

archived as www.stealthskater.com/Documents/DarkEnergy_01.doc

(also ...[DarkEnergy_04.pdf](#)) => [doc](#) [pdf](#) [URL-doc](#) [URL-pdf](#)

more of this topic on the [/Science.htm](#) page at [doc](#) [pdf](#) [URL](#)

note: because important websites are frequently "here today but gone tomorrow", the following was archived from <http://www.sciam.com/article.cfm?id=does-dark-energy-exist> on March 23, 2009. This is NOT an attempt to divert readers from the aforementioned website. Indeed, the reader should only read this back-up copy if the updated original cannot be found at the original author's site.

Does Dark Energy Really Exist?

or does Earth occupy a very unusual place in the Universe?

by Timothy Clifton and Pedro G. Ferreira
Scientific American / March, 2009

Key Concepts

- The Universe appears to be expanding at an accelerating rate, implying the existence of a strange new form of energy ("dark energy"). The problem: no one is sure what dark energy is.
- Cosmologists may not actually need to invoke exotic forms of energy. If we live in an emptier-than-average region of space, then the cosmic expansion rate varies with position which could be mistaken for a variation in time or acceleration.
- A giant void strikes most cosmologists as highly unlikely. But so for that matter does dark energy. Observations over the coming years will differentiate between the 2 possibilities.

In Science, the grandest revolutions are often triggered by the smallest discrepancies. In the 16th Century, based on what struck many of his contemporaries as the esoteric minutiae of celestial motions, Copernicus suggested that Earth was not, in fact, at the center of the Universe.

In our own era, another revolution began to unfold 11 years ago with the discovery of the accelerating Universe. A tiny deviation in the brightness of exploding stars led astronomers to conclude that they had no idea what 70 percent of the Cosmos consists of. All they could tell was that space is filled with a substance unlike any other one that pushes along the expansion of the universe rather than holding it back. This substance became known as "**dark energy**".

It is now over a decade later and the existence of dark energy is still so puzzling that some cosmologists are revisiting the fundamental postulates that led them to deduce its existence in the first place. One of these is the product of that earlier revolution: the Copernican Principle that Earth is not in a central or otherwise special position in the Universe. If we discard this basic principle, a surprisingly different picture of what could account for the observations emerges.

Most of us are very familiar with the idea that our planet is nothing more than a tiny speck orbiting a typical star somewhere near the edge of an otherwise unnoteworthy galaxy. In the midst of a Universe populated by billions of [galaxies](#) that stretch out to our cosmic horizon, we are led to believe that there is

nothing special or unique about our location. But what is the evidence for this cosmic humility? And how would we be able to tell if we were in a special place?

Astronomers typically gloss over these questions, assuming our own typicality sufficiently obvious to warrant no further discussion. To entertain the notion that we may, in fact, have a special location in the Universe is -- for many -- unthinkable. Nevertheless, that is exactly what some small groups of physicists around the World have recently been considering.

Ironically, assuming ourselves to be insignificant has granted cosmologists great explanatory power. It has allowed us to extrapolate from what we see in our own cosmic neighborhood to the Universe at large. Huge efforts have been made in constructing state-of-the-art models of the Universe based on the **Cosmological Principle** -- a generalization of the Copernican Principle that states that at any moment in time all points and directions in space look the same.

Combined with our modern understanding of space, time, and matter, the Cosmological Principle implies that space is expanding; that the Universe is getting cooler; and that it is populated by relics from its hot beginning predictions that are all borne out by observations.

Astronomers find, for example, that the light from distant galaxies is redder than that of nearby galaxies. This phenomenon (known as **redshift**) is neatly explained as a stretching of light waves by the expansion of space. Also, microwave detectors reveal an almost perfectly smooth curtain of radiation emanating from very early times (the **Cosmic Microwave Background** - a relic of the primordial fireball). It is fair to say that these successes are in part a result of our own humility (i.e., the less we assume about our own significance, the more we can say about the Universe).

Darkness Closes In

So why rock the boat? If the Cosmological Principle is so successful, why should we question it?

The trouble is that recent astronomical observations have been producing some very strange results. Over the past decade, astronomers have found that for a given redshift, distant supernova explosions look dimmer than expected. Redshift measures the amount that space has expanded. By measuring how much the light from distant supernovae has redshifted, cosmologists can then infer how much smaller the universe was at the time of the explosion as compared with its size today. The larger the redshift, the smaller the Universe was when the supernova occurred and hence the more the Universe has expanded between then and now.

The observed brightness of a supernova provides a measure of its distance from us. Which in turn reveals how much time has elapsed since it occurred. If a supernova with a given redshift looks dimmer than expected, then that supernova must be farther away than astronomers thought. Its light has taken longer to reach us and hence the Universe must have taken longer to grow to its current size. Consequently, the expansion rate of the Universe must have been slower in the past than previously expected.

In fact, the distant supernovae are dim enough that the expansion of the Universe must have accelerated to have caught up with its current expansion rate [see "Surveying Spacetime with Supernovae" by Craig J. Hogan, Robert P. Kirshner, and Nicholas B. Suntzeff; *Scientific American*, January 1999].

This accelerating expansion is the big surprise that fired the current revolution in Cosmology. Matter in the Universe should tug at the fabric of space-time, slowing down the expansion. But the

supernova data suggest otherwise. If cosmologists accept the Cosmological Principle and assume that this acceleration happens everywhere, we are led to the conclusion that the Universe must be permeated by an *exotic* form of energy (i.e., **dark energy**) that exerts a repulsive force.

Nothing meeting the description of dark energy appears in physicists' Standard Model of fundamental particles and forces. It is a substance that has not as yet been measured directly; has properties unlike anything we have ever seen; and has an energy density some 10^{120} times less than we may have naively expected. **[SS: is this supposed to be 10^{120} ?]** Physicists have ideas for what it might be. But they remain speculative [see "The Quintessential Universe" by Jeremiah P. Ostriker and Paul J. Steinhardt; *Scientific American*, January 2001].

In short, we are very much "in the dark" about dark energy. Researchers are working on a number of ambitious and expensive ground- and space-based missions to find and characterize dark energy (whatever it may be). To many, it is the greatest challenge facing modern Cosmology.

A Lighter Alternative

Confronted with something so strange and seemingly so improbable, some researchers are revisiting the reasoning that led them to it. One of the primary assumptions they are questioning is whether we live in a representative part of the Universe. Could the evidence for dark energy be accounted for in other ways if we were to do away with the Cosmological Principle?

In the conventional picture, we talk about the expansion of the Universe on the whole. It is very much like when we talk about a balloon blowing up: we discuss how big the entire balloon gets and not how much each individual patch of the balloon inflates. But we all have had experience with those annoying party balloons that inflate unevenly. One ring stretches quickly and the end takes a while to catch up.

In an alternative view of the Universe -- one that jettisons the Cosmological Principle -- space also expands unevenly. A more complex picture of the Cosmos emerges.

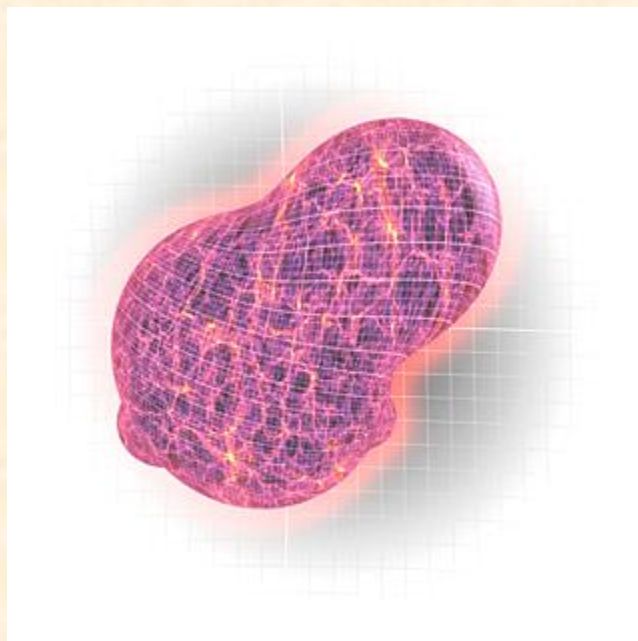
Consider the following scenario first suggested by George Ellis, Charles Hellaby, and Nazeem Mustapha (all at the University of Cape Town in South Africa) and subsequently followed up by Marie-Noëlle Chabrier (of the Paris-Meudon Observatory in France). Suppose that the expansion rate is decelerating everywhere as matter tugs on space-time and slows it down. Suppose further that we live in a gargantuan cosmic void not a completely empty region but one in which the average density of matter is only a half or maybe a third of the density elsewhere.

The emptier a patch of space is, the less matter it contains to slow down the expansion of space. Accordingly, the local expansion rate is faster within the void than it is elsewhere. The expansion rate is fastest at the very center of the void and diminishes toward the edge where the higher-density exterior begins to make itself felt. At any given time, different parts of space will expand at different rates like the unevenly-inflated party balloon.

Now imagine supernovae exploding in different parts of this inhomogeneous universe -- some close to the center of the void and others nearer the edge and some outside the void. If we are near the center of the void and a supernova is farther out, space expands faster in our vicinity than it does at the location of the supernova. As light from the supernova travels toward us, it passes through regions that are expanding at ever faster rates.

Each region stretches the light by a certain amount as it passes through and the cumulative effect produces the redshift we observe. Light traveling a given distance is redshifted by less than it would be if the whole universe expanded at our local rate. Conversely, to achieve a certain redshift in such a universe, the light has to travel a greater distance than it would in a uniformly expanding universe. In which case the supernova has to be farther away and therefore appear dimmer.

Another way to put it is that a variation of expansion rate with position mimics a **variation in time**. In this way, cosmologists can explain the unexpected supernova observations without invoking dark energy. For such an alternative explanation to work, we would have to live in a void of truly Cosmic proportions. The supernova observations extend out to billions of light-years (a significant fraction of the entire observable Universe). A void would have to be of similar size. Enormous by (almost) anyone's standards.



Uneven expansion of space caused by variations in the density of matter on an epic scale could produce the effects that astronomers conventionally attribute to "dark energy".

A Far-fetched Possibility

So how outlandish is this cosmic void? At first glance -- very. It would seem to fly in the face of the Cosmic Microwave Background (which is uniform to one part in 100,000) not to mention the apparently uniform distribution of galaxies [see "[Reading the Blueprints of Creation](#)" by Michael A. Strauss; *Scientific American*, February 2004]. On closer inspection, however, this evidence may not be so conclusive.

The uniformity of the relic radiation merely requires the Universe to look nearly the same in every direction. If a void is roughly spherical and if we lie reasonably close to its center, these observations do not necessarily preclude it. In addition, the Cosmic Microwave Background has some anomalous features that could potentially be explained by large-scale inhomogeneity.

As for the galaxy distribution, existing surveys do not extend far enough to rule out a void of the size that would mimic dark energy. They identify smaller voids, filaments of matter and other structures hundreds of millions of light-years in size, but the putative void is an order of magnitude larger.

A lively debate is now under way in Astronomy as to whether galaxy surveys corroborate the Cosmological Principle. A recent analysis by David Hogg of New York University and his collaborators indicates that the largest structures in the Universe are about 200 million light-years in size. On larger scales, matter appears smoothly distributed in accordance with the Principle. But Francesco Sylos Labini of the Enrico Fermi Center in Rome and his colleagues argue that the largest structures discovered so far are limited only by the size of the galaxy surveys that found them. Still larger structures might stretch beyond the scope of the surveys.

By analogy, suppose you had a map showing a region 10 miles wide, on which a road stretched from one side to the other. It would be a mistake to conclude that the longest possible road is 10 miles long. To determine the length of the longest road, you would need a map that clearly showed the end points of all roads so that you would know their full extent.

Similarly, astronomers need a galaxy survey that is larger than the biggest structures in the Universe if they are to prove the Cosmological Principle. Whether surveys are big enough yet is the subject of the debate.

For theorists, too, a "colossal void" is difficult to stomach. All available evidence suggests that galaxies and larger structures such as filaments and voids grew from microscopic quantum seeds that cosmic expansion enlarged to astronomical proportions. Cosmological theory makes firm predictions for how many structures should exist with a certain size. The larger a structure is, the rarer it should be. The probability of a void big enough to mimic dark energy is less than one part in 10100. **[SS: again, should this be 10^{100} ?]** Giant voids may well exist out there. But the chance of our finding one in our observable Universe would seem to be tiny.

Still, there is a possible loophole. In the early 1990s, one of the authors of what is now the "standard model of the early universe" -- Andrei Linde -- and his collaborators at Stanford University showed that although giant voids are rare, they expand faster early on and come to dominate the volume of the Universe. The probability of observers finding themselves in such a structure may not be so tiny after all. This result shows that the Cosmological Principle (i.e., that we do not live in a special place) is not always the same thing as the principle of mediocrity (i.e., that we are typical observers). One can, it seems, be both typical and live in a special place.

Testing the Void

What observations could tell whether the expansion of the Universe is driven by dark energy or whether we are living in a special place (such as at the center of a giant void)? To test for the presence of a void, cosmologists need a working model of how space, time, and matter should behave in its vicinity.

Just such a model was formulated in 1933 by Abb Georges Lema tre, independently rediscovered a year later by Richard Tolman, and further developed after World War II by Hermann Bondi. The universe they envisaged had expansion rates that depended not only on time but also on distance from a specific point just as we now hypothesize.

With the Lema tre-Tolman-Bondi model in hand, cosmologists can make predictions for a range of observable quantities. To begin, consider the supernovae that first led to the inference of dark energy. The more supernovae that astronomers observe, the more accurately they can reconstruct the expansion history of the Universe.

Strictly speaking, these observations cannot ever rule out the void model because cosmologists could re-create any set of supernova data by choosing a suitably shaped void. Yet for a void to be completely indistinguishable from dark energy, it would have to have some very strange properties indeed.

The reason is that the putative accelerating expansion occurs right up to the present moment. For a void to mimic it exactly, the expansion rate must decrease sharply away from us and in every direction. Therefore, the density of matter and energy must increase sharply away from us in every direction. The density profile must look like an upside-down witch's hat (the tip of which corresponds to where we live). Such a profile would go against all our experience of what structures in the Universe look like. (i.e., They are usually smooth, not pointy).

Even worse, Ali Van der veld and Anna Flanagan (both then at Cornell University) showed that the tip of the hat (where we live) would have to be a **singularity** like the ultra-dense region at the center of a black hole.

If, however, the void has a more realistic, smooth density profile, then a distinct observational signature presents itself. Smooth voids still produce observations that could be mistaken for acceleration. But their lack of pointy-ness means that they do not reproduce exactly the same results as dark energy.

In particular, the apparent rate of acceleration varies with redshift in a telltale way. In a paper with Kate Land, then at the University of Oxford, we showed that several hundred new supernovae -- on top of the few hundred we currently have -- should be enough to settle the issue. Supernova-observing missions stand a very good chance of achieving this goal soon.

Supernovae are not the only observables available. Jeremy Goodman of Princeton University suggested another possible test in 1995 using the microwave background radiation. At the time, the best evidence for dark energy had not yet emerged and Goodman was not seeking an explanation for any unexplained phenomena but proof of the Copernican Principle itself. His idea was to use distant clusters of galaxies as mirrors to look at the Universe from different positions like a celestial dressing room.

Galaxy clusters reflect a small fraction of the microwave radiation that hits them. By carefully measuring the spectrum of this radiation, cosmologists could infer some aspects of what the Universe would look like if viewed from one of them. If a shift of viewpoint changed how the Universe looked, it would be powerful evidence for a void or a similar structure.

2 teams of cosmologists recently put this idea to the test. Robert Caldwell of Dartmouth College and Albert Stebbins of the Fermi National Accelerator Laboratory in Batavia, Ill. studied precise measurements of distortions in the microwave background. Juan Garcia-Bellido of the University of Madrid and Troels Haugbølle of the University of Aarhus in Denmark looked at individual clusters directly.

Neither group detected a void. The best the researchers could do was to narrow down the properties that such a void could have. The Planck Surveyor satellite (scheduled for launch this month) should be able to place stronger limits on the void properties and maybe rule out a void altogether.

A third approach advocated by Bruce Bassett, Chris Clarkson and Teresa Lu (all at the University of Cape Town) is to make independent measurements of the expansion rate at different locations. Astronomers usually measure expansion rates in terms of redshift which is the cumulative effect of the expansion of all regions of space between a celestial body and us. By lumping all these regions together, redshift cannot distinguish a variation of expansion rate in space from a variation in time. It

would be better to measure the expansion rate at specific spatial locations, separating out the effects of expansion at other locations.

That is a difficult proposition, though, and has yet to be done. One possibility is to observe how structures form at different places. The formation and evolution of galaxies and galaxy clusters depend in large part on the local rate of expansion. By studying these objects at different locations and accounting for other effects that play a role in their evolution, astronomers may be able to map out subtle differences in expansion rate.

A Not So Special Place

The possibility that we live in the middle of a giant cosmic void is an extreme rejection of the Cosmological Principle. But there are gentler possibilities.

The Universe could obey the Cosmological Principle on large scales. But the smaller voids and filaments that galaxy surveys have discovered might collectively mimic the effects of dark energy. Tirthabir Biswas and Alessio Notari (both at McGill University) as well as Valerio Marra and his collaborators (then at the University of Padua in Italy and the University of Chicago) have studied this idea.

In their models, the Universe looks like Swiss cheese uniform on the whole but riddled with holes. Consequently, the expansion rate varies slightly from place-to-place. Rays of light emitted by distant supernovae travel through a multitude of these small voids before reaching us. And the variations in the expansion rate tweak their brightness and redshift.

So far, however, the idea does not look very promising. One of us (Clifton) -- together with Joseph Zuntz of Oxford -- recently showed that reproducing the effects of dark energy would take lots of voids of very low density distributed in a special way.

Another possibility is that dark energy is an artifact of the mathematical approximations that cosmologists routinely use. To calculate the cosmic expansion rate, we typically count up how much matter a region of space contains; divide by the volume of the region; and arrive at the average energy density. We then insert this average density into Einstein's equations for Gravity and determine the averaged expansion rate of the Universe. Although the density varies from place to place, we treat this scatter as small fluctuations about the overall average.

The problem is that solving Einstein's equations for an averaged matter distribution is not the same as solving for the real matter distribution and then averaging the resulting geometry. In other words, we average and then solve when really we should solve and then average.

Solving the full set of equations for anything even vaguely approximating the real Universe is unthinkably difficult. And so most of us resort to the simpler route. Thomas Buchert of the University of Lyon in France has taken up the task of determining how good an approximation it really is. He has introduced an extra set of terms into the cosmological equations to account for the error introduced by averaging before solving. If these terms prove to be small, then the approximation is good. If they are large, it is not.

The results so far are inconclusive. Some researchers have suggested that the extra terms may be enough to account for dark energy entirely whereas others claim they are negligible.

Observational tests to distinguish between dark energy and the void models are set to be carried out in the very near future. The Supernova Legacy Survey -- led by Pierre Astier of the University of Paris, and the Joint Dark Energy Mission -- currently under development should pin down the expansion history of the Universe.

The Planck Surveyor satellite and a variety of ground-based and balloon-borne instruments will map out the microwave background in ever greater detail.

The Square Kilometer Array (a gigantic radio telescope planned for 2020) will supply us with a survey of all the galaxies within our observable horizon.

This revolution in Cosmology began a decade ago. And it is far from over.

About the Authors

Timothy Clifton and Pedro G. Ferreira are cosmologists at the University of Oxford. Both study the physics of the early Universe and potential modifications to Einstein's General Theory of Relativity.

Clifton -- a keen oenophile -- says his true interest in life is Burgundy wine.

Ferreira is the author of the popular-level astronomy book The State of the Universe. He runs a program for artists in residence at Oxford and participates in various projects to support science education in Africa.

Readers' Comments

1. suresh10in at 03/17/09 , 01:06 AM

While it is true that a large void can simulate the effects of dark energy, it goes against the Cosmoogical Principle which is accepted as per current observations and calculations based on the theoretic predictions. But if the Universe has a fractal structure in spite of a large-scale homogenous nature, then voids have a place as some have pointed out.

But there is a possibility that the problem may be with the signal itself. That light particles or the electromagnetic wave quanta or photons that convey the information may hide the puzzle within. The photon travels at the speed-of-light or absolute velocity because it has zero rest mass. Why not the photon contain a deeper structure with a dark energy interior within that neutralizes the mass due to its radiational energy that we measure from outside. Inside the photon could be equally balanced by dark and radiant energy principles such that it is neutralizing its mass principle.

In the very early Universe, the intense enry radiation-matter interactions might have been characterized by ultra-high energies and smaller spatial lengths correspondingly so as to reveal the deeper structures of photons and its dark energy interiors. This component could have contributed to the Inflation which seemed to have smoothed out the anisotropies and inhomogeneities.

At the very periphery of the Universe (or in certain stellar forming regions or wherever there are intense matter-radiation interactions), this process can repeat giving rise to dark energy effects or what would appear as black-holes to an outside observer from a distance (though, in fact, these could be dark energy stars as well).

This can also explain the gamma ray bursts of intense energy in certain directions and the observation of quasars in neighborhood galaxies (which need not be due to gravitational lensing effects).

If photons have a structure which are revealed as a dark energy principle in high-energy interactions with matter, then the energy density in Universe could be accounted for by photons themselves without having to resort to assumptions of dark energy. The large presence of electromagnetic radiations in the Universe is at present accounted for only on the basis of its attractive gravitational potential in terms of its energy density. Which may not be considerable.

But if the photon opens up in high energy interactions with matter, then the dark energy component could be significant due to its repulsive gravity showing up as dark energy. Vacuum energy could also be muted by virtual photon envelope.

-- SURESHKUMAR.NIIST

2. jtankers at 03/17/09 , 04:34 PM

The article proposes a clever possibility -- suggesting that acceleration of universal expansion is just an illusion and dark energy may not exist. But there may be another possibility worth exploring:

Assuming the Universe is in fact flat/disc shaped rather than spherical and acceleration of universal expansion is real and not an illusion, then there may be at least one simple explanation for the effects we attribute to a mysterious "dark energy":

Has anyone done the math to determine if measured acceleration of universal expansion is consistent with the possibility that the Universe is in rotation around the gravitational center of the Universe?

(Similar effect as dropping marbles on the center of a rotating turn table [old style record player] and viewing the accelerating expansion of the other marbles from the view point of one of the marbles. The reference marble would have difficulty knowing if it was rotating just by viewing the other marbles except that the rate of expansion of the other marbles would appear to increase as the marbles moved away from the center...)

What might that say about the mechanics of the 'Big Bang' that might have set the Universe in rotation?

3. suresh10in at 03/18/09 , 12:52 AM

if matter-energy interactions could have revealed the structure of photon and caused dark energy effects to evidence, then it should be possible to verify this through the super or large hadron collider experiments once resumed.

Assuming a mass of 10^{65} -to- 10^{70} gms for visible Universe, we can postulate a similar range for radiational energy mass (at the rate of 1 photon per cu.cm). If we consider that most of this energy comes from high-energy cosmic rays or gamma radiation, then we can work out dark energies larger by an order of magnitude, enveloped within the photonic structure, decaying towards the exterior such that it is equal and opposite to the radiant energy or charge of the photon at the outside as measured by an external observer.

This will give dark energy densities of an order of magnitude higher than the observed energy density with attractive gravity potential where as the internal dark energy with repulsive gravity is shrouded in the photonic structure. This will be revealed to posit dark energy effects with densities a few times higher than baryonic mass densities as the photon opens up in high particle interactions with energies simulating the early Universe conditions when matter-radiation interactions were strong.

Such strong interactions had caused the dark energy effects to evidence causing Inflation in the early Universe.

--SURESHKUMAR.S,ADVISER,NIIST,TRIVANDRUM,INDIA

4. jtankers at 03/18/09 , 12:15 PM

Hello suresh10in --

Good creative thinking that a repulsive gravity would make sense for both universal expansion and 'Big Bang' inflation. Good conjecture probably not ruled in or out at this time. But is it the simplest explanation?

Another less complex possibility that does not require new and unconfirmed forces might also answer the related emailed question that I received "please try to explain your figure...".

Solar systems are flat and disc-shaped and rotate around a star (gravity of the star balances with centrifugal forces of orbiting planets). Galaxies are flat and disc-shaped and rotate around a supermassive black hole (gravity of the super massive black hole balances with centrifugal forces of orbiting stars). The Universe may be flat and disc-shaped and unknown if it rotates around its center of gravity (gravity of center of universal mass opposed by centrifugal forces of orbiting galaxies).

A rotating universe does not have a fixed central point like a "center-of-gravity". The universe's center-of-gravity expands as the universe expands.

As the universe expands outward, the gravitational pull from its center of mass decreases and centrifugal forces of orbiting galaxies dominate, causing an acceleration of expansion away from the center -f-rotation.

... another possible [simple] explanation for apparent observed acceleration of the rate of expansion of the universe, assuming universal expansion is actually accelerating and it is not just an illusion as is also possible ["interpretation error concerning the infrared-effect"].

5. imyfujita at 03/19/09 , 09:31 AM

The light bends the gravity. The matter produces the gravity field and the energy of emission produces the separation field.

It is said by all the people that the gravity has the same intensity regardless of the direction of measurement and that it is isotropic. But I think that the gravity will work not only 3-dimensionally but also 2- or 1-dimensionally. In the 2- or 1-dimensional gravity, the gravity will be concentrated in one plane or line and will have a stronger effect than 3-dimensional gravity has.

Then the separation forces are necessary in order to smash the gravity into 2 or 1 dimension. Then the imaginary factor is necessary.

-- Iori Fujita <http://www.geocities.jp/imyfujita/galaxy/galaxy01.html>

6. Robin Cox at 03/21/09 , 11:49 AM

I applaud the authors' efforts to find an alternative to "dark energy" to explain the apparent increase in the expansion rate of the Universe. To any normal scientist, "dark energy" as a concept seems highly improbable. However, the proposed increase in the expansion rate of the Universe rests upon just one observation that far distant supernova explosions are dimmer than they should be.

There is a fundamental assumption made here that no-one seems to explicitly acknowledge. That the rate of passage of time has remained constant throughout the history of the Universe (i.e., that one second now is the same as one second ten billion years ago).

We know via Einstein that the rate of passage of time can in fact vary under certain conditions. One of these is the matter density. For instance, time passes more slowly the closer one approaches a black hole. One certain fact seems to be that the amount of mass/energy in the Universe (whatever its form) has not changed since the 'Big Bang'. So in the early Universe, the matter density must have been higher than it is now.

My feeling is that these supernova observations are in fact sampling an era when time in the Universe passed more slowly than it does now. This assumption would explain the observations as well as any "dark energy" assumption. Has anyone done any calculations along these lines? I would greatly value the authors' opinion here.

If true, this has extreme implications for the history of the Universe. One would be that in fact it had no beginning. Since the matter density in the proposed singularity involved in the 'Big Bang' would have been infinite, time would have been passing infinitely slowly.

I know that those seeking a "Theory of Everything" do not like infinities and will make any assumptions to avoid them. But perhaps they are unavoidable and the Universe is a kind of hyperbola.

7. Mick_Malkemus at 03/23/09 , 08:50 AM

This has been my idea all along. Just because space appears to expand doesn't mean that it does. It is only our collective assumption based upon our visual sense. And as we all know, the senses are subject to illusory conclusions. If localized conglomerates of matter are shrinking, this would account for precisely the same observational results.

<http://www.thebigcollapse.net>

8. zandoria at 03/23/09 , 11:10 AM

Why does the author say that matter slows down the supposed expansion of the Universe? That doesn't make any sense.

Remember the illustration of Gravity with space represented by a rubber sheet and planets and stars as marbles and ball bearings? In that example, space is "stretched" by mass. Well, wouldn't

light have to pass through more-and-more stretched space the farther away it had shined from? Wouldn't this account for redshift just as well as the theory of Expansion?

Maybe the Universe was never expanding at all. Maybe the reason you pick-up a background radiation is that past a certain distance, you are just picking up an average, out of focus, blur....tired-out, exhausted light from parts of the infinite Universe beyond that 15 billion light year range.

if on the Internet, Press <BACK> on your browser to return to the previous page (or go to www.stealthskater.com)

else if accessing these files from the CD in a MS-Word session, simply <CLOSE> this file's window-session; the previous window-session should still remain 'active'