Galaxies pin down dark energy

Nov 25, 2010 23 comments

Galaxy pairs point to dark energy

A new way of measuring the geometry of the universe confirms that dark energy dominates the cosmos and bolsters the idea that this unusual form of energy is described by Einstein's cosmological constant. The technique, developed by physicists in France, involves a relatively easy measurement of the orientation of distant pairs of galaxies.

Over the past decade or so, several kinds of observation, such as measurements of the distances of remote supernovae, have provided strong evidence that the expansion of the universe is accelerating. Cosmologists believe that this expansion is being driven by what is known as dark energy – a substance with negative pressure that opposes the pull of gravity. Unfortunately, however, they have little idea of what dark energy actually is, having been unable to measure its properties well enough to distinguish between rival hypotheses.

The new approach, devised by Christian Marinoni and Adeline Buzzi of the University of Provence in Marseille, should help narrow down the options as well as provide another means of working out the geometry of space. It involves comparing the known shape of very distant objects with the shape of those objects as revealed by astronomers' observations. Astronomers don't measure distances, and hence shapes, directly, but instead measure the extent to which the wavelength of radiation from a distant object has increased – or redshifted. This tells them the speed at which the object and Earth are moving apart.

Unusual geometry

Hubble's law states that the speed at which objects within the universe move apart from one another is proportional to the distance between them, so knowing the speed of a distant object reveals how far away it is (although this is only approximately true at very great distances). But if the space between that object and the measurer has an unusual geometry or if the expansion of the universe is actually accelerating then the distance measured will not be accurate. So the idea is to vary the quantities that represent the geometry and the strength of dark energy until the distances of interest match up with expectations.

This principle was first proposed by the astronomers George Alcock

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Christian Marinoni
Alan Heavens

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Nature **468** 539

and Bohdan Paczyński in 1979 but has been difficult to carry out in practice because the redshift due to the local motions of the objects themselves tends to mask that caused by the expansion of the universe. What Marinoni and Buzzi have done is to study a system for which the local motions can be filtered out in quite a straightforward way. They don't measure a shape as such but instead the orientation of pairs of galaxies several billion light years from Earth that are in orbit around one another in binary systems. They reason that such galaxy pairs should be randomly oriented and so a large set of these binary systems should have an even distribution of orientations. Any deviation from that even distribution would reveal the influence of spatial geometry and dark energy, once the local effects have been removed.

To compare their technique against real observations they measured the orientations of galaxy pairs using data from the DEEP2 galaxy redshift survey and then used more local data from the Sloan Digital Sky Survey to calibrate the motion of the galaxies themselves. Their analysis agreed with the standard cosmological model regarding both the geometry of the universe and the abundance of dark energy – confirming that the universe is flat, in other words that it follows the ordinary laws of Euclidean geometry, and that dark energy makes up around 70% of the energy-matter content of the universe.

Cosmological constant is best bet

They also calculated a value for the strength of dark energy that suggests this substance comes in the form of the cosmological constant – a term that Einstein added to (and then removed from) his equations of general relativity. If correct, this means that the repulsive force is constant throughout the evolution of the universe and that it is mathematically is equivalent to the quantum-mechanical energy of the vacuum.

Marinoni argues that their technique represents a valuable additional approach to understanding dark energy, since, he says, it is "simple, transparent and faithful". In particular, he says, it does not rest on any questionable physical assumptions. "If you keep the technique simple you can avoid biases," he says. "Cosmology is a science where systematic errors are just behind the door."

If you keep the technique simple you can avoid biases. Cosmology is a science where systematic errors are just behind the door

Christian Marinoni, University of Provence

Alan Heavens of the University of Edinburgh, who wrote a commentary piece to accompany the paper, agrees that the new method is "nice and direct". But he warns that it does contain an assumption that must be tested – that the orbital properties of local galaxy pairs are equal to those of galaxies from 7 billion years ago, when the light left the objects catalogued in the DEEP2 survey.

The research is described in *Nature* **468** 539.

About the author

Edwin Cartlidge is a science writer based in Rome

23 comments

Comments on this article are now closed.

1 **andwor** Nov 25, 2010 3:03 PM

Advanced quantum Gravity

The energy in space-time is not really a mystery. The energy density signature (9.9 x 10^-27 kg/m^3) suggest is merely Planck energy h, distibuted in space time at the Planck length.

Offensive? Unsuitable? Notify Editor

2 **John Duffield**

Interesting article, this sounds like good solid spadework. And the upshot fits in with my conceptual

Nov 25, 2010 3:09 PM
United Kingdom

understand from general relativity and fundamental physics:

"If correct, this means that the repulsive force is constant throughout the evolution of the universe and that it is mathematically is equivalent to the quantum-mechanical energy of the vacuum".

This vacuum is space itself, and space has its stress-energy. Since stress is directional pressure (stress and pressure both being being measured in Pascals) space is under pressure, hence the universe expands. But what I can't understand is this:

"Cosmologists believe that this expansion is being driven by what is known as dark energy – a substance with negative pressure that opposes the pull of gravity".

How do cosmologists work out that space has negative pressure? It gets bigger like anything else under pressure that isn't confined, separating the galaxies within it just like the raisin-in-the-cake analogy. Anybody?

3 **Jarek Duda**
Nov 25, 2010 3:35 PM
Cracow, Poland

Why expect noise only for EM degrees of freedom?

Observe that we see a part of such repelling energy as microwave background - corresponding to EM degrees of freedom of vacuum are thermalized to 2.725K noise - according to Wikipedia, this energy density gives 6*10^-5 of energy of our Universe ...
... but there are also other interactions, which are much more difficult to directly observe in analogous way - gravitational, weak, strong - corresponding fields also have degrees of freedom - their interaction is very weak, but there was billions of years to thermalize them - equipartition theorem suggests that random interactions made that all/most of them should contain the same expected energy(1/2kT, where T=2.725K) - couldn't it be what they call dark energy?
Some of these degrees of freedom could interact weaker, such that in practice they are thermalized only in relatively active regions like galaxies, causing larger density of such energy there ... couldn't it be what is interpreted as dark matter?

What is wrong with such simple and natural dark energy/matter candidates?
EM isn't the only field/interaction we have and so background microwave radiation isn't the only kind of noise in space we should expect ...
Strong interaction is usually related with much larger energies than EM and the number of thermodynamical degrees of freedom grows with depth of potential well ...

Edited by Jarek Duda on Nov 25, 2010 3:37 PM.

4 **andwor**
Nov 25, 2010 4:22 PM

Quote:

> *Originally posted by **John Duffield***
> Interesting article, this sounds like good solid spadework. And the upshot fits in with my conceptual understand from general relativity and fundamental physics:
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> How do cosmologists work out that space has negative pressure? It gets bigger like anything else under pressure that isn't confined, separating the galaxies within it just like the raisin-in-the-cake analogy. Anybody?

Agreed John

But even though it is not confined, cosmologists where expecting the expansion to slow down due to gravity.

The surprise they got was it is speeding up, so that meant there had to be energy in space-time.

So when the Universe got big enough, about 5 billion years ago that energy in spacetime was able to oppose gravity (because the mass density was at a critical low point)and the Universe started accelerating.

What the article does't make clear because they only go back 7 billion years, is that initially there was more spacetime substance in the Universe, which did not for some reason cause acceleration.

The reason for that is that the substance of space-time was busily accreting to make matter. Yes space-time,the forces of Nature such as the photon and gluon, and matter itself are all made of the same stuff, but just differently configured - you knew all that any way

5 **TDSchneider**
Nov 25, 2010 5:00 PM

Quote:

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Maybe I can make this a bit more clear:

In the most common cosmological model the universe is treated as isotropic and all constituents are modeled as so called "perfect fluids" (no shear stresses, viscosity, or heat conduction,...). The equation of state for such a fluid can be expressed using the proper units (speed of light c=1) as

p=w*rho, rho: energy density, p: pressure,

so the dimensionless number w uniquely characterizes the fluid (examples: "ordinary cold" matter: w=0, radiation: w=1/3). Putting such a fluid into the so called Friedmann equations for cosmological expansion one finds for the evolution of the energy density

rho~a^(-3(w+1)), a: scale factor in metric ds^2=a(t)*dx^2-dt^2("size" of the universe)

In order to maintain a constant energy density during cosmological evolution a fluid needs to have negative pressure since for rho=const. one needs w=-1 which is equivalent to p=-rho and rho>0.

Maybe two more comments:

Since pressure is a scalar quantity, positive pressure (w>0) always contributes to the gravitational field in the same way as mass or energy.

One result of solving the Friedmann equations is, that for w<-1/3 one always gets an accelerated increase of the scale parameter a with time, which seems to be the case for our universe. That would mean, that the currently dominating constituent of the universe is something with w<-1/3 and observations so far seem to point more towards w=-1.

Edited by TDSchneider on Nov 25, 2010 5:12 PM.

6 **dchakalov**
Nov 26, 2010 12:00 AM

Why positive mass only?

Quote:

> *Originally posted by* ***TDSchneider***
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Dear Dr. Schneider,

The speculation about some substance "with negative pressure that opposes the pull of gravity" is derived on the basis of the unwarranted, and tacit, presumption that this same substance has *positive mass* density. On the other hand, you may have "constant energy density during cosmological evolution" with the two mass charges:

0 = (-m) + (+m)

The obvious problem with the conservation equation above is that you need to separate adiabatically the two charges in the r.h.s., yet it seems the task is doable, while the traditional approach based on the tacit presumption that we're dealing exclusively with positive mass substances leads to a dead-end: you're searching for an elephant in a china shop, only to find out that the elephant must be many times larger than the store itself.

A penny for your thoughts!

D. Chakalov

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7 **eugenesittampalam**
Nov 26, 2010 3:15 AM
Ottawa, Canada

"Over the past decade or so, several kinds of observation, such as measurements of the distances of remote supernovae, have provided strong evidence that the expansion of the universe is accelerating."

The high-profile researchers in the field here are, perhaps, unaware of some critical developments by way of those "several kinds of observation" made in the recent past. To make it short here, let's quickly see what a Nature editorial, of four years ago, had to say on the matter:

Type Ia supernovae are used as cosmological distance indicators. It is through them that the accelerating expansion of the Universe was detected, and with it the implied existence of dark energy. Their presumed reliability as 'standard candles' stems from the fact they have a fixed amount of fuel and a uniform trigger: they are predicted to explode when the mass of the white dwarf nears 1.4 solar masses, the 'Chandrasekhar' mass. Howell et al. now show that the high-redshift supernova SNLS-03D3bb does not play by these rules: its exceptionally high luminosity and low kinetic energy imply a super-Chandrasekhar mass progenitor. So future cosmological studies may need to consider possible contamination from such events when calculating distances.
Candle in the wind, Editor's Summary on: The type Ia supernova SNLS-03D3bb from a super-Chandrasekhar-mass white dwarf star, D. Andrew Howell (University of Toronto) et al., Nature 443, 308-311 (2006)

Please see also:
www.sittampalam.net/Editors.htm and
www.sittampalam.net/TheCosmologicalRedshift.htm
(Opens best with Internet Explorer)
Thank you all, and Cheers!

Offensive? Unsuitable? Notify Editor

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8 **S.Dino**
Nov 26, 2010 6:25 AM

Cosmolological Constant functions like G

I think a lot of people confuse the Cosmological constant (let's call it A) with the cosmological force. The repulsive force experienced by a galaxy is Amc^2r/3 where A is about 10^-52/m^2. The repulsive force is not constant but increases with distance(r). The Cosmological constant functions like G in Newton's equation Gm1m2/r^2.

The present day ratio of the repulsive dark energy force to the attractive gravitational force is 2 times the dark energy density/matter energy density or about 2x.73/.27 = 5.4. About 5 billion years ago the ratio was = 1. And that is one of the mysteries; why do we happen to be alive in the era when that ratio is about one?

Edited by S.Dino on Nov 26, 2010 6:42 AM.

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9 **huayuekang**
Nov 26, 2010 7:27 AM

Thanks

That's a good news, I get this news from my emal, though I'm not a physics student and I don't understand it all, I am happy to see any progress in science, and Thanks!

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10 **TDSchneider**
Nov 26, 2010 12:10 PM

Quote:

> *Originally posted by **dchakalov***
>
> Quote:
>
> > *Originally posted by **TDSchneider***
> > Putting such a fluid into the so called Friedmann equations for cosmological expansion one finds for the evolution of the energy density
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>
> A penny for your thoughts!
>
> D. Chakalov

It is true that in my short explanation above only positive energy/mass was considered (also called the positive energy condition in general relativity (GR)). It is also true that this condition is not strictly necessary for GR to be mathematically consistent. Examples for possible negative energies from theoretical physics include the Casimir effect, cosmic strings and wormholes.

However, so far there is no strong experimental evidence that such exotic objects exist in nature (at least in sufficiently large quantities to dominate the cosmic evolution). As seen above they are also not required to get accelerated cosmic expansion. And the existence of large quantities of negative energy would currently create more problems than it would solve , which many consider a bad thing by a kind of Occam's razor argument (but which in itself is not neccessarily a bad thing if you make a living by doing physics research ;)).

So my personal oppinion on this matter is, the positive energy assumption might not be strictly required, but is quite reasonable to start with and to stick to (avoiding lots of new problems) as long as you can.

Edited by TDSchneider on Nov 26, 2010 12:16 PM.

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11 **reader01**
Nov 26, 2010 1:57 PM

So cosmological constant can be calculate

from geometry of different galaxies. It depends of how far they are and what are the shapes and orientations of these galaxies. And it do not seem to be hard to calculate. And if it is so easy and the result is cosmological constant than can be really true.

Offensive? Unsuitable? Notify Editor

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12 **John Duffield**
Nov 26, 2010 3:09 PM
United Kingdom

Quote:

> *Originally posted by **andwor***
> ...The reason for that is that the substance of space-time was busily accreting to make matter. Yes space-time,the forces of Nature such as the photon and gluon, and matter itself are all made of the same stuff, but just differently configured - you knew all that any way.

Sure, but accreting doesn't sit well with the "silly putty" analogy: stretch a blob of it and it starts drooping, but the strand thins and weakens so the drooping accelerates. I ponder on the vacuum catastrophe caused by the strong force. Expansion means it gets weaker over time like you're coming out of a gravity well, so the expansion accelerates.

Quote:

> *Originally posted by **TDSchneider***
> In the most common cosmological model the universe is treated as isotropic and all constituents are modeled as so called "perfect fluids" (no shear stresses, viscosity, or heat conduction). The equation of state for such a fluid can be expressed using the proper units (speed of light c=1) as...

Thanks for this feedback, TD, I do appreciate it. There's number of issues that I might raise concerning what a gravitational field actually is, but they would detract from the article and take us off topic. Meanwhile you've answered my question, thanks.

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13 **genastyletto**
Nov 26, 2010 3:15 PM
United States

Just a thought

It is my humble understanding/thought that perhaps the expansion of the universe is gravitationally independent of celestial bodies. Rather it is expanding faster and faster because the universe is somehow expanding in order for the ends of the universe to meet, making it a round orb, thus disproving that the universe is flat. Think about it... it is expanding in all directions towards a circular shape and the charges/energies that be are being pulled closer to each other the closer they get due to the matter of which the universe is made.

Just a thought. I don't have the time to express the true vision/thought process behind this, but I have more proof this
could be the case.

Edited by genastyletto on Nov 26, 2010 3:29 PM.

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14 **mikki**
Nov 26, 2010 3:26 PM

Good summary of Nature editorial: In fact, the 'red-shift' or 'blue-shift' is a mistaken idea- because radiation has no-color, the colors you sense are created by the glass-prisum set-up within your telescope...The high-profile researchers in the field, I am afraid, are blinded by Newton's prisum & 7-colors (although Newton did not advocate mis-use of his colors...) Quote:

> *Originally posted by **eugenesittampalam***
> "Over the past decade or so, several kinds of observation, such as measurements of the distances of remote supernovae, have provided strong evidence that the expansion of the universe is accelerating."
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> The high-profile researchers in the field here are, perhaps, unaware of some critical developments by way of those "several kinds of observation" made in the recent past. To make it short here, let's quickly see what a Nature editorial, of four years ago, had to say on the matter:
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> Thank you all, and Cheers!

Offensive? Unsuitable? Notify Editor

15 **jimbo**
Nov 26, 2010 4:54 PM
eugene, United States

CC for Me !

D Chakalov champions negative mass in vain. The recent trapping of anti-Hydrogen at CERN will soon lead to The definitve, & hopefully final verdict on this contentious subject.
Actually, a pre-verdict was delivered almost a 1/4 century ago, when the Super-K neutrino detectors registered the arrival of both neutrino & anti-neutrino pulses from SN1987A. The pulses suffered identical gravitational interactions, yet arrived w/in a 12 sec. window after a journey of 170,000 yrs. If the anti-neutrinos had negative mass, it affected their arrival times by only a few parts per Trillion ! Thats good enough for me.
If it walks, quacks, & flies like a duck, Occam demands a duck.
Likewise for Dark Energy as the CosmoConstant. Over a decade now, the observations are best fit by a CC, despite the moaning denials of QFT theorists who refuse to accept the possibility that QFT is not applicable here. QFT has its own problems...
In 2009, Vikhilin et.al made measurements of Galaxy clusters, which nailed the CC to better than 5%: w = -0.991 +/- 0.045.
This fabulous work should end the arguments, once & for all.
Looks like a Duck to me !

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16 **dwyersuncreation**
Nov 26, 2010 5:19 PM

Why energy?

What is dark energy? An energy produced by dark matter? Until the subject of dark matter can be defined as to the "cause" -- there can be no energy emitted from it. Einstein's cosmological constant can definitely be equated to dark matter even though his inclusion of an all-pervading matter was only to "counter" gravity as he perceived it in Empty Space. Perhaps dark matter (aka pressure ether per a new theory in 2010) is a steam/mist/quantum foam whose overabundance will do the pushing or nudging of objects apart over Universal Time, but does not in and of itself possess energy. Without the cause, there can be no energy association.

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17 **karun.j** Nov 26, 2010 7:31 PM

interesting................ will have to think more on it.

Offensive? Unsuitable? Notify Editor

18 **Imre von Soos** Nov 26, 2010 9:55 PM

John Duffield wrote: "How do cosmologists work out that space has negative pressure? It gets bigger like anything else under pressure that isn't confined, separating the galaxies within it just like the raisin-in-the-cake analogy. Anybody?"

What is "negative pressure"? it must be suction. Where is its containing origin?

If I may allow myself a pun, the famous "fruit-cake analogy" is rather nutty: there exists no analogy. The cake is expanding in tiny bubbles, each driven by in-kneaded biochemical energy. While the raisins keep their sizes within their skins, which represent solid boundaries of interaction, no such boundaries exist in space.

If space as such is expanding and is taking the cosmic objects with it, there must be an interaction between space as such and each and every object it contains, and there must be a boundary, a surface of interaction between them; a boundary that maintains the size of the object.

Should space consist of some kind of a containing medium, within which the cosmic bodies are moving and should it expand as such, while taking the galactic clusters and galaxies with itself, it would have to do so concurrently with all the other objects in the cosmos, quotidian events, molecules, atoms and nucleons. This would be impossible to observe, because the observer, his rest frame and his devices would expand proportionally, being left with no absolute gauge to measure against, or event to compare to.

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19 **stonewallnz** Nov 27, 2010 12:33 AM

Physics and astrophysics

The techniques described sound good and I hope they sort out some of these questions. I am more worried by the trend to do some of this physics at the ends of the universe rather than in the lab down the street. Gravity is out there for the astrophysicist - no question. But physics should be examinable right here at home. I would question whether matter and antimatter do in fact both have positive gravitational mass? - not in theory but by experiment. What is the status of home lab experiments to measure attraction due to gravity? Are all the expts of the Cavendish type using lead, or has the simple law due to Newton, let alone Einstien, been examined for all materials. Of course in theory it should not matter. But what if it does? Then the differences might be so small that nobody (not measuring to the nth decimal) will notice till we get to dealing with huge things like the universe. It may be that the function for antimatter involves i, a complex function, which only becomes real and measurable in the interaction between two particles of antimatter. What happened about 14 minutes after neutrons formed in the universe, when they on average decayed, producing antiparticles? Has the matter-antimatter balance been constant? This dark energy seemes to be a pressure arising from space that does vary - it is meant to have at least made the acceleration in the expansion of the universe begin about 7 billion years ago. If we are going to evoke some new idea about gravity to "explain" this phenomenon, should we not examine the old expts and measurements more locally. It may be more tedious, but it could give results.

Offensive? Unsuitable? Notify Editor

20 **S.Dino** Nov 29, 2010 3:16 PM

Quote:

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I agree with a good deal of what you are saying here. Could have used your help about ten Physics World news articles
ago: "Antihydrogen trapped at CERN". There is a good deal of misinformation on this subject on the web. Many people are convinced that antimatter falls down and that this has been proven experimentally. In truth antimatter may fall down, but it may not - no decisive experiment has yet been conducted. However, there are plans to determine the gravitational acceleration of antihydrogen in the Earth's gravitational field. Check

out "AEGIS". Results should be in by 2014.

As to Eotvos type experiments; many (several dozen) different types of materials have been tried over the years, so far everything falls at the same rate to a high degree of accuracy. The first space based test of the equivalence principle -"MICROSCOPE" is due to be launched in late 2012. I think it will make use Platinum and Titanium and will be 100 times more accurate then Earth based experiments.

With regard to dark energy; I know a lot of physicists don't like it, but the experimental evidence indicates that some kind of repulsive force overcame gravity about 5 billion years ago and has been causing the Universe to expand at an accelerating rate. Currently that repulsive force is about 5.4 times stronger than the gravitational attraction.

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21 **bobroude**
Dec 1, 2010 3:28 AM
Carpentersville, United States

Quote:

> *Originally posted by* ***Imre von Soos***
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A solid continuation of Einsteins Spacetime moving mass is needed and there has been some progress. I agree with John that space has energy but we are still clueless as to how this energy becomes the force "Gravity". What are the mechanics of Spacetime? This puzzle should be able to be deciphered locally in the lab. Some Quantum gravity people see space in units or volumes. If space is in units then the units must expand but not multiply. We have measured spacial energy, expansion and it's effect on time. Space does appear to be quite dynamic so maybe Dark energy and Dark matter are just properties of Spacetime.

Offensive? Unsuitable? Notify Editor

22 **Imre von Soos**
Dec 1, 2010 11:30 AM

Reply to bobroude comment # 23:

I start up from the following fundamental propositions:

One of the basic ideas introduced by Einstein was that space and time are not from each other independent concepts, but constitute an unique, four-dimensional spacetime reference system, with width, depth, height and time as its four co-ordinates by which the dimensions, relative locations and movements of all physical events can be defined and interrelated. This was, in fact, an unprecedented statement of the obvious, as no physical events can be perceived and expressed without spatio-temporal structure. They are, as conceptual fundamentals, relative to the observer's reference system and belong to his spatio-temporal definition and correlation of all events.

Representing a conceptual and virtual structure, neither spacetime, nor space or time separately, can be "negative" or "imaginary"; can have subjective or objective roles or qualities; can "have energy", "move", "flow", "expand", "contract", "curl up"; or serve as containing or conveying medium for, or interact with electro-magnetic energy or matter.

Energy is a contained force-potential that becomes active through interaction with another force-potential or a structured energy process – matter – according to the respective intrinsic qualities and energy-level of each.

Electromagnetic energy follows basic harmonies as it takes form as fundamental elementary particles, each with definite and stable identities expressed with the manifestations of the same energy that also is their bonds and their movements. There is an underlying principle behind all processes expressing material forms; a principle that is not of the energy, but that is inherent and is transcending every physical manifestation. Therefore, a particle – fundamental or ephemeral – could be defined as: structured energy in harmoniously ordered form and action.

An energy-form – as a force, or as a structured process – can interact – that is, produce an effect through applied force – only with another energy-form of its own fundamental kind: it must be of electromagnetic nature.

All physical energy manifestations – detectable, definable and measurable by currently accepted scientific methods – are founded on the electromagnetic energy; are characterised by movement at some structural stratum; and their dimensions are never absolute, but relative to particular inertial frames.

Energy forms manifest themselves in different effects, can be perceived through different ways, are measurable with different methods: nevertheless they are not different energies, but different transduceable forms of the same fundamental electromagnetic energy. Accordingly, the first principle of thermodynamics, stating that "heat and mechanical energy are mutually convertible", can be generalized for "all electromagnetic energy forms are mutually convertible".

The gravitational, molecular, atomic and subatomic interactions, masses and other attributes of the particles are all due to their intrinsic qualities, originated in electromagnetic energy and are not due to some kind of extrinsic forces or ephemeral particles to be searched for by using destructive tests.

Can we continue on the same basis, or any other rational proposition?

23 **mikki**
Dec 1, 2010 12:13 PM

"Gravity" is force- there is no energy in space- only Magnetic & Electric forces at 90 degrees to each other. So, the Q is what is causing this force? Not Einstein's space-time; reverse might be true- it is the time that defines space under a force. Earth or Planet location in space depends upon the time- if you want to know how far away you are in space from our-Sun?
Space has no-negative pressure. Space is all atoms like in you, I or the tree. Do you think you or I have negative pressure within our-atoms and keep cells accelerate or expand into a huge... No.

> Quote:
>
> *Originally posted by **bobroude***
>
> > Quote:
> >
> > *Originally posted by **Imre von Soos***
> > John Duffield wrote: "How do cosmologists work out that space has negative pressure? It gets bigger like anything else under pressure that isn't confined, separating the galaxies within it just like the raisin-in-the-cake analogy. Anybody?"
> >
> > What is "negative pressure"? it must be suction. Where is its containing origin?
> >
> > If I may allow myself a pun, the famous "fruit-cake analogy" is rather nutty: there exists no analogy. The cake is expanding in tiny bubbles, each driven by in-kneaded biochemical energy. While the raisins keep their sizes within their skins, which represent solid boundaries of interaction, no such boundaries exist in space.
> >
> > If space as such is expanding and is taking the cosmic objects with it, there must be an interaction between space as such and each and every object it contains, and there must be a boundary, a surface of interaction between them; a boundary that maintains the size of the object.
> >
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