Cosmic Inflation and Energy Conservation of the Universe

Introduction and relevance

Many cosmologists simply state that "energy conservation is a local statement", based on Einstein's theories[1]. The current universal model (Lambda-CDM) uses "dark energy" (Lambda) and "cold dark matter" (CDM) to explain observations. Dark energy would take about 70% and cold "dark matter" would take about 25% of all universal mass-energy. In the Lambda-CDM model *energy is not conserved*, the "dark energy" would require more and more universal energy, since acceleration requires energy. In this model, the future would be "dark energy" only.

The authors will argue that a universal model can be built based on *existing* laws of physics and based on universal *energy and momentum conservation*. The cosmological principle requires space to be homogenous (everywhere the same) and isotropic (the same in all directions). The *perfect* cosmological principle adds the requirements of homogeneity and isotropy to time (constants and laws of physics to be the same at any time).

Energy conservation and momentum conservation are clearly defined by Noether's theorem, based on symmetries. For example, the symmetry of space (homogeneity and isotropy of space) leads to momentum conservation. The symmetry of time (the laws and constants of physics remaining the same over time) leads to energy conservation. In other words, the requirements to the *perfect* cosmological principle are *also* the requirements to energy and momentum conservation of the universe according to *Noether's theorem*.

The universal model of the authors abides by the *perfect* cosmological principle, thus ensuring universal energy and momentum conservation. The model does not require "dark energy. This model explains and specifies "cosmic inflation", specifies the total universal energy, and presents you with a cosmic distance ladder for remote galaxies. It also explains the CMBR and why its photons do not have lost any energy.

Constants of nature remaining the same over time

The constants of nature like the speed of light "c", the Newton constant "G", the Hubble constant "H", and the Planck constant "h" (plus all other constants of nature) must be the same everywhere and all the time to fulfill Noether's theorem. The current notion (in the widely accepted Lambda-CDM model) of a Hubble constant being different in the past is thus in conflict with Noether's theorem. Either universal energy is conserved and the Hubble constant is a real constant, or the Hubble constant varies over time and universal energy is not conserved. The authors have built their model on energy conservation and thus on a *constant Hubble constant "H" over space and time*.

The Hubble constant defines the size (maximum distance is c / H) and age (age "t" is 1 / H) of our universe. If the Hubble constant is a real constant, how is it then possible that the universe expands? The answer was given by Robertson and Walker, introducing "comoving coordinates". Comoving coordinates leave the space coordinates (locations of galaxies) the same in an expanding universe. This means that the *unit meter*, symbolized by [m], *expands over time*. In that way, the location of a galaxy (without local speed) within a universal coordinate system remains the same over time, while the universe expands in its unit meter [m].

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[1] Hawley J. and Holcomb K. "Foundations of Modern Cosmology" Chapter 14

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The requirement of a constant speed of light "c" according to Noether's laws and according to Einstein's theory of Special Relativity, leads to an expanding unit second [s] too! Physicists define the unit meter as the distance light travels in vacuum in 1 / c seconds. In other words, the unit meter expansion must be coupled to a unit second [s] expansion in order to ensure a constant speed of light over time and thus ensuring energy conservation of the universe. The question now is, *how fast is the universe expanding* in its units meter [m] and its second [s]?

Cosmic-factor and the units second and meter

The units meter [m] second [s] must have been smaller in the past, but by how much? The rate at which this happens determines the expansion of the universe. The expansion of the universe is determined by a crucial condition: *The Big Bang must be equally long ago (1 / H) and equally far away (c / H) to all universal observers in the present and in the past*. To fulfill the perfect cosmological principle, the *Hubble constant must be a constant*. In other words, the unit meter [m] and unit second [s] must have been smaller in the past such that the Big Bang stays at the same space-time distance.

For example, halfway the universal history (t = 1 / 2H) the unit second and meter must have been half as large. Restated: when H.t = ½, then the unit meter and second are half as large. Let us call H.t the cosmic-factor "λ" and let us subscribe coordinates and units like [s_{cosm}] of the past with "cosm". We then get:

λ	$= H.t$	[ ]	cosmic-factor	(1)
$[s_{cosm}]$	$= \lambda.[s]$		cosmic unit second	(2)
$[m_{cosm}]$	$= \lambda.[m]$		cosmic unit meter	(3)

The expansion of the universe is thus expressed by formula (3), which is exactly what Robertson-Walker were telling us in 1936, the actual distances of galaxies remaining the same (the same coordinates), while the unit meter expands. They called this way of looking at the universal expansion "comoving coordinates", coordinates remaining the same, while the unit meter expands over time. Interestingly, we have now two independent sources to confirm the growing unit meter in the universe, one based on an invariant Hubble constant and one based on comoving coordinates.

The expanding unit meter gives us geometry (and physics in general) in comoving coordinates, but what is the influence of the expanding unit second?

Cosmic unit second and cosmic time

The unit second is expanding too in our universal model (just like the unit meter), but what does that mean? In physics, the unit second is defined as 9,192,631,770 cycles on a cesium clock. An expanding unit second means thus a slower cesium clock over cosmic time. Or, the other way around, the (hypothetical) cesium clock of the distant past must have been ticking a lot faster. We call the difference in clock rate: "cosmic inflation". Cosmic inflation tells us how much faster the cesium clock ticked in the past.

We know that in the "cosmic inflation era" shortly after the Big Bang, the cosmic inflation was indeed extreme. The cesium clock is representative for the progress of physics, this means that the expansion in that era went extremely fast. To find out how fast, we need to make use of a measurement principle, the "principle of uniform measurements". This principle tells us that the multiplication of a coordinate and unit must remain the same between different observers with different units, its "uniform" value. For example, my *uniform* length "l_u" equals *both* 1.80 x [m] *and* 5.9 x [foot]. Applying this principle to a time difference "dt_{cosm}" of the cosmic past, we get:

$dt_u = dt.[s] = dt_{cosm}.[\, s_{cosm}]$ *uniform* time difference "dt_u"

The *uniform* time difference "dt_u" must be measured the same by cosmic observers as by current observers on earth! Since we know from formula (2) that the unit second is the cosmic-factor smaller, we get for the difference in time differences:

$dt_{cosm} / dt = 1 / H.t$ [ ] cosmic inflation (4)

In this equation is "dt_{cosm}" the time difference as measured by cosmic observers in the cosmic past on a (hypothetical) cesium clock, while "dt" is the time difference as measured on a current cesium clock on earth. Since we know that the universal expansion includes an expanding unit second, we need to standardize "dt" as the time difference as measured in the fixed unit second of the year 2000, a standardization which is common in astronomy. So, "dt" is the time difference on a clock now (which is virtually the same as in the year 2000), while "dt_{cosm}" is the time difference as measured by a cosmic observer in the past.

A cesium clock also accumulates its seconds into an absolute time, so "t_{cosm}" is the time indicated on a cesium clock. Accumulation is integration, integrated formula (4) delivers:

$t_{cosm} = \ln(H.t) / H$ [s_{cosm}] cosmic time "t_{cosm}" in cosmic seconds (5)

Note that we have chosen to make the integration constant zero. In this way, the cosmic time of the past "t_{cosm}" is negative, indicating how long ago eras and events took place on a cesium clock. Since the cesium clock is representative for the progress of physics, it also indicates the real history in terms of physical processes! The cosmic time is a natural logarithm of current time, ranging from minus infinity at the Big Bang to zero in the year 2000.

The natural logarithm is the opposite function of the natural exponent "e", you could also state that: $H.t = e^{H.t_{cosm}}$. Our time "t" progresses exponentially! This formula ensures that the Big Bang is equally long ago (1 / H) to all cosmic observers as we stated in the previous paragraph.

Cosmic inflation and redshift of galaxies

What we need to know is the relation between cosmic inflation and the redshift "z" of galaxies. Redshift "z" is the shift of the spectrum of light to the red:

$z + 1 = \nu_s / \nu_r$ [ ] redshift plus one (6)

In this formula is "ν_s" the color frequency of photons at the source, and "ν_r" the color frequency of photons at the receiver. For example, the redshift of galaxy GN-z11 is 11.09. This means that the absorption lines of hydrogen and helium of the light as transmitted by GN-z11 are received on earth as frequencies that are 12.09 times lower! The visible light at the source has turned into infrared light as received on earth. Redshift is the major measurement of highly redshifted galaxies.

The relation between cosmic inflation and redshift is:

$dt_{cosm}/dt = 1 / H.t = z + 1$ [ ] cosmic inflation and redshift (7)

This formula is a combination of formulas (4), and (6), observed faster clocks are highly redshifted. In other words, apart from other causes of redshift (local speed and local gravitation), the cosmic inflation equals z + 1. To support cosmic inflation of z + 1, let us look what ESA and NASA say about star formation as observed by the Hubble Space Telescope in deep space.

The deep space redshift measurement of galaxies range from seven to eleven, which means that *we predict a cosmic inflation from eight to twelve*. The NASA and ESA both published on their web-sites the following statement in the article "*Hubble finds hundreds of young galaxies in the early Universe*" at: www.nasa.gov/mission_pages/hubble/hst_young_galaxies_200604_prt.htm: "The findings also show that these dwarf galaxies were producing stars at a furious rate, *about ten times faster* than is happening now in nearby galaxies". QED

So, for those who wonder how much cosmic inflation there was in the "cosmic inflation era" at an estimated time "t" of 10^{-36} [s], we get using formula (4) or (7): 3 x 10^{53}, the hypothetical cesium clocks and thus the progress of physics proceeded 3 x 10^{53} faster than in the year 2000!

Universal energy conservation

The cosmic inflation is based on the perfect cosmological principle and Noether's theorem, explaining the observed cosmic inflation of star formation and the cosmic inflation era shortly after the Big Bang. The universal energy must thus be conserved in the "comoving coordinates" of Robertson and Walker too. This brings up the question of the unit Joule and kilogram. Are the units Joule [J] and [kg] expanding along with the units meter and second? We know that at the SLS (surface of last scattering) the temperature was close to 2,978 [K] based on the behavior of photons in an environment of hydrogen and helium ions. We measure the radiation of the SLS as the CMBR (cosmic microwave background radiation) at about 2.725 [K].

Photons do not change over time, according to Einstein's theory of Special Relativity (proper time equals zero). In other words, the photons of the CMBR have not changed since leaving the SLS. How come that photons coming from an environment of 2,978 [K] do not change and are measured as 2.725 [K] on earth? The answer is simple, the unit Kelvin was a lot smaller in the cosmic past too. Since the unit Kelvin is linked to the unit Joule by the Boltzmann constant, the unit Joule must also have been much smaller. The unit [J] was 2,978 / 2.725 = 1,093 = z + 1 smaller than the unit Joule right now. A smaller unit [J] means a smaller unit [kg], $E = m.c^2$.

You get the picture, all *four* basic units (second, meter, kg, and Coulomb) must have been z + 1 smaller in the past than these are now. The universal size, age, mass, and energy are conserved in comoving coordinates, while the basic units expand. This means from physics point of view (physics deals with *measured* quantities), that you measure the same universal energy at any time. The laws of physics and the measurements are independent of the (expanding) units! We measure the same amount of energy now as we did many billions of years ago and as we will do several billion years from now! That is the power of consistent use of "comoving coordinates".

We can even put a number to the universal mass-energy:

$E_{cosm} = c^5 / G.H$ $[J_{cosm}]$ universal energy (8)
$M_{cosm} = c^3 / G.H$ $[kg_{cosm}]$ universal mass

These formulas come from the simple assumption that the universe is all there is or 100% or 1.0 in natural coordinates, see book "Repairing Robertson-Walker's Solution". The NASA estimates that there are currently about 125 billion galaxies around. Do not forget that observed galaxies from very far have likely merged into larger galaxies right now. The authors support the NASA number for the estimated number of galaxies *right now*. The universal mass of formula (8) divided by the number of galaxies that are currently around comes close to the mass of our Milky Way. Our Milky Way is then just about an average galaxy, confirming the right order of magnitude of formula (8).

Consequences

The consequences of Noether's theorem and Robertson and Walker's comoving coordinates are a whole new cosmological model in which there is no place for variable constants of nature and no place for "dark energy". The cause of redshift of far galaxies is then mainly the cosmic inflation, while peculiar (local) speed is a small contributing factor. Our model is supported by all observations! This model explains the distribution of galaxies over redshift (see book III) and provides you with a new distance "D" ladder in current units meter as function of redshift "z" and vice versa:

$D = \{z / (z + 1)\}.c / H$ [m] distance ladder of remote galaxies (9)
$z = H.D / (c - H.D)$ [ ] cosmic redshift of remote galaxies (10)

Note that the formula that Hubble and Humason used in 1931: $z = H.D / c$ is a good *approximation* of formula (10) for lower values of "z". In other words, Hubble and Humason were the first scientists who discovered the relation between redshift "z" caused by *cosmic inflation* (and not by speed alone!) and distance "D"!

Our books

In our books we resolve the problems of Special Relativity and of General Relativity solutions; no more paradoxes or singularities. Energy is conserved according to Noether's laws. There is no need for the introduction of "singularities" in black holes or "dark energy" in the universal model. You may freely download the first three chapters of our books at www.loop-doctor.nl; We hope that you get as many "aha" experiences as we did.

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