Observations on the Hubble Expansion of the Universe

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(1) *Ordinary space is an indecomposable 3-dimensional continuum.*

All tangible objects must be fully 3-dimensional, with positive volume.

Argument: when straight lines are defined as the unforced paths of particles or fields, the dynamic structure is seen to be that of Euclidean geometry. Abstract mathematical models can focus on 1 or 2 dimensional simplifications of the things we see around us, but any object, body or entity encountered in daily life must have positive volume.

One can argue, successfully I believe, that even electrons and quanta must have volume, and that the notion of a "point particle" is once more an abstraction and not a reality. This is because we accept the validity of the Hawking-Penrose postulate, which states that nature cannot possess naked, or unshielded singularities: a "point electron"

implies the "naked" presence of an infinite electromagnetic potential in real space. This postulate is necessary to avoid a breakdown in customary notions of causality.

(2) Einstein showed that we actually live in a full 4 dimensional space-time. What is true of space must therefore also be true of space-time: even as one never encounters real, tangible objects which are 2-dimensional slices without volume , or 1-dimensional curves, or pure dimensionless points, in the same way, all "objects" in space-time must be fully 4-dimensional.

(3) This has important consequences for all of physics. It means that when one speaks about static objects, like rocks and stars, one is always simplifying the reality, which is that of 4-dimensional "events" happening in non-vanishing intervals of time.

In particular it is absurd to speak of the "expansion of space".

Two errors are committed by the use of this expression:

(a) To speak of the "expansion of space" alone is to imply a separation

of time from space, which is contrary to the spirit of Relativity, in which time is a geometric dimension.

(b) To speak of the"expansion of space" is also an error in logic. Space can no more expand than time can move. These are *dimensions* , not magnitudes or quantities. Measured amounts of change, or, as Aristotle observed, motion, are *expressed* in units of time. The relative separations of objects are *expressed* in units of length, area and space.

(4) Because space-time must be treated as an indecomposable unity, and because "space" and "time" themselves can neither move nor expand, one must can therefore only talk about the *"expansion of* some entity *whose relative distances and motions are changing* in *space-time"*.

That space must be thought of as indecomposable, can be seen from the following consideration: even though local spatial coordinates are designated by a coordinate system x,y,z, yet the orientation of this system is arbitrary: I can choose to have the z-axis point in the direction of the sun, or the moon, or the center of the earth. This would not be possible if space were not an indecomposable homogeneous unity.

In the same way, one's orientation in space-time is also arbitrary (up to the speed of light). I can choose any object moving at constant velocity less than light and designate it as the origin of my rest-frame. This shows that space-time must also be considered an indecomposable unity, that, in particular, all measurements of "events" must be 4-dimensional.

Otherwise stated, *there is no time 'direction'* , independent of space. Even as the "x-axis" can be freely chosen, so (within the limits of Minkowshi space), the "time axis" can also be freely chosen.

(5) Granting that there is "something" *in* space-time that is expanding, how can one make sense out of the idea that "time is expanding" or, more accurately, *something* is expanding in time? As explained above, time itself does not *move* , any more than space *expands*: systems change over time, even as lengths are distances between objects. Following more than a century of discoveries in physics, one can say that these "somethings" are either *particles* (bosons), or *fields* (fermions), that is to say, actualizations of *energy*.

(6) **Therefore:** *a space-time object is the set of all transformations between two "stable" (relatively motionless) states of a entity (system of fermions and bosons) in 3-space.* **We will use the word "events" to designate "space-time objects". This is very much in the spirit of Relativity, which relates events to one another, rather than speaking of bodies in fixed locations. The phrase "Hubble expansion of** *distances* **in space", should therefore be corrected to "the Hubble expansion of** *events* **in** *space-time".*

(7) We illustrate the need to look at the expansion of temporal quantities *in addition to* **the expansion of spatial measurements, by the following examples:**

a. A change of reference frame from rest to one with relative velocity "v" leads to changes in coordinate measures by the constant of proportionality $\beta = \sqrt{1 - (v/c)^2}$ **. The Lorentz contraction** *shrinks* **distances and** *slows down* **clocks. In the same way, a universal expansion must** *expand* **distances and** *accelerate* **clocks.**

(8) For events to happen there must be the introduction

or removal of energy, and energy is the "substance" of *fields* .

(9) Combining all these considerations , we claim that the "expansion of (measurements of events in) time", which must (given the unity of the 4-continuum) accompany the "expansion of (measurements of events in) space" is made apparent to us through the *augmentation of a quantity of energy*. The natural candidate for this is *Dark Energy* .

(10)   Where there is no matter, no energy, and no fields, one cannot speak of the existence of space. Perhaps such regions should be described as *Voids* . Space exists *between* objects, as Leibniz argues .

 Even if one wants to contest this view, one has to agree that to speak of the "expansion of the space" within such a void region, is utterly meaningless: for 'space' can no more expand on its own, than time somehow develop its own motion!

(11)   This leads us to the following hypothesis: that what is called the "Hubble expansion of space" is best interpreted as the intrusion or conquest of an encompassing 4+2 (4 spatial, 2 temporal) dimensional *Void* by a 3+1 dimensional *universal field*. The most natural

candidate for that is the gravitational field. The argument for a *second*

time dimension will be given below.

(12)   The employment of this hypothesis allows one to create a more

effective understanding of the construction generally employed in

popularizations of cosmology, namely : our universe exists on the

surface of a 3-dimensional balloon (the 3-sphere surface of a 4-ball) that

expands equally in all directions.

The best theoretical framework for this picture (a somewhat abstract

'picture', admittedly) is to think of our universe as being embedded in a

4-Void, which is being *reclaimed, in an second time dimension* τ , by the

expansion of a space-time field , whose spatial component is on the 3-

sphere surface of a 4-ball. Even as the fields of our 3-dimensional

universe expand into the Void, so the time t, measured by the

trajectorieas of photons, expands into a void time τ . The equation of this

surface is looks something like:

$$x^2 + y^2 + z^2 + u^2 = R^2(\tau)$$

"u" is the added dimension of the surrounding Void into which the

matter/gravitation *field* of our universe is expanding. The dimension u is directed orthogonally away from our ordinary 3-space. R is the radius of that expansion, and τ is the "time" in which the expansion of both space Sand time t, are occurring. Once again, time, whether local or cosmic, cannot move or expand, which is why we hypothesis a *second time dimension* τ in which the universal expansion is occurring. (There is no reason of course why this metric should be Euclidean)

   (13)   Let us try to make more robust the claim that 4 spatial dimensions (x,y,z,u) , and two time dimensions (t and τ) are needed to describe the space/time/matter universe that we live in. The two temporal dimensions are:

           a. The time t in which radiation, or light rays move about. One cannot speak of this as either "expanding" or "decreasing" as it is fixed by the condition r(t)/t < c, for any material particle, and by r(t) =ct for radiation.

           b. The time dimension τ in which the universal

expansion occurs , that is, the encroachment of the fields of the 3+1-sphere 3 of space, one of time) onto the 4 +2 (4 of space, two of time) Void.One can imagine that *ordinary time* t is expanding into *void time* τ . To date no upper limit has been found for the speed of this expansion, but I suspect that there must be one: "infinity" is a concept of mathematics, not of physics.

(14)   Since gravity appears to be the only force that one finds in either dark matter or dark energy, it is erroneous to speak of gravity, or gravity waves, as travelling at the speed of light. Here is the argument:

It is observed and claimed that dark matter and dark energy are everywhere present throughout the universe. As our 3-universe expands , at exponentially increasing speeds, (the expansion must be exponential to avoid being nullified by a change of reference frame) over larger surface areas in the 4-void, the dark matter and dark energy fields *automatically and instantaneously* enter into new enlarged 3-spherical surfaces . The speed of gravitational radiation must therefore be pegged to the expansion of the universe. Indeed, these "new" regions are

actually *expansions of these fields* , given that to talk of the expansion of

pure space is as absurd as to assert that time moves.

Since, at the present time, we are recording redshifts much larger

than 1, it follows that the universal gravitational field is also expanding

at speeds greater than light. Thus there is, at present, no known limit to

the speed at which gravity travels across the expanding space-time

universe.

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