Elaborated by Helmut Söllinger
Vienna, Austria

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contact: 64.soellinger@aon.at

About the Nature of "Dark Energy".

Abstract

The concept of dark energy has been integrated in the cosmology in order to explain some phenomena of the universe, such as the flatness of its geometry or its (accelerated) expansion. If dark energy contains information as some physicists are claiming, it has to consist of quantums, being the smallest units of dark energy. Because the universe expands the ultra-long wavelengths of the supposed dark quantums also expand and the dark quantums therefore release energy. The released energy of the dark quantums is sufficient for expanding the universe against gravity. **The fascinating idea is, that the universe saves the energy needed for its continuous expansion in it.** In this paper the author shows by an appropriate calculation using General Relativity, that an universe only consisting of dark quantums would expand at constant speed. There is no necessity for a cosmologic constant in order to explain the observed (accelerated) expansion of the universe.

(Because arXiv did not accept a first version of this paper in April 2005 it is published now in February 2013 on viXra in an updated extended version).

Total Information Content of the Universe =

Number n of its Dark Quantums

$$n \approx R^2 c^3 / Gh$$

$c = 2.99 \times 10^{8}$ m/s

Radius of visible Universe R

$h = 6.62 \times 10^{-34}$ kg m^2/s

$G = 6.67 \times 10^{-11}$ m^3/kgs^2

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Introduction

In “Scientific American” of November 2004 there was an interesting article titled “Black Hole Computers” (see [1]). As the authors of this article (S. Lloyd and Y.J. Ng) explained impressively the universe maximally contains about 10^{123} bits of dark energy, provided that it is as large as they assumed.

The concept of dark energy was integrated in the cosmology to be able to explain the observed behaviour of the universe. On the one hand dark energy is needed to explain that the density of the universe corresponds to the critical density causing the observed flatness of the cosmic geometry. On the other hand dark energy is needed to explain, why the expansion rate of the universe is not decreasing as it would be the fact if the universe would contain only ordinary matter.

Lloyd and Ng´s findings led the author to some considerations around the most interesting question in this context: What could be the nature of dark energy?

The authors considerations

If dark energy contains bits of information it has to consist of quantums, being the smallest units of dark energy, hereafter referred to as dark quantums. Otherwise dark energy would be a kind of continuum not able to save digital information.

First of all it is necessary to ask: What is a common characteristic of all known quantums or particles? One common characteristic is their individual wavelength depending on their energy or their mass, respectively. The wavelength λ of a quantum e.g. a photon, is determined by the Compton length λ= hc/e, e being the quantums energy. But of which magnitude could the wavelength of a dark energy quantum be?

Following Lloyd and Ng´s assumptions that the universe consists of about 10^{72} Joule energy and of 10^{123} bits of information, dark quantums would have an average energy of about 10^{-51} Joule, provided one quantum is able to save only one bit of information. An energy of 10^{-51} Joule corresponds to a wavelength of 10^{26} m, which is of the same magnitude as the radius of the observable universe.

It is an exciting idea to image, that dark energy consists of particles (perhaps bosons) with a wavelength being as huge as the universe itself. But assuming their number is about 10^{123}, there is no other possibility. Demanding smaller wavelengths would mean demanding a smaller number of bits or quantums. Anyway the number of dark quantums has to be much more than 10^{110}, otherwise the existence of dark quantums should in principle be directly or indirectly observable, because of their interaction with matter-structures at small cosmological scales. In this case dark energy would not really be dark for us.

Accepting ultra-long wavelengths we arrive at the next question: What happens to the dark energy when the universe is expanding? When the space-time of the universe expands the wavelengths of quantums expand in the same ratio. This is for example the fact for the so-called cosmic background radiation and this should be the fact for dark quantum waves too. But stretching the wavelength of a dark quantum means that the quantum loses a part of its energy. When the observable universe expands from radius R_1 to R_2 the dark quantums reduce their energy by

$$e_1-e_2 = (hc/y)\bullet(1/R_1- 1/R_2), \qquad (1)$$

where y is the ratio of the dark quantums wavelength to the radius of the observable universe ($y= \lambda/R$).

But where to with the released energy? It is obvious that this energy can be saved as potential energy in the gravity field of the universe. To verify this, it is necessary to estimate the potential energy of the gravity field of the universe and its modification through expansion. An appropriate calculation using Newtonian Mechanics shows the increase of the potential energy, when the observable universe is expanding from radius R_1 to R_2:

$$E_{pot2} - E_{pot1} = (3GM^2/5)\bullet(1/R_1- 1/R_2), \qquad (2)$$

where M is the total mass of the observable universe and G the gravitation constant. It is evident that the structures of equation (1) and (2) are similar. Notice however, that Newtonian Mechanics provides only an approximation in comparison to General Relativity. Therefore the rational number 3/5 in (2) should be seen as artefact of the this approximation. But General Relativity allows no global energy balance for a simple demonstration of the effect, because General Relativity describes the geometry of space-time and not the gravitational forces.

Setting (1) and (2) equal, by fixing the number of dark quantums at 10^{123} and by assuming that y would be 1 (wavelength of quantums as long as the radius of the universe) leads to the rough approximation that the square of the mass of the universe M^2 is proportional to $(10^{123}hc)/G$. This results in M being about 10^{54} kg, which is equivalent to the energy of 10^{71} Joule. Remembering that our starting point was the assumption that the total energy of the universe is about 10^{72} Joule, this outcome is really promising and the problem is worth to be further investigated. The difference between 10^{71} und 10^{72} Joule maybe an effect of approximations used by the author or the authors of “Black Hole Computers”.

A hypothetical universe

For further analysing the problem it is advisable to consider the hypothetical case, that the universe would only consist of dark quantums with the ultra-long wavelength $\lambda = yR$. Under this assumption the mass of the universe could be expressed by

$$M_{u,quant} = (nh)/(yRc), \qquad (3)$$

n being the total number of dark quantums in the universe.
The total released energy caused by the expansion of the universe then would be:

$$E_1-E_2 = (nhc/y)\bullet(1/R_1 - 1/R_2) \qquad (4)$$

Demanding that the difference of potential energy (2) and the released quantum energy (4) should be equal gives the following relation (by using (3)):

$$n = (5yR^2c^3)/(3Gh) \qquad (5)$$

Equation (5) shows that a hypothetical universe consisting purely of dark quantums can only be in energetic equilibrium, if the number of dark quantums increases proportionally to the square of the radius of the universe.

In order to understand, that an expanding universe with a constant number of dark quantums cannot be in energetic equilibrium, we have to look at the relation between mass and potential energy. According to (3) the total mass and therefore the energy ($M_{quant}c^2$) of the dark quantums decreases with the factor $1/R$ while the amount of potential energy (2) is proportional to M^2/R and therefore decreases with the factor $1/R^3$. If the number of dark quantums would be constant there would be a surplus of released energy from the dark quantums compared to the potential energy necessary for expanding the universe against gravity.

In addition, the increasing number of dark quantums fits with the second law of thermodynamics. According to this entropy has to increase over time. Because information and entropy are equivalent, the information content respectively the memory capacity of the universe also has to increase over time. This condition can be fulfilled by the enhancing number of dark quantums.

Further remarkable in (5) is that n, representing the number of bits is a function of R^2 and therefore proportional to the surface and not to the volume of the universe. This corresponds to the holographic principle, which claims that the ultimative memory capacity of a sphere limited by the radius R is proportional to the surface of the sphere and not to its volume (see [2]). The second variable on which n depends is the wavelength of the dark quantums (expressed by y). The shorter the wavelength and the heavier therefore the quantums the less quantums can a certain mass contain.

What is the density of an universe of dark quantums? Putting (5) into (3) and dividing by the volume of the universe gives the density:

$$\rho = (5c^2) / (4\pi R^2 G) \qquad (6)$$

Remarkable that in a Newtonian approximation the density only depends on R but not on the number and the wavelength of the quantums. Therefore the radius of our hypothetical "Newtonian" universe could approximately be determined by measuring only the density. A possibility that General Relativity only offers to us, if the density is equal to the so called critical density $\rho_k = 3H_o^2/8\pi G$ for a flat universe and if the Hubble Constant $H_o = c/R$. Then

$$\rho_k = 3c^2/8\pi R^2 G \qquad (7)$$

and the structure of (6) and (7) differs only by a constant number certainly caused by the difference between Newtonian Mechanics and General Relativity.

Furthermore it should be noticed that the density (6) of the dark quantums in our hypothetical universe decreases with the square of the expanding radius. This is a fundamental difference to the concept of the famous "Cosmologic Constant" or to a constant vacuum energy by which cosmologists usually explain the behaviour of the universe (see chapter 4 of [3]) . Both a cosmologic constant and a constant vacuum energy are inherent characteristics of space. If new space is "created" by the expansion of the universe, this new space is simultaneously filled by the same level of energy or something like energy as the existing space. But how can new space be filled by anything coming from anywhere?

However the density of dark quantums depends on the size of the universe, because new dark quantums can only be "created" by the surplus of released quantum energy, which is not needed for expanding the universe against gravitational forces.

Dark Quantums and General Relativity

Does the concept of dark quantums fit with General Relativity?

To examine this, we have to combine our hitherto made assumptions with General Relativity. If our hypothetical universe consists of about $n = a(R^2c^3)/(Gh)$ dark quantums with mass $m_d = h/ycR$ then its density

$$\rho = a(3c^2)/(y4\pi R^2G), \qquad (8)$$

where a should be a constant number.

For describing the temporal evolution of a homogeneous and isotropic universe the so-called Friedmann Equation

$$R'^2/R^2 + kc^2/R^2 = (8\pi G/3)\,\rho, \qquad (9)$$

$$R' = dR/dt$$

a special case of General Relativity is used (see chapter 4 of [3]). k in (9) represents the curvature of space (with k = 0 for flat space).

Inserting (8) and k= 0 in (9) and assuming y = 2a we get

$$R' = c \qquad (10)$$

y = 2a is the prerequisite for the observed flat geometry of the universe and that equation (8) can be transferred into (7).

Considering (8) and (10) we can conclude, that a flat universe of critical density only consisting of dark quantums is expanding at the constant speed of light. This is a remarkable, beautiful and moreover simple fact.

Even if y would differ from 2a – in the case of an universe of dark quantums without critical density – it would expand at constant speed without acceleration [of $c(2a/y)^{1/2}$].

The author is not the first, who arrives at the conclusion that there are models, which predict a constant expansion of the universe (at the speed of light). Thomas Görnitz stated in chapter 6.1 of [4], that his considerations suggest a closed cosmos expanding with the speed of light. By a far more fundamental and theoretical investigation Görnitz has obtained these findings in the extension of Carl Friedrich Weizsäcker's so-called *Urhypothese*.

A universe with ordinary matter

Because the universe contains dark quantums, dark matter and ordinary matter, there are some more possibilities for its development compared with our hypothetical universe. That´s why the released quantum energy cannot only be used for producing additional dark quantums but also for producing additional dark or ordinary matter or maybe for reheating the ordinary matter. Vice versa dark and ordinary matter could dissolve into dark quantums, which could cause temporary acceleration.

Conclusions

The above used model of the universe and its results show that dark energy consisting of dark quantums with ultra-long wavelengths has the potential to explain in principle the observed behaviour of the universe.

That is the new and fascinating idea in comparison with Big Bang concepts: **The universe saves the energy needed for its continuous expansion in it.** There is no need for an initial "bomb" and an enormous explosion, which produces the necessary energy for the whole expansion process. So Big Bang becomes a continuous Smart Growth. The universe seems to be rather like a sprout, which spreads out of a small seed containing the needed energy for the sprout´s growing. It seems that there is also no necessity for a cosmologic constant in order to explain the (accelerated) expansion of the universe.

There is more need for explaining the inner coherence between the mass of the universe, the Hubble constant, the number and wavelength of the dark quantums and the radius of the universe. The manner how the universe expands obviously depends on the inner coherence between these parameters. Probably it will be the challenge for a future theory of quantum gravitation or for a theory of everything to offer the adequate equations for the inner coherence between M, H, n(y), and R.

A first but important step in this direction was made by the author in his paper "The Code of Nature" (see [5]). The scope of this paper is a systematic investigation as to whether or not the mass of the proton and the electron can be represented by other fundamental constants. The author arrives at the conclusion that the mass of the proton and the electron can be expressed by a combination of five constants that occur in nature; namely, e (elementary electric charge), ε_0 (vacuum permittivity), h (Planck´s constant), c (speed of light), G (gravitational constant) plus a time-variable parameter.

References

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