. Both theories predict the same gravitational redshift effect, although they predict slightly different light deflection and periastron precession effects; the differences vanish in the limit of infinite. Initially a popular alternative to General Relativity, the Brans-Dicke theory lost favor as it became clear that must be very large-an artificial requirement in some views. Nevertheless, the theory has remained a paradigm for the introduction of scalar fields into gravitational theory, and as such has enjoyed a renaissance in connection with theories of higher dimensional space-time. However, constancy of is not conceptually required. In the generic scalar-tensor theory studied by Peter Bergmann, Robert Wagoner, and Kenneth Nordtvedt, is itself a general function of. It is even possible for to evolve systematically in the favored direction. Thus in the variable mass theory VMT, see Table 1 , a scalar-tensor theory devised to test the necessity for the strong equivalence principle, the expansion of the universe forces evolution of toward a particular value at which diverges. Thus, late in the history of the universe and today is late , localized gravitational systems are accurately described by general relativity although the assumed gravitational theory is scalar-tensor. Comparison of Selected Gravitational Theories Theory.

Chapter 5 : Alternatives to general relativity - Wikipedia

Gravity at the atomic scale is actually the best description of the mechanism to how the force of gravity transmits. Outdated academic understanding of gravity has created an arena of chaos with in this field of research.

Alternative theory of gravity explains large structure formation -- without dark matter December 14, , Phys. Benitez JHU , T. Ford JHU , M. In the standard theory of gravityâ€”general relativityâ€”dark matter plays a vital role, explaining many observations that the standard theory cannot explain by itself. But for 70 years, cosmologists have never observed dark matter, and the lack of direct observation has created skepticism about what is really out there. Until one or more of these things happen, skeptics are still allowed. The ways that galaxies rotate and starlight bends gravitational lensing stray from predictions based on visible matter. Our Figure 1 [see citation below] illustrates that, in standard gravity, a no-dark-matter model does not do well at all. For, the case of dark energy also hinges on the assumption that general relativity describes gravity on larges scales. Dark energy is even more difficult to explain than dark matter, so it seems almost natural to look at gravity as the culprit in both cases. Building on this finding from scientists Skordis et al. General relativity describes space-time with only a tensor the metric , so it does not include these vector perturbations. In our solar system or galaxy, when we attack the problem of gravity, we solve the equation for the Newtonian potential. Actually, there are two potentials that characterize gravity: These two potentials are almost always very nearly equal to one another, so it is not usually necessary to distinguish them. This is ultimately what drives the overdense regions to accrete more matter than in standard general relativity. The quite remarkable thing about this growth is that Bekenstein introduced the vector field for his own completely independent reasons. Other problems that their theory or any alternative theory will have to confront include accounting for the mismatch in galaxy clusters between mass and light. Also, the theory must conform to at least two observations: In light of this, it is important to keep an eye open for possible alternative explanations. Even when, after the analysis, alternative theories turn out to be wrong, the result is still important, as it strengthen the evidence for dark matter as the only possible explanation of observations. Dodelson, Scott and Liguori, Michele.

Chapter 6 : New theory of gravity might explain dark matter

This work investigates alternative theories of gravity, the solutions to their ï¬•eld equations and the constraints that can be imposed upon them from observation and experiment.

Recent observations of a neutron star merger million light years away found that gravitational waves and light from the event arrived at Earth within 2 s of one another. This indicates that the two fundamentally different types of wave travel at the same speed to within 1 part in 1 1 5. In such theories, the value of the scalar field needed to explain acceleration would lead to gravitational waves orange that travel at significantly different speeds from that of light light blue [2 â€" 5]. This indicates that the two fundamentally different types of wave travel at Show more Figure 1: It accurately describes the dynamics of astronomical objects over a vast range of sizes from planets and stars, to black holes, all the way to galaxies. GR also predicts the expansion of the Universe as a whole. But the theory has fallen short in one respect: The second imagines that the cosmological constant is actually dynamical. Finally, the third possibility is that gravity behaves differently on large distance scales, requiring a modification of GR. Using the recent detection of a gravitational wave and light from a distant binary neutron merger, four research groups have now placed some of the tightest constraints to date on this third scenario [2 â€" 5]. The extraordinary observation that made this work possible occurred on August 17, , when the gravitational-wave detectors at the Advanced LIGO and Advanced Virgo experiments picked up a loud signal [6]. Within 2 s of the event, known as GW, an instrument onboard the Fermi gamma-ray satellite detected a short burst of gamma rays from a similar location in the sky [7]. Follow-up observations by telescopes across the globe confirmed that the gravitational wave and gamma rays came from the same sourceâ€"a binary neutron star merger in the NGC galaxy, approximately million light years away from Earth see 16 October Viewpoint. The fact that the two signals traveled from such a great distance, yet arrived at Earth just a few seconds apart, implies that gravitational waves travel at the same speed as light to within 1 part in 1 1 5 [8]. Previous constraints on the relative speeds had only been at the level of 1 part in 5, so this single observation improved our knowledge of a fundamental property of nature by 14 orders of magnitude. To understand how GW provides a stringent test for alternative gravity theories requires some background. GR is, in some sense, simple, involving just one dynamical field whose massless excitations are gravitational waves that travel at the speed of light. Theories that go beyond GR plus a cosmological constant generally do so by introducing new dynamical fields. The most general example of this approach is an extension of a theory first derived by Gregory Horndeski [9] known as beyond-Horndeski theory. Following this argument, the four research teams use the near-identical speeds of light and gravitational waves measured in GW to rule out any cosmologically relevant scalar field in disformal theories of gravity [2 â€" 5]. The papers present particularly severe constraints on what is known as the covariant Galileon model. This popular model is characterized by four free parameters and allows for acceleration without a cosmological constant. But GW implies a near vanishing of two of these parameters when one uses the model to derive the modified wave equation for gravitational waves. This is shown by three of the teams: Their results could be the death knell for covariant Galileons. Although the remaining two parameters in the theory can still be adjusted to yield an accelerating Universe, these adjusted values are incompatible with a variety of other cosmological observations, such as the correlation between galaxy distributions and the cosmic microwave background. This is a beautiful example of how multiple observables are needed to test acceleration models [10]. Indeed, the fourth paper in the quartet, by Jeremy Sakstein and Bhuvnesh Jain at the University of Pennsylvania, Philadelphia, uses GW and other astrophysical observations to rule out a narrower subclass of covariant Galileons. Looking beyond scalar fields, Baker and colleagues found that GW places tight constraints on dark energy models that involve coupling gravity to vector fields [2]. Similarly, a preprint uses the gravitational-wave event to constrain models that attempt to explain the dynamics of galaxies and other cosmological objects without dark matter [11]. GW indicates that gravitational waves must have experienced exactly the same delay. GW has had a surprisingly big impact on the field of dark energy, ruling out a significant fractionâ€"though most definitely not allâ€"of the parameter space of theories involving a scalar field coupled to gravity. Now that the gravitational-wave window is ajar, we can soon expect the detection of many more events like GW These will likely offer new ways to probe gravity and the physics behind the acceleration of the Universe. This research is published in Physical Review Letters. After completing his undergraduate degree in cosmic-ray physics at Humboldt University in Berlin, he transitioned to cosmology, obtaining his Ph. His thesis work was on simulations of cosmological-structure formation in modified gravity theories.

Chapter 7 : Alternative gravity theories -

The paper lists as modified gravity theories: General Relativity, Scalar-Tensor, Einstein-Aether, and Bimetric theories, as well as TeVeS, f(R), general higher-order theories, Horava-Lifschitz gravity, Galileons, Ghost Condensates, and models of extra dimensions including Kaluza-Klein, Randall-Sundrum,DGP, and higher co-dimension braneworlds.

Some ideas and suggestions from the Thunderbolts Project forum discussion on Gravity Waves. Could an electromagnetic event cause so-called "gravitational lensing" and other black-hole-related phenomena, AND also create something they might perceive as gravitational waves? The "lensing" that they see in space is just Plasma in different modes. Post by Zyxzevn A solar flare triggers a small change in the magnetic field. The field triggers the Aharonovâ€"Bohm effect which changes the phase of the signal in the direction of the magnetic field potential. This effect ignores any shielding. This can not be avoided in any means. The phase changes when the beam goes through a higher energy potential, so going back does not change the phase back again it increases the phase change instead. Looking at the signal it seems that the hanford detector received a slightly bigger signal. And that the signal is not purely sinusoid, more like a saw-tooth. A signal that is more common in electrical systems than gravity systems. The signal sure has all the earmarks of an electromagnetic chirp from high in the atmosphere, and the magnetosphere-ionosphere region tends to emit these very same frequencies. That motion was tiny, and nearer examples of gravity waves would create larger motions. To say it another way, to get a collision of black holes to chirp with the same strength as an electron being hit by a laser, you have to take your black holes out to an incredible distance If you study the published diagrams, you find they are reporting a signal peak at around Hz and a strain of 10 Again, that strain is so small you should find it highly curious. It puts the signal way down at the quantum level. That strain is a very odd place to look for gravity waves and black hole collisions, and it should look highly suspicious to you. It is simply the wrong level of size to look for anything to do with gravity or black holes. Intuitively, you would look for atomic wobbles or quantum fluctuations at that level of size, not gravity waves or star collisions. It is basically a signal of the light interacting with the electrons themselves. Why would they need to create a gigantic interferometer to detect gravity waves? Gravity is not an electromagnetic effect, of course, so it has no perpendicular component. Gravity Waves of Propaganda Miles Mathis link to PDF Thunderbolts Picture Of the Day article It is assumption upon assumption, building theories on the backs of other theories that can provide no experimental evidence. LIGO is not announcing some new principle of physics, it is announcing the confirmation of computer models fashioned according to presumptions. If black holes do not exist, there is no gravity wave detection. Seismic noise is a problem because the detector is near an interstate highway and a rail line. When trains went by, the interferometer was knocked out. Nearby logging is also a continuing problem. The team claims that dampening and filtering systems solved those issues. The laser mirrors deteriorated, requiring two of them to be removed and replaced. Wasps made nests in the beam tubes. Their waste caused a leak in the vacuum system. The wasps were evicted. The point here is that LIGO is a device concept that is rife with potentially fatal flaws. Were all of those flaws, as well as others fully rectified? The speed of the alleged waves is coordinate dependent. A different set of coordinates yields a different speed of propagation. Einstein and his followers deliberately choose a set of coordinates that gives the speed of propagation as that of light in vacuum. There is no a priori reason why this particular set of coordinates is better than any other. The sole reason for their choice is to obtain the desired result. Such a method has no validity in science. Einstein gravitational waves do not exist. In this paper various arguments are presented according to which the basic theoretical assumptions, and the consequential claims of detecting gravitational waves, are proven false. The apparent detection by the LIGO-Virgo Collaborations is not related to gravitational waves or to the collision and merger of black holes. More from an external source on Stephen Crothers and his paper on the subject of The Schwarzschild solution and its implications for gravitational waves link to PDF. Wallace Thornhill on black holes and the Electric Universe theory Wal Thornhill is one of the leading investigators into the EU theory and helped set up the Thunderbolts Project which is the official site of the unofficial EU theory. The question for the Electric Universe is therefore: The well-established study of plasma cosmology shows that galaxies are an electrical phenomenon. It has been found that filaments, arcs, and shells characterize the small-scale structure of molecular gas in the Galactic Center. They are all well-documented electrodynamic plasma configurations. A single charged particle in 10, neutral gas molecules is sufficient to have the gas behave as plasma, where electromagnetic forces dominate. It does not require strange matter or a strange star. The x-ray pulses are caused by regular electric discharges between two or more orbiting, normally constituted, electrically charged bodies. It is a manifestation of a periodic arc instead of a spinning star. If beaming of the radiation is occurring then that should be verifiable here on Earth in the lab by studying the plasma focus device. The Electric Universe model lets go of the Newtonian dogma that gravity is the driving force in the cosmos. It allows for the possibility that the fundamental characteristic of normal matter â€" its electric charge â€" plays the most significant role. And particle physicists who are trying to work out how the universe was constructed from strange matter early in the Big Bang are wasting their time. The astronomer Halton Arp, author of the Atlas of Peculiar Galaxies, has conclusively disproven the theory of an expanding universe and so knocked out the foundation of the Big Bang theory. Strange Star or Strange Science? Holoscience Anthony Patch - Wrong. At the moment this is about the only other video or article arguing against this proof of Gravity Waves. The chap who it is about, Anthony Patch, seems to believe in an Electric Universe. The youtube video and linked sites might be described as crackpot conspiracy theory. Yesterdays announcement of proof of gravitational waves is pure nonsense. Just as black holes are nonsense. The universe is composed of electrically charged particles and plasma. Thus, what mainstream science labels as gravity, gravity waves and graviton particles is at a minimum misleading to the public. At worse deliberate covering up of the truth as to how the universe and our understanding of its mechanics described by modern day physics and science in general.

Chapter 8 : Gravitational Waves not detected. Alternative theories to GWs

Any alternative theory of gravity would imply immediately an alternative cosmological theory since current modeling is dependent on general relativity as a framework assumption. There are many different motivations to modify general relativity, such as to eliminate the need for dark matter or dark energy, or to avoid such paradoxes as the firewall.

Chapter 9 : Colliding neutron stars apply kiss of death to theories of gravity | Ars Technica

Nevertheless, the theory has remained a paradigm for the introduction of scalar fields into gravitational theory, and as such has enjoyed a renaissance in connection with theories of higher dimensional space-time.