Cosmic Expansion As A Virtual Problem

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Abstract. Based on [1], it is shown that the gravitational field in a steady, non-expanding universe itself can cause the universe to be virtually accelerating with the radial distance (when time t is large compared to r, i.e. in the non-relativistic situation).
By no means does that mean that the universe should be steady: By general relativity, acceleration and gravitational fields are to be equivalent. The point here is simply to start to work out, whether and to what degree the observed expansion can be understood in terms of the gravitational field model.

1. Preliminaries

1.1. The Problem Model

Looking at the universe from our earthly position at a given time t_0, what we see is a 3-dimensional ball that extends to the past with increasing radial distance and has its boundary at big-bang time, the socalled cosmic horizon. And from what we know is that this universe preseves energy and momentum and is Lorentz-covariant.
That makes our universe an adiabatic system (see [1]).

1.2. External Potentials of Neutral Adiabatic Systems

I ended [1] with the remark that

$$U(j', j)(x) := (Const) \int \frac{j'_\mu(x') j^\mu(x)}{(x_0 - x'_0)^2 - \cdots - (x_3 - x'_3)^2} d^4x'$$

appears to become an interesting candidate for the interaction of two adiabatic systems. In fact, given two interacting adiabatic systems $j = (j_0, \ldots, j_3)$ and $j' = (j'_0, \ldots, j'_3)$, which are spatially apart at all times t, we expect the composite $\tilde{j}$ to be adiabatic as a whole. Hence, $\sum_{0 \le \mu \le 3} \partial_\mu \tilde{j}_\mu \equiv 0$, and therefore, $\sum_\mu \partial_\mu j_\mu = -\sum_\mu \partial_\mu j'_\mu$.
Now, supposing that j' is a neutral system, $\partial_\mu j'_\nu$ is to be symmetric (see:[1]), and j' can be integrated (in the Euclidean metrics) to a scalar function G,

say, and since the j'_μ are supposed to have their support disjoint from the light cone (as they describe masses unequal zero), $F := \Box^{-1}G$ exists, where $\Box^{-1}$ is the inverse of the wave operator. That inverse operator is a convolution operator by a function f, in physics called Green's function, which is defined as Fourier inverse of the distribution $\frac{1}{x_0^2-x_1^3-x_2^2-x_3^2}\delta(x)$, and the mathematically correct result is $f(x) = (const)\frac{1}{x_0^2-x_1^2-x_2^2-x_3^2}$, where the constant depends on the parameter $\lambda = (2\pi)^{-1}(const)^{1/4}$, chosen in the exponent of the Fourier inverse $\int e^{i\lambda(x_\mu y^\mu)}\delta(y_\mu y^\mu)d^4y$.

Remark 1.1. Given two well-behaved functions f and g on $\mathbb{R}^4$, the convolution $f * g$ of f and g is defined as $f * g : \mathbb{R}^4 \ni x \mapsto \int f(x-y)g(y)d^4y$. (Apart that the partial derivatives commute with the convoluted functions, the second remarkable feature is that the Fourier transform of the convolution is the product of the Fourier transforms of the two functions.)

With the above, F is the gauge function for the perturbated adiabatic system due to the external interaction, and its partial derivatives $\partial_\mu F$ add the appropriate external vector field components

$$A_\mu(x) = (const)\int \frac{j'^\mu(y)}{(x_0-y_0)^2 - \cdots - (x_3-y_3)^2}d^4y.$$

Remark 1.2. I refer to [2], where it is shown that the retarded Green's function, G say, which commonly is considered to be "physically correct", does not really solve $\Box G = 1$ and causes infinite self-interaction.

2. Assembling the Pieces

In [1] it was shown that the complex phase of the action ϕ and therefore the vector potentials A_μ can be chosen such that the complex conjugation becomes the time inversion $\mathcal{T}$, which in turn is $\mathcal{PC}$. That is handy, because it meets the expectation of the neutral mass to be time-inversion invariant, and so we may restrict $j = (j_0, \ldots, j_3)$ to consist of a non-negative, real valued energy density j_0 and likewise real-valued momentum fluxes j_1, j_2, j_3 associated with non-negative masses, either. (Implicitly, we take a leave from considering the four components of spin and charge.)
The next simplification is to restrict to the non-relativistic limit $c \to \infty$, which means dropping the spatial vector potentials A_1, A_2, A_3 as being small compared to A_0 the energy, and this implicitly implies that we restrict space-time and energy momentum to the internal of the positive, forward light cone, as is usual.

In order to calculate the interaction of the cosmic horizon with the rest of the universe, we should first get the perspective right: The observer is not looking from the inside against the cosmic horizon as a sphere, but it's the other way round: the observer looks from within the universe at the former center of mass, and the cosmic horizon is the point (or small ball) at this

universal center of mass. This suggests defining the cosmic horizon to be at the coordinate position $(t, 0, 0, 0)$ for all times t. Let $r(t) := (x_1(t)^2 + x_2(t)^2 + x_3(t)^2)^{1/2}$ denote the radial distance of some spatial location at time $t >> r(t)$, and let M be the total mass of the cosmic horizon.
With this, a mass point $j_0(t, x) = j_0(\theta(t), \phi(t), r(t))$ within the universe gets added the interaction is: $V(t, r) = (const)\frac{mM}{t^2 - r^2}$, where $m := j_0(t, r)$ for $t >> r$, and $(const)$ must be negative, in order to yield the assumed attraction of the masses.
Then $dV(t, r)/dr$ is the force needed to sustain the radial gravitational force $-dV(t, r)/dr$. And because $\frac{1}{1-(r/t)^2} = \sum_{n \geq 0}(r/t)^{2n}$, that force is roughly proportional to Mr. In other words, the pressure of the cosmic horizon on the universe, without taking into account the cosmic expansion, causes an observed accelation of its internal approximately proportional to the distance (and the total mass M).

Now, M should be a constant over time. And this means that the slope of acceleration is governed by an additional expansion or a collapse of the universe: an additional acceleration would subtract from the observed mass M, and an additional collapse of the universe would increase that slope:
Let me explain that: Cosmic expansion does work against the gravitational field of the center of mass M. That means that the force of inertia is opposite to the gravitational force. In particular, the universe is stationary if and only if the forces of expansion acceleration cancel against the gravitational forces. In this case, any mass would not feel the gravitational force from the cosmic horizon. In case of an additional accelerated expansion, the masses will be repelled from the cosmic horizon: the energy needed for these to reach the horizon will be greater zero, and the masses will be blue-shifted toward the horizon. In the opposite case of a deceleration or even collapse, they gain energy from the deceleration on their way towards the horizon, i.e. they get attracted by the gravitational field, and so their spectrum is red shifted. Put together, that means that the observed red shift demands deceleration, if not contraction, but not an accelerated expansion of the universe!

Rather than ask for more and more precise astronomical data as to the acceleration of the universe, let us estimate what the red shift was about to be, given that the universe was stationary and held in place by a magic force, that we forget to include:
The formula for the red shift due to a non-rotating, spherically symmetric gravitational field has already been worked out within general relativity and is given by

$$1 + z(r) = \frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}}$$

, where M is the gravitational mass, G the gravitational constant, r the radius of the radiating object to the center of the gravitational mass, c is the speed of, light, and $z := \frac{\nu_{emit} - \nu_{observed}}{\nu_{observed}}$ is the red shift parameter (see: [4]).

We can now estimate the red shift by inserting the current estimated mass of the universe, $M \approx 3 \cdot 10^{52} kg$, the value of the gravitational constant

G, $-(const) = G \approx 6.67\dot{1}0^{-11} m^3 kg^{-1} s^{-2}$, with $c = 3 \cdot 10^8 m/s$ denoting the speed of light, at different radiusses $r = \gamma R_0$, where $0 < \lambda \leq 1$, and where $R_0 \approx 4.6 \cdot 10^{26} ly$ is the current estimated radius of the cosmic horizon.

That turns out to be: $z \approx 5 \cdot 10^{-8}$ for $\lambda = 1$, $z \approx 5 \cdot 10^{-7}$ for $\lambda = 1/2$, and $z \approx 5 \cdot 10^{-5}$ for $\lambda = 10^{-3}$.

Compared with the measured red shift data $0.16 \leq z \leq 0.62$ for distant supernovae (see: [3]), the calculation of the gravitational redshift above, is about a factor $10^{-4} - 10^{3}$ too small.

There are two major positions as to this: Either I am missing energy (perhaps the interaction is stronger than assumed: but then: how will adiabaticity and classical gravitation as the non-relativistic limit be preserved for the universe?), or the current universe is strongly decelerating, if not already collapsing. In the latter case, at least, the possibility of a steady universe is to be excluded.

Remark 2.1. Let's ask, whether I could have lost energy: Maybe heat? - It seems no: Just like momentum flux, which can be in either direction and which are captured in the two spin components of the 4-dimensional space of states $(\chi_1, \dots, \chi_4) \in \mathbb{C}^4$ (see: [1]), that space also captures positive and negative energetic states in dedicated components. So, on there, all shows up as mass, contributing to a gravitational field. In the above, I just picked one of the four components, but the results will be the very same for the other three ones in place.

One obvious question now is: If the universe is decelerating, then it should have been accelerating once before: How else would we get a big-bang at the beginning? And even those who would like to deny a big-bang, will have to ask themselves, where an ever decelerating process would have started...

So, we'd definitely need a point of inflexion at a past time t_0, at which a prior acceleration turned into a deceleration. That implies, that the observer would recognize a deceleration for time $t < t_0$ and an acceleration for time $t > t_0$. In this form, it is currently postulated by current astronomy (see e.g. [3]).

And, perhaps surprisingly, the simple formula for the interaction of j and j', above,

$$U(j'(x'), j(x)) := (Const) \frac{j'_\mu(x') j^\mu(x)}{(x_0 - x'_0)^2 - \cdots - (x_3 - x'_3)^2},$$

allows an explanation:

If only j and j' are smooth and vanish with all their derivatives on the light cone itself - and a stronger condition would be mass gap: j and j' are to vanish on $\{x \in \mathbb{R}^4 : |x_0^2 - \cdots - x_3^2| < \epsilon\}$ for some $\epsilon > 0$ - then $\lim_{|(x'_0 - x_0)^2 - \cdots - (x'_3 - x_3)^2| \to 0} U(j'(x'), j(x))$ exists, and is 0, and we can trespass this boundary of divergency towards smaller $|x'_0 - x_0|$. And in that (space-like) region, the forces invert: masses that are attractive in the time-like region, become repulsive in the space-like one. But that will then also hold for charges either!

Again, there always are two ways to react on an observation: One is to say, that this cannot be, because it must not be, the other one is to accept this and to draw profit from it: When particles come close together, especially, when they collide, $(x_0' - x_0)^2 - \cdots - (x_3' - x_3)^2 < 0$ cannot be excluded. What, if not that force will hinder the electrons in the atomic shell to bind with the oppositely charged nucleusses? Why do the electrons exclude oppositely charged particles in the atomic shell?

References

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