The Fallacy at the Heart of Big Bang Cosmology
Mechanics of a Self–creating Universe

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Abstract

If there would be only a single electrically charged particle in the entire universe so it cannot express its charge in interactions, then it cannot be charged itself, so charge –or any property, for that matter– is something which lives within particle interactions, something a particle cannot privately own. If in a universe which creates itself out of nothing, without any outside intervention, particles, particle properties must be as much the cause as the effect of their interactions, then their communication must be instantaneous.
This only is possible if the constant of nature called 'the speed of light' doesn't refer to a velocity but to a property of spacetime: if we don't live in a universe where it is the same time, where time passes at the same pace everywhere (in empty space, far from masses), which lives in a time continuum not of its own making –where there is a universal 'now,' but in a universe which, as it only exists as seen from within, creates all time inside of it so time must be observed to pass at a slower pace at larger distances. In such universe the communication between particles –and hence the transmission of light– is instant: not over any space distance but over any spacetime distance.

Like a particle cannot be charged itself if there is no other charge; if by definition there is nothing outside the universe, nothing relative to which it can be said to exist, nothing to interact with to express its existence, relative to which its properties and state can be specified, quantified, then a self-creating universe cannot have particular properties nor be in some particular state as a whole as 'seen' from without nor as seen from within. As it only exists as seen from within, as it creates all time inside of it so time cannot be observed to pass at the same pace at all distances, past, present and future are relative, observer dependent notions.
This study investigates how the universe might create itself out of nothing, without any outside intervention.

Contents

Abbreviations

BBC	big bang cosmology
BFPD	but for practical difficulties
BBU	big bang universe
CM	classical mechanics
GR or GRT	general relativity theory
GTD	gravitational time dilation
IH	interaction aka observation horizon
OH	observation horizon = interaction horizon
QCD	quantum chromodynamics
QED	quantum electrodynamics+
QFT	quantum field theory
QG	quantum gravity
QLG	quantum loop gravity
QM	quantum mechanics
SCU	selfcreating universe
SR or SRT	special relativity theory
SSU	steady state universe
ST	string theory
SUSY	supersymmetric
UP	uncertainty (indefiniteness or indeterminacy) principle

We have tried for centuries to look deeper and deeper into finding causes and explanations, and suddenly, when we go to the very depths, to the behavior of individual particles of individual quanta, we find that this search for causes comes to an end. There is no cause. In my eyes, the fundamental indeterminateness of the universe has not really been integrated into our worldview yet. –Professor Quantinger, the alter ego of Anton Zeilinger.[1]

1
Premise

We assume that the way we look at, think about the universe is essentially correct, that modern physics is so sophisticated and evidence based that conceptual fallacies like the belief that the Earth is flat or that it is the center of the universe definitely belong to the past, that it is inconceivable that we might be wrong. This study aims to show that big bang cosmology (BBC) describes a fictitious universe. Though the observational evidence for a big bang seems to be overwhelming; it only is decisive if the constant of nature *c* called 'the speed of light' refers to a velocity and not, as in a selfcreating universe (SCU), to a property of spacetime.

The premise of this study is that if we define the universe by saying that there is nothing outside of it, not even space and time, it cannot have particular properties nor be in any particular state as a whole, have an external[2] reality. We only can speak about the properties and state of the universe if there is something outside of it relative to which it can be said to exist, something it interacts with to express its existence, something relative to which its properties and state can be quantified, not if it only exists –and only can be understood– as seen from within.
If the universe can create itself out of nothing, without any outside intervention –what kind of particles to create, what physical laws to install and what values to set the constants of nature– then we should, in principle, be able to figure it out as well, reverse-engineer it from what we see how it is and works.
This study is not about the nuts and bolts of such selfcreation, but about what principles it would follow, about the questions it poses, whether it even is possible to conceive of a plausible scenario, to find out whether the sole fact that particles, particle properties must be as much the cause as the effect of their interactions opens a new perspective on old problems.

One such question is whether, if when it can create itself, it always could, it can have a beginning. The problem of a beginning is that it implies a decision when to start its creation, an intent to create it, that –despite the (cl)aim of BBC to describe the universe from within– time already passes before there is a universe and even outside of it, that it lives in a time continuum not of its own making, meaning that it has been created by some outside intervention –a possibility we have to reject as it doesn't satisfy the definition of what a universe is.
Though according to BBC time only started at the big bang so there was no time in which the universe didn't exist; as a beginning presupposes a previous state, a previous time in which it didn't yet exist, it only can have a beginning if time

[1] *Dance of the photons* (2010) Anton Zeilinger p. 105
[2] If, for practical reasons like the absence of space and time outside of it for an observer to find herself in and look at it, unobservable reality.

already passes before there is a universe and even outside of it even though nothing much lasting may have happened before its actual creation.
The problem of the assumption that it has a beginning, that it has particular properties, and at any moment in cosmic time is in some particular state as a whole, that it obeys the cosmological principle according to which there is no point in space which is more special than any other so every point or particle can consider itself to be (at) the center of the universe so it cannot have a boundary where it ends, a definite, external dimension –which is at odds with the assumption that it was infinitesimal at the big bang: relative to what? For if it has a (de)finite size as seen from within, then it has the same dimension as 'seen' from without, never mind that it cannot actually be measured from the outside, meaning that it also lives in a space continuum not of its own making.

The crucial difference is that if in a SCU particles, particle properties are cause and effect of their interactions, they only exist to each other and only if, to the extent and for as long as they interact, exchange energy to express and at the same time preserve their, each other's properties: as their properties in classical mechanics (CM), in BBC only are the cause and not also the effect of their interactions, they also exist to a hypothetical observer outside the universe[1] as otherwise it wouldn't make any sense to speak about its properties, state and size.

Though the definition of what a universe is implies that it cannot have a beginning; a universe which has no beginning seems as unimaginable. It is because the universe traditionally was believed to have been created by some outside creator why we came to think of it as an ordinary object we may imagine to inspect from the outside, that there exists a unique, absolute, objective, universe-wide reality at the origin of our observations, causally preceding its observation.
In the words of Einstein

> We all, more or less in the same way, say that a rose is red, smells like perfume, and feels like velvet. In other words, there is an objective reality which is conceived by the senses, and behind this objective reality are natural laws which are the privilege of the scientist to discover. Nature doesn't know chance, it operates on mathematical principles. As I have said so many times, God doesn't play dice with the world.[2]

However, if by definition there is nothing outside of it relative to which it can be said to exist, nothing relative to which its properties and state can be specified, quantified, if reason insists that what comes out of nothing must add to nothing – let's call this the Nix law, the most fundamental of all laws of physics, the mother of all conservation laws– then there also cannot exist a single, objective universal reality as seen from within –which is the assumption CM and BBC are based upon. If the universe has a beginning, a definite age, an external reality so lives in a time realm not of its own making, then all objects and observers only are real, live (as in attending a concert instead of watching a video of it) within an infinitely narrow

[1] An observer who could see the entire universe as it is, of itself, at some particular moment in cosmic time, without the time delay due to the speed of light.
[2] Einstein in *Einstein and the Poet: In Search of the Cosmic Man* (1983), William Hermanns, p. 58

time interval: that there is a universe-wide 'now' and hence a single, objective universe-wide reality which causally precedes its observation.

Though Einstein stated that 'God doesn't play dice with the world' because he insisted on causality in trying to understand nature so couldn't but reject the indeterminacy inherent to quantum mechanics; such indeterminacy is self-evident in a universe where particles, particle properties are as much the cause as the effect of their interactions. If the world at macroscopic level, the world we perceive with the naked eye constitutes an objective reality which causally precedes its observation, if it obeys causality, then that doesn't mean that the world at its most fundamental –particle, quantum– level also has to obey causality. Clearly, their behavior only can be understood rationally, not causally if when particle properties are cause and effect of their interactions so a measurement of their behavior cannot but affect what we measure –which is inconceivable in classical mechanics.

As a SCU only exists as seen from within so doesn't live in a time realm not of its own making but creates all time inside of it, there is no universe-wide 'now' all observers live in and hence no single, objective reality they have in common.
In a SCU we must specify the observer or observing particle when investigating –not how *the* universe looks like as there is no such thing– but how *their* universe may look like –which then can be different to different observers or observing particles. While the discovery that the Earth, despite appearances, isn't, after all, the center of the universe was generalized to the assumption that no point in space is more special than any other, that every point or particle can consider itself to be (at) the center of its universe, of its interaction aka observation horizon; in a universe which 'contains,' produces all time inside of it, there also is no point in time which is more special than any other, no unique universal now, no infinitely thin time slice in which all objects and observers are real, live, no single, universe-wide reality.

(As an interaction between particles is an exchange of information, particles in this study also appear as observers, as sources, carriers and receivers of information, so in this text 'observer' can refer to a person as well as a particle. Unless specified otherwise, the protagonists in this text are an unspecified kind of particles though they may, for the sake of argument, adopt any property of any particle species. Depending on the context, particle can mean an elementary particle, a particle which is in the process of evolving to an elementary particle, but also to a star, galaxy or cluster of galaxies. Observation doesn't imply consciousness, a capability to reflect on the received information –unless we call the process whereby particles adjust their behavior to changes in their environment 'consciousness.')

While according to BBC the creation of the universe was a one-off event whereby all matter and energy the universe contains today in some mysterious manner was created from one moment to the next at the big bang,[1] where all particles popped up readymade, with all their properties measured off to the last decimal

[1] That is, before observations indicating the existence of dark matter and energy.

–properties which like some kind of DNA predetermine the properties of the stars and galaxies they eventually contract to, as if the universe is a wind-up toy which once wound up, only can unwind in a completely predetermined fashion; if when their properties in a SCU are as much the cause as the effect of their interactions, then elementary particles can evolve, acquire their properties in a more or less gradual trial and error process –an evolution which, as will be discussed, doesn't necessarily mean that the universe then has a beginning as a whole.

If from the point of view of physics, everything in nature is about energy, if a particle only can be said to exist, if it only can express its existence, its properties in interactions if it has energy and the universe is to create itself out of nothing, then energy, whatever kind of stuff it may turn out to be, must be something which has the tendency to increase, to keep creating itself –a tendency we know as gravity. If reason insists that what comes out of nothing must add to nothing, then the net energy or electric charge of the universe, say, cannot be nonzero even though it does contain energy and electrically charged particles –which is like a zero which keeps splitting itself into positive and negative numbers the sum of which always remains nil.
Though according to the energy conservation law, energy cannot be created nor destroyed; this is different if the energy of particles is a dynamic, wavelike quantity, in one phase as positive as it is negative in the next, if particles express and at the same time preserve their, each other's properties by alternately borrowing and lending each other the energy to exist, to exchange energy, to interact. Or, equivalently, if the energy of the universe is nil so no conservation law is violated, then that is because it has no external reality but only exists as seen from within.
Energy then, is not something particles can privately own but something which lives within their interactions, which manifests itself as it is exchanged between particles to express and preserve their, each other's properties, their existence.
Only if their rest energy would be a privately owned and hence fixed, static quantity, only the cause and not also, the effect of their interactions would it be justified to think of the universe as an ordinary object we may imagine to look at from without, an object which lives in a space and time realm not of its own making.

Though the uncertainty principle (UP) often is interpreted to say that a particle can pop into existence by borrowing energy from the vacuum for a time which is shorter as its energy is higher, as if the energy conservation law may be violated for a shorter time as the violation is more serious; if particle properties are cause and effect of their interactions, then a scenario suggests itself whereby particles borrow and lend each other the energy to exist, to each other –as opposed to BBC where, as their properties are privately owned quantities, only the cause of interactions, particles would keep existing even when isolated from interactions.
Whereas particles in a SCU have to keep interacting, exchanging energy, information to keep existing; in a BBU it takes no effort on the part of particles to keep existing even though it does take energy to express their existence in interactions.

That the rest energy of particles cannot be a static quantity follows from the UP according to which the strength of a field –the energy of its quanta– cannot be *and* remain constant and an elementary particle is a quantum of some field. The higher its energy is, the shorter it can have that energy (and vice versa), the higher its rate of change in space and time is, the faster it alternates between a phase in which its energy increases and decreases, at which its energy sign alternates.

We can then think of the selfcreation of particles as an event whereby particle *A* pops up with a positive energy it borrows from particle *B* –which then pops up in counterphase, with an equal, negative energy so no conservation law is violated. However, if according to the UP their lifetime, the period of the loan is shorter as the energy they lend to / borrow from each other is higher, then they would vanish as their time is up unless they manage to set up a continuous energy exchange by means of which they force each other to reappear again and again after every disappearance. If so, then the magnitude and sign of their energy varies in a wave-like manner within every cycle of their oscillation, of their energy exchange, be higher as its rate of change is higher, as the frequency they exchange energy at, at which their energy sign alternates, at which they alternately pop up, vanish and reappear is higher, oscillating between opposite states.

However, if when *A* borrows all its energy from *B*, then *A* and *B* would only exist to each other, not to the particles in the midst of which they pop up, in which case there would be no force between *A* and *B* –so they wouldn't even have energy, exist to each other in the absence of other particles– as according to Newton's 3rd law a force between *A* and *B* only can be as strong as the force they feel from particles in opposite directions. Only if they borrow and lend part of their energy from and to the particles in the midst of which they appear, do they all start to exist to, interact with each other. If according to the UP the energy of particles increases as their position, their distance becomes less uncertain –as their distance decreases, as they contract to clusters– then particles can create themselves, each other only if they contract to clusters (and clusters of clusters) everywhere in concert, if their communication is instant over any spacetime distance.

Real particles then can be thought of as virtual particles which managed to set up a continuous energy exchange by means of which they force each other to keep reappearing after every disappearance, by alternately borrowing and lending each other the energy to exist, to each other, to express and at the same time preserve their, each other's properties. The shorter, the less uncertain or less indefinite[1] their distance is, the higher the energy is they observe each other to have, the higher, according to the Planck-Einstein relation $E = hv$, the frequency v is at which they exchange energy[2] (with h the Planck constant), at which they alternately borrow and lend each other the energy to exist, to each other, at which their energy sign alternates, so this relation is just another formulation of the UP.

If according to the UP the energy of a particle is higher as it is confined to a smaller volume, as its position is less indefinite and its energy in a SCU is a dynamic,

[1] As 'uncertainty' leaves open the possibility that we for some reason cannot know the exact position and momentum of a particle at the same time, but nature always knows where exactly it is and how it moves –which she doesn't– in this text the term 'indefiniteness' is preferred above 'uncertainty.'

[2] And which is the frequency at which the wave function vibrates.

wavelike quantity so its sign and magnitude varies in a wavelike manner within every cycle of its oscillation, then so does the indefiniteness in its position: the higher its energy is, its rate of change in space and time in one phase, the less indefinite the position is it acts from, the greater the probability is to find it within a smaller volume; the less definite its position is in the next phase, the position its energy acts from, the weaker and more equally it simultaneously acts from all points within a larger area, the lower its energy, its rate of change in space and time is.

As they only can exchange energy at equilibrium when they are in counterphase – which they are at distances equal to 1/2, 3/2, 5/2, … times the wavelength they exchange energy in– their distance is quantified and with it the energy they emit or absorb as they jump between different equilibrium states, distances, a jump whereby both their distance and the wavelength they exchange energy in changes with a discrete amount. As their energy only exists, manifests itself as it is being exchanged between particles, in one phase as positive as it is negative in the next, particles have a wave character, giving rise to interference phenomena without which energy wouldn't be quantified and there would be no particles, no universe. If interference only is possible if the magnitude and sign of their energy varies in a wavelike manner, then so should the magnitude and sign (or color) of any kind of charge which contributes to, is an expression of their energy –in which case a particle oscillates between a state in which it looks like what in the present view is a particle and a state in which it looks like an antiparticle. Though this is at odds with the assumption that the rest energy of particles is a privately owned and hence static quantity,[1] only the cause of their interactions so any kind of charge similarly ought to be a fixed, static quantity, agreeing with the observation that their electric charge is either positive or negative, always;[2] particles then wouldn't have a wave character so there would be no interference, no particles.
Whereas in BBC it is a mystery how the elementary particles created at or shortly into the big bang could know what properties to be created with; if they, their properties are cause and effect of their interactions, then they can evolve to elementary particles as a particle then cannot, as in CM, have an infinitely sharp, fundamental boundary where it, its properties end and space begins, implying the existence of fields,[3] that space has properties related to the properties of particles.

Whereas if in a SCU we could cut off the communication between particles, the energy exchange by means of which they express and preserve their, each other's properties, they would cease to exist and with it the universe; as their properties in CM only are the cause of forces, they would keep existing even when prevented to interact –though they wouldn't then be able to communicate their existence.

[1] That is, the UP implies that their energy and hence any kind of charge is subject to quantum fluctuations about which more elsewhere.

[2] But not the color charge of quarks which does alternate as they exchange gluons.

[3] According to quantum field theory particles are excited states, quanta of their underlying quantum fields. Though they are thought to be more fundamental than particles; if particle properties are cause and effect of their interactions, then we can as well say that they are the source of the associated fields.

Only if particle properties would be the cause of their interactions would it be justified to think of the universe as an ordinary object which has particular properties and at any moment in cosmic time is in some particular state as a whole, an object which then can be described from the outside, an object which lives in a time continuum not of its own making. In conceiving of the universe as an ordinary object which has certain properties and at any time is in some particular state as a whole, in assuming that it is the same time, that time passes at the same pace everywhere[1] in empty space, far from masses –that all objects and observers everywhere only are real, live, within an infinitely thin time slice 'now' at some particular moment in cosmic time, in assuming that there is a universal now, that the universe has a beginning– big bang cosmology is the pseudo-scientific continuation of the belief that the universe has been created by some outside intervention.

People like us, who believe in physics, know that the distinction between past, present and future is only a stubbornly persistent illusion. A Einstein
The past is never dead. It's not even past. W Faulkner[2]

2
Causality

Though BBC (cl)aims to describe the universe from within; as it has particular properties and at any time is in some particular state as a whole, it has an external (if, for practical reasons, unobservable) reality, just as the assumption that is the same time, that time passes at the same pace everywhere – ignoring any velocity and gravitational time dilation (GTD) – that it has a definite age, means that it lives in a time realm not of its own making, that time passes, is defined even outside of it. As a SCU only exists as seen from within so contains, produces all time inside of it, here time cannot be observed to pass at the same pace at all distances, meaning that past, present and future are relative, observer-dependent notions.

According to general relativity (GR), a clock is observed to run at a slower pace, a measuring rod to look shorter as the gravitational field at the clock and rod is stronger than it is at the observer. If localized energy is a source of gravity, if it is localized energy which makes positions at different distances physically different, distinguishable –the observed pace of clocks and length of rods– which turns an abstract space where, if it would make sense to speak about time, it would pass at the same pace everywhere, into a real, physical spacetime –here is defined as a space where two points only can be observed to be at different distances if time is observed to pass at a slightly slower pace at the more remote point– then in a SCU the creation of energy *is* the creation –not of space in time but of spacetime. By contrast, as the concept 'energy density of the universe' central to BBC defines energy and space as independent quantities, here energy exists, is defined even in the absence of space and space exists, is defined even when devoid of energy –

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[1] In an expanding (big bang) universe, only clocks which always are at rest relative to the Hubble flow since the big bang show the same time.
[2] *Requiem for a Nun* (1951)

which if true would mean that energy cannot curve nor expand space as energy only can act upon energy.

If by definition there is nothing outside the universe, then it cannot have particular properties nor be in any particular state as 'seen' from without nor as seen from within. If it would have properties and be in some state as seen from within, then it also would have those properties, be in that state as 'seen' from the outside, have an external reality, no matter that it cannot actually be observed from the outside. If it only exists as seen from within so doesn't live in a time realm not of its own making but creates all time inside of it, then there is no universal 'now.' Though a prominent physicist like Carlo Rovelli seems to agree

> … the idea that there exists a ''now'' all over the universe does not square with what we know about the universe. … The picture of a Universe changing from one global instant to the next is incompatible with what we know about the world.[1]
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> If there was an object that had no interactions, no effect upon anything, emitted no light, attracted nothing and repelled nothing, was not touched and had no smell, … it would be as good as nonexistent. To speak about of objects that never interact is to speak of something -even if it existed- that could not concern us. It is not even clear what it would mean to say that such object 'exists'.[2]

he hasn't yet concluded that big bang cosmology then cannot be a valid description of the universe.

If when particle properties are cause and effect of their interactions, their communication must be instantaneous –not over any space distance (in which case the speed of light would have to be infinite)– but over any spacetime distance, then we don't, as in a BBU, see a distant galaxy as it *was*, of itself, in a distant past, in *the* past, but as it *is*, to *us*, when we look at it, in what only to *us* is the present, and, if time in a SCU is observed to pass at a slower pace at larger distances, in an earlier phase of its evolution as it is more distant. The constant of nature called 'the speed of light' then doesn't refer to a velocity but to a property of spacetime: only in a universe which lives in a time continuum not of its own making, where (ignoring any velocity and gravitational time dilation) it is the same time, where time passes at the same pace everywhere would *c* refer to a velocity.

If clocks in a SCU must be observed to run at a slower pace at larger distances so the energy of a particle, the frequency it oscillates, exchanges energy at is lower as observed from a larger distance and, if when energy tends to increase, to keep creating itself, a lower energy can be associated with an earlier evolutionary phase –not with an earlier moment in cosmic time as there is no such thing in a SCU– then particles at the rim of each other's interaction horizon observe each other to have an infinitesimal, nonzero energy, to be in the most early phase of their evolution so a particle can have a beginning without this meaning that the universe has a beginning as a whole.

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[1] *The Disappearance of Space and Time* in *The Ontology of Spacetime* (2006) p 34 Edited by Dennis Dieks

[2] *Helgoland* (2020) Carlo Rovelli p 68, ISBN 978 0 241 45469 5

As its observed energy also depends on the rest energy, distance and motion of the observing particle relative to the observed so it is observed to have a different energy by different observing particles or identical particles at different distances, then its beginning is not, as in BBC, a state which, once achieved, vanishes into the past, but remains an active part of any later state as there always will be observing particles at the rim of its IH which observe it to be in its earliest evolutionary phase. If time in a SCU is observed to pass at a slower pace at larger distances, then the same goes for the frequency a particle is observed to oscillate at so it is observed to have a lower energy, to exchange energy at a lower frequency as observed from a larger distance, to be in an earlier evolutionary phase, an energy which keeps contributing to the energy it is observed to have in a later evolutionary phase or as observed from a shorter distance –*if* we define a lower energy to correspond to an earlier evolutionary phase.

Though Einstein in saying that God doesn't play dice with the world rejected the indeterminacy of quantum mechanics; such indeterminacy is self-evident if particle properties are cause and effect of their interactions. Though he had to reject the idea of a universal now,[1] it is curious that Einstein nevertheless accepted the big bang hypothesis which hinges on precisely that assumption: that the universe at any moment in cosmic time is in some single particular state as a whole.
It is the interpretation of *c* as a velocity, the concept cosmic time, the assumption that the universe lives in a time realm not of its own making why we assume that we see a distant galaxy as it was, in a distant past, in *the* past –which, however, is at odds with his statement that "The distinction between past, present and future is only a stubbornly persistent illusion," a statement which isn't compatible with BBC, with the belief that we see a distant galaxy as it was in a distant past, in *the* past, with the interpretation of *c* as a velocity.
As in BBC all objects and observers only are real, live within an infinitely thin time slice 'now,' we shouldn't even speak about spacetime but of space and time as the universe as it was a second ago then doesn't, *shouldn't* exist anymore. That is, if when particles, particle properties are cause and effect of their interactions, we cannot escape the conclusion that their communication –and hence the transmission of light– then must be instant over any spacetime distance, then the radiation a star in a distant galaxy emits in a supernova affects events in the Milky Way at (what only to us is the) present, however slightly, then we cannot say that the star as it was at the time of emission doesn't exist anymore at the time we observe the supernova, that the nova is finished, completed long before we receive its radiation: that only would be the case in a universe where, as it has an external reality so lives in a time realm not of its own making, the constant of nature *c* refers to a velocity.
In a SCU there is no action at a distance but action at a spacetime distance.
The advantage of an instant communication is that elementary particles, the building blocks of atoms, of stars and galaxies then acquire properties in the building

[1] "Overthrowing the concept of a universal "now" was, according to Einstein himself, by far the most difficult step in arriving at special relativity." *The lightness of being* (2008) Frank Wilczek Ch. 8.

process, that they evolve in a more or less gradual trial and error process –as opposed to a BBU where it remains a mystery how the particles created shortly into the big bang could know what properties to pop up with.

It is our addiction to causality –the belief that there is an objective reality at the origin of our observations– why we came to think of the universe as an ordinary object we may imagine to look at from the outside. It is one or the other: either the universe has been created by some outside intervention –in which case it *is* an ordinary object which lives in a time realm not of its own making– or we live in a universe which has no external reality, which only exists as seen from within.

To understand how the universe can create itself we must examine it from the point of view of the particles doing the creating, how the world looks at its most fundamental -quantum- level, a world which doesn't obey, which cannot be understood causally, so how the world at macroscopic level looks like, the world we perceive with the naked eye and seems to obey causality and is described by CM will be largely ignored in this study.
To avoid any misunderstanding, a selfcreating universe should not be confused with Hoyle's steady-state universe as this suffers the same flaw as a BBU in that it is thought of as an ordinary object which has particular properties and is in some particular state as a whole and similarly lives in a time realm not of its own making, the difference being that it has no beginning and always looks about the same.

If the universe by definition cannot have particular properties, be in any particular state as a whole, if it only exists as seen from within, then it isn't the homogeneous, isotropic object the Friedmann equations (which relate the rate of expansion of the universe to its energy density) presume it to be, nor does it then make sense to speak about its composition at some particular (moment in cosmic) time if there is no universal 'now.'
If particles exist to each other only if, to the extent and for as long as they interact, then we cannot pick an electron out of the universe, say, and measure its mass and electric charge outside of it as it would cease to exist if we could cut off its energy exchange with the particles to which it owes its properties, its existence.
Even if it would keep existing would it be impossible to quantify its properties as there is nothing outside of it relative to which its mass and charge can be compared, quantified: that only would be possible if mass and electric charge would exist, be defined even outside the universe. We only can speak about, quantify the composition of an object if its components also exist in its environment, not of the composition of the universe if by definition there is nothing outside of it.

The fact that there is nothing relative to which the pace of cosmic time (the time in the Friedmann equations) can be quantified, whether it passes fast or slow –or that to do so would require the existence of a clock outside the universe to compare its pace with, a clock the pace of which to quantify in turn would require the existence of yet another clock to compare its pace with etc.– should have alerted us to the possibility that there is something fundamentally wrong with the concept of cosmic time, the assumption that time always passes at the same particular, unperturbable pace, that it only is the gravitational and velocity time dilation which affects its *observed* pace, not the pace at which it passes, of itself, so to say.

As a selfcreating, self-contained universe creates, 'contains' all time inside of it, time cannot be observed to pass at the sane, particular pace everywhere, of itself, unrelated to anything but must be observed to pass at a slower pace at larger distances, to be infinitesimal at the rim of the interaction / observation horizon of the observer or observing particle so its observed pace somewhere is relative, as is the notion of past, present and future. Whereas in BBC it is a mystery why time passes at all; in a SCU it is gravity, the tendency of energy to increase, to keep creating itself which drives the changes we experience as the passing of time.

Though the distinction between cause and effect has been instrumental to the development of classical mechanics; the flaw of causality is that if we understand some event only if we can identify it as the effect of a previous event and can comprehend this event only if we can trace it back to another, preceding event which caused it and going back in time this chain of cause and effect goes on *ad infinitum,* then we never can understand or prove anything definitely, whereas if this chain ends somewhere, if it starts with a primal cause which, as it cannot be explained as the effect of a previous event, cannot be understood even in principle, then causality ultimately cannot explain anything.
Though the world at macroscopic level, the world described by CM does seem to obey causality, to be deterministic, enabling us to quantify the relation between cause and effect, to predict the result of experiments without which no science is possible; in a universe where particle properties are cause and effect of their interactions, events at particle level cannot be understood causally, only rationally, from the point of view of the particles doing the creating, if we keep in mind that they only exist to each other if, to the extent and for as long as they interact, and not, as in BBC, also exist to a hypothetical observer outside the universe, if we acknowledge that the universe by definition only exists as seen from within.

While a meteorologist can explain rain causally –sun heats air (and water) so absorbs more water as gas and expands as it heats, and, as its specific weight decreases as it expands, starts to ascend and cools on the way up until it becomes oversaturated with water which then condenses, forms droplets which grow and eventually start to fall as rain; a physicist has to explain why raindrops fall, why there is gravity, what the nature and origin is of the mass of its particles.

Causality has become an obstruction to the progress of physics, the source of some fundamental problems which, while they sometimes can be circumvented, cannot be solved because it are pseudo problems, problems which arose from a skewed way of looking at, of thinking about things, such as conceiving of the universe as an ordinary object, of particle properties as being only the cause and not, also, simultaneously, the effect of their interactions, leading to infinities.
It is because we're used to examine the subject of our study from the outside, with the naked eye, a microscope or telescope why we came to think of the universe as an object we similarly may imagine to inspect from the outside, speak about its

properties and state, an approach which only would be justified if particle properties would only be the cause and not also, the effect of their interactions: if the universe would have been created by some outside intervention.

3
Superposition of states

If we *define* the energy particles observe each other to have as proportional to the frequency at (or inversely proportional to the wavelength in) which they exchange energy, then they observe each other to have a lower energy, to be in an earlier evolutionary phase as their own rest energy is lower, as they are or move faster apart. Like the distance between particles here is defined as less definite as there is less energy involved in a change of their distance per unit distance –as they are farther apart; a wavelength is less definite as it is longer, as the distance between the tops of two successive wave crests is greater, as the exact position of the tops of the waves and hence the position of the particle is less definite. The shorter the distance is between particles, the shorter, the less indefinite the wavelength is they exchange energy in, the higher the energy they observe each other to have. If (and when) particles cannot emit or absorb photons of a wavelength which is shorter, less indefinite than corresponds to the indefiniteness in their position, then the wavelength they exchange energy is longer as they are farther apart.

If a particle owes its energy to all particles within its IH, then we might think of its energy, of the wavelength λ associated with it as the sum, the superposition of all wavelengths it simultaneously exchanges energy in with particles at all distances. If the wavelength particles exchange energy in is less definite as it is longer, as it matters less, energetically how long it exactly is, then particles exchange energy in a wavelength which is longer, less definite as their distance is greater, less definite, and their own rest energy is lower. The farther apart two particles are and/or the lower their rest energy is, the less definite their distance is, the position from which they exchange energy, interact, the longer, the less definite the wavelength they exchange energy in, the less definite they observe each other's position and hence their motion to be, the lower they observe each other's energy to be, the weaker they interact and the earlier the evolutionary phase they observe each other to be in, the less evolved, the less definite they observe each other's properties to be. The farther apart two particles are, the less their IH's, their universes coincide, overlap, the less definite they observe each other's position to be, the lower the frequency they exchange energy at or the slower they observe time to pass at the other particle, the earlier the evolutionary phase they observe each other to be in, the less definite they observe each other's properties to be, the less their behavior is related, the less they have in common, the less they belong to each other's universe, the less it makes sense to say that it is the same time, that time passes at the same pace at both particles.

The relatively high energy a particle is observed to have, the relatively late evolutionary phase it is observed to be in by a nearby observer then can be thought of

as the sum, the superposition of all wavelengths in which it exchanges energy with particles at all distances, the superposition of all 'earlier,' lower-energy phases of its evolution, all of which keep contributing to the energy the nearby observer observes it to have in what to her is a relatively late evolutionary phase –though we can as well say that it is its relatively high energy it is observed to have as seen from nearby why it is observable by, can interact with distant particles, particles to which it owes (part of) its energy and to the energy of which it contributes.
If the energy of a galaxy similarly can be thought of as the sum, the superposition of all wavelengths it simultaneously exchanges energy in with objects at all distances, in a longer wavelength, at a lower frequency as they are more distant so they observe the galaxy to be in an earlier evolutionary phase, time to pass at a slower pace as observed from a larger distance, then all earlier evolutionary phases of the galaxy keep existing, contributing to the relatively high energy the galaxy has according to a nearby observer, just like the high energy it is observed to have from nearby enables it to interact with, to contribute to their energy.

If we may interpret the UP to say that the energy of a particle is higher as its position is less indefinite, as it is confined to a smaller volume, then the lower its energy is, the less definite the position is from which it interacts with the objects in its environment, the less definite it observes the position of their mass centers to be, the less definite, the longer the wavelength it exchanges energy in with these objects, the lower it observes their energy to be, the earlier the evolutionary phase it observes them, its universe to be in, the earlier the phase it is in itself.
If the energy of particles which are in the process of evolving to elementary particles only starts to increase, their properties to become less indefinite as their position and motion relative to each other becomes less indefinite, as they contract to clusters, to what eventually will become stars and galaxies, then (the properties of) stars and galaxies evolve together with (those of) the particles they are going to consist of, together with the appropriate laws and constants of nature –as opposed to BBC where it is a mystery how the elementary particles created at the big bang knew what properties to pop up with, properties which like some kind of DNA predetermine the properties of and processes in stars and galaxies.

As far as it makes sense to speak about the beginning of a particle or galaxy if it also depends on the energy of the observing particle, its distance and motion relative to the observed what energy it observes the particle or galaxy to have, in what evolutionary phase it is; it is not a beginning we can think of as having been completed, finished in *the* past, as a state which has vanished from the universe, which no longer affects the state of affairs elsewhere at later times. There always will be particles at the rim of the interaction horizon of a particle or galaxy which observe it to be in its most early evolutionary phase –if with 'earlier' we mean that it is observed to have a lower energy. If the energy it is observed to have from nearby is the sum, the superposition of all wavelengths it exchanges energy in with objects at all distances, then the state it is observed it to be in similarly is a superposition of all corresponding evolutionary phases, all of which remain part of, keep contributing to the energy it is observed to have from nearby.

This of course is completely different in a universe where particle properties only are the cause of interactions so don't have to keep interacting to keep existing. If we define the rim of the IH of a particle to be at that distance at which it observes time to pass at an infinitesimal pace, where it observes objects to have an infinitesimal, nonzero energy, to be in the earliest phase of their evolution, then any particle can be said to have a beginning without this meaning that the universe has a beginning as a whole, a beginning, however, which isn't, as in a universe which lives in a time realm not of its own making, a one-off event, a state which, once achieved, ought to vanish from the universe into *the* past. Ought to but doesn't in actual fact as in a BBU we see a galaxy as it was at an earlier (moment in cosmic) time as it is more distant, meaning that the state we observe it to be in only becomes real, happens as we observe it to happen, real, live in the sense that it affects the state of affairs in the Milky way at the time we observe it.

As the energy of particles varies in a wavelike manner within every cycle of their energy exchange, they in some sense repeat their evolution to higher energies, to elementary particles within every cycle of their oscillation –the advantage of which is that they can adjust their behavior, the effective magnitude of any charge which contributes to, is an expression of their energy –and with it the properties of and processes in stars and galaxies– to circumstances and achieve equilibrium. If the rim of the IH of a particle is at that distance where it observes time to pass at an infinitesimal pace so it observes the creation of a particle at the rim of its IH to take an infinite time, then we might say that the observed particle always has existed and always will exist, be it that as the indefiniteness in its position then is infinite, its energy is infinitesimal –and with it any effect of its existence. As there is no sharp boundary between a zero and an infinitesimal, nonzero energy and a lower energy corresponds to a less definite position, we might say that it always existed everywhere, be it that its existence is less distinguishable from its nonexistence as its energy is lower, its position less definite. As it cannot witness its own nonexistence, from its own point of view there is no time in which it and its universe didn't yet exist, nor is there a particle which can claim to be the first to exist as there is no such thing as cosmic time in a SCU.

If particles have to interact to express and preserve their properties, then a particle only can be said to have some property, be in some particular state, be at some location or move in some particular fashion as it is observed to have that property, be in that state, at that location and move as it does by the observing particle as all these factors affect the frequency they exchange energy at. By contrast, as particles in a BBU have an autonomous existence, as their properties only are the cause of interactions, the information about each other has to be communicated by messenger particles which if massless move at the speed of light, so here the information they receive about each other is outdated for a time proportional to their distance, meaning that the energy of a particle can differ from the energy it actually is observed to have: as if the energy it has, it has, of itself, as if it is something which, but for practical difficulties, can be measured even from outside the universe, as if energy exists, is defined even outside of it.

It is the concept of cosmic time, the assumption that the universe is an ordinary object which lives in a time realm not of its own making, the interpretation of the constant of nature *c* as a velocity why we (can delude ourselves that we) can determine what precedes what in absolute sense, what is cause of what, suggesting that every event ever to happen has been predetermined to happen to the last detail at the big bang –if not for the UP which prevents such predeterminism.

As the instant communication between particles in a SCU means that a particle then participates in all interactions the particles to which it owes its energy and to the energy of which it contributes are involved in and they participate in, affect the interactions the particle is involved in itself, we might say that a particle to some extent[1] is present everywhere it affects events, that all particles within each other's IH to some extent are entangled –which is why in QFT fields are supposed to be more fundamental than their excitations, their quanta:

> Particles are epiphenomena arising from fields. Thus the Schrödinger field is a space-filling physical field whose value at any spatial point is the probability amplitude for an interaction to occur at that point. The field for an electron *is* the electron; each electron extends over both slits in the 2-slit experiment and spreads over the entire pattern … Quantum fields have one particle-like property that classical fields don't have: They are made of countable quanta. Thus quanta cannot partly vanish but must (like particles) be entirely and instantly created or destroyed. Quanta carry energy and momenta and can thus "hit" like a particle. … When a field changes its energy by a single quantum, it must do so instantaneously, because a non-instan-taneous change would imply that, partway through the change, the field had gained or lost only a fraction of a quantum. Such fractions are not allowed because energy is quantized. Field quanta have an all-or-nothing quality. The QFT language of creation and annihilation of quanta expresses this nicely. A quantum is a unified entity even though its energy might be spread out over light years--a feature that raises issues of nonlocality intrinsic to the quantum puzzle. "Fields are all there is" should be understood literally. For example, it's a common misconception to imagine a tiny particle imbedded somewhere in the Schrödinger field. There is no particle. An electron *is* its field. … any free … relativistic quantum "particle" must, if it's localized to a finite region to begin with, *instantly* have a positive probability of being found an arbitrarily large distance away. But this turns out to violate Einstein causality (no superluminal signaling). The conclusion is then that an individual free quantum can never--not even for a single instant--be localized to any finite region. … Field-particle duality exists only in the sense that quantized fields have certain particle-like appearances: quanta are unified bundles of field that carry energy and momentum and thus "hit like particles;" quanta are discrete and thus countable. But quanta are not particles; they are excitations of spatially unbounded fields. Photons and electrons, along with atoms, molecules, and apples, are ultimately disturbances in a few universal fields.[2]

It is because particle properties are cause and effect of their interactions, source and product of the associated fields why a particle doesn't, as in CM, have an infinitely sharp, fundamental boundary where it, its properties end and spacetime

[1] An extent which is given by the wavefunction, so the probability to find it anywhere is nonzero.

[2] *There are no particles, there are only fields*. (2012) Art Hobson: https://arxiv.org/ftp/arxiv/papers/1204/1204.4616.pdf

begins, why it can 'spread' a field, or rather, that there isn't a qualitative difference between a particle and its field but only a quantitative difference, that the field looks, acts more like a (point-) particle at the times in its cycle when its energy, its rate of change in space and time is high, as the position it acts from is less indefinite, and more like a field, a wave phenomenon in the phase in which its energy, its rate of change in space and time is lower, as it acts more equally and more simultaneously and hence weaker from all points within a larger region.

As according to the UP a field cannot be *and* remain zero, empty space is thought to be uniformly filled with these fields / virtual particle-antiparticle pairs which continuously pop up out of the vacuum to annihilate after a time which is shorter as their energy is higher, the problem being that its calculated vacuum energy density is some 120 orders of magnitude greater than would fit observations. However, if the universe cannot have particular properties as a whole, then the vacuum energy density cannot be the same everywhere, be an intrinsic property of space. It is because we assume that the properties of the virtual particles of the vacuum only are the cause of whatever effects we want them to explain why we suppose that its energy density is the same everywhere.

If energy only exists, manifests itself if it can be localized, if it has a position to act from and be acted upon, act as a source of gravity, like mass, and according to the UP the energy of particles increases as the uncertainty, the indefiniteness in their relative position decreases, which it does as their distance decreases, as they contract to clusters and in a universe where particle properties are cause and effect of their interactions, mass cannot causally precede gravity, then instead of saying that, as in BBC, particles contract to clusters because they somehow have been endowed with mass at their creation at the big bang and masses for some mysterious reason attract, that their mass is the cause of their gravitational attraction; in a SCU their energy, their mass only increases *if and when* they contract to clusters, to what eventually will evolve to stars and galaxies.
This they are bound to do as the gravitational field they sit in increases as they contract and with it the GTD which, as it tends to freeze, to prolong in time a state in which they are nearer together above a state in which they are farther apart -a state of higher above a state of lower energy- as a shorter, less indefinite distance corresponds to a higher energy which, as it is a source of gravity, increases the mass they observe, cause each other to have, the strength of the gravitational field they sit in and produce, and with it the gravitational time dilation which tends to keep them at that, shorter distance.

The misleading thing about gravity, then, is that in driving the changes we experience as the passing of time –the contraction of particles to stars and galaxies– we have a sequence between events we misinterpret as proof that their mass is cause of their contraction, as if mass can causally precede gravity and time always passes at the same pace everywhere, no matter whether or not something happens, changes. In a SCU it is gravity, the tendency of energy to increase, to keep creating itself which drives (the changes we experience as the passing of) time.

Though one might object that for this mechanism to work, particles must already have a nonzero starter mass; if, as will be discussed, a gravitational field is an area of 'condensed' spacetime as seen from outside the field, where it is weak and it is mass, localized energy which powers, manifests itself as a gravitational field, which turns an abstract space where, if it would make sense to speak about time, it would pass at the same pace everywhere into a real, physical spacetime –here defined as a space where two points only can be observed to be separated in space if time is observed to pass at a slightly slower pace at the more remote point– then we might say that the state of zero energy is preserved where the strength of the gravitational field is infinitesimal, a state which is separated in space and time from the higher energy states nearer to its mass center, states which also are separated in space and time from each other, that they don't, as in a BBU, coexist at the same (moment in cosmic) time as there is no universal 'now' in a SCU.

This isn't the whole story, however, one reason being that the contraction isn't just the motion of particles toward each other *through* space, *in* time –as if space and time already exist, are defined even before there is energy; another that this energy creation only works for particles which are evolving to higher energies, to elementary particles, not for particles the properties of which are fixed, the contraction to clusters of which *takes* energy –that is, until the conditions in which they can exist, are stable are exceeded, like when the star they form collapses to or falls into a black hole. Though according to the energy conservation law, energy cannot be created nor destroyed; if the energy of particles is a dynamic, wavelike quantity, in one phase as positive as it is negative the next, then the total energy of the universe remains nil, meaning that it has no external reality but only exists as seen from within, that particles only exist to each other if, to the extent and for as long as they interact, exchange energy and not, as in BBC, that they also exist to a hypothetic observer outside the universe.

As the speed of light is the same everywhere as measured locally,[1] the gravitational time dilation implies that a measuring rod looks shorter as the gravitational field at the rod is stronger than it is at the observer so the gravitational field of a massive object, of black hole, say, is an area of 'condensed' spacetime as seen from outside the field, as inferred from the time it takes a photon to move toward the hole as seen from outside its gravitational field (if we could observe the photon as it travels toward the hole –which is impossible). Quote marks on condensed because it wrongly suggests that the mass of the hole causes an already existing volume of space to contract about the hole. Though the hole does curve spacetime in its vicinity (a spacetime as it would exist in the absence of the hole); as it is its own energy which makes positions at different distances physically different, the gravitational field nearer to the hole is more local, more 'private' extension of spacetime, so to say, a spacetime which unfolds to the photon penetrating it.

If particles observe each other to have a higher energy as their distance is smaller and a higher energy corresponds to a stronger gravitational field they feel and are

[1] Which is a tautology if we *define* the second as the time it takes light to travel 299,792,458 meter and the length of a meter as the distance light travels in 1/299,792,458 second.

the source of, a greater time dilation, then they'll tend to contract to clusters at places rather than move apart, a process whereby the indefiniteness in their relative position decreases and (UP) that in their momentum increases: if the uncertainty, the variation in the magnitude and direction of their momentum increases, then so does their kinetic energy and, as it is a source of gravity, their mass, the mass they observe each other to have, and so should the mass of the cluster.
However, if a greater mass corresponds to a stronger gravitational field and the mass of a particle cluster can be thought to reside at its mass center and its gravitational field is a region of 'condensed' spacetime so as seen from outside of it, the field increases the spacetime distance between its mass center, the point its energy acts from as a source of gravity and the objects it acts upon, then its own field decreases, 'dilutes' the expression of its energy as gravity, so to say, so if we ignore the spacetime creation implied in the increase of its gravitational field, then the mass of a cluster may, depending on how we define mass, (seem to) decrease as it contracts.

If we were to assume that a black hole in a SCU has no event horizon if *c* doesn't refer to a velocity but to a property of spacetime nor a gravitational singularity if its mass is cause and effect of its interactions and its gravitational field is a region of condensed spacetime, then the distance between an observer outside its field, where it is weak, and the mass center of the hole as measured inside the field, the point its energy acts from, is greater than as measured outside of it, as inferred from the positions of the observer and the hole's mass center relative to surrounding stars. If as seen from the outside in, the field of the hole increases the spacetime distance between the point its energy acts from as a source of gravity, then its own field decreases, 'dilutes' the expression of its own mass, the force it exerts on masses in the environment, as if to distance itself in space and time from them to minimize its interactions with them.
However, as seen from the opposite direction, from inside the field out, from the mass center of the hole, the same field, the same GTD accelerates the pace at which clocks outside the field are observed to run, the frequency particles are observed to oscillate at, at which they exchange energy with the hole, enhancing their energy, the mass of neighboring objects, as if to make up for the distance increasing, force-diluting effect the field has as seen from outside the field in. As a result, massive objects can keep interacting gravitationally over large distances even though gravity seems to be so weak a force.

If as seen from outside of it, the gravitational field of a particle is a region of condensed spacetime, if time is observed to pass at a slower pace where the field is stronger so spacetime seems to be more viscous, frozen in time nearer its mass center, then it is the gravitational time dilation which opposes, which slows down in time the penetration of the tips of a tiny tweezer in its gravitational field we might use to try to pick it up, to confine it to a smaller space –which, as it decreases the uncertainty in its position, takes increasingly more energy, grants it the tangibility which, together with its inertia, we associate with matter.

Only if the rest energy of particles would be a privately owned, fixed quantity, only the source of forces would mass causally precede gravity, the universe have an external reality, live in a time continuum not of its own making and the constant of nature *c* refer to a velocity. However, if particle properties indeed would be fixed quantities, only the cause of interactions so they cannot gain anything by behaving in some particular manner, then they wouldn't be able to interact, exert and feel any force at all so it wouldn't even be properties: only if their properties are cause and effect of their interactions *and* energy tends to increase, to keep creating itself can particles interact, contract to stars and galaxies. If the rest energy of a particle is invariant, then that doesn't mean that it is a privately owned quantity, only the cause of interactions, but because a change would require the energy of all particles within its IH to change: it isn't something they have with respect to an imaginary observer outside the universe –in which case energy would have to exist, be defined even outside of it, but something they have relative to each other. If we always measure an electron, say, particle to have the same mass and electric charge, then that is because a measurement is a standardized interaction, executed in the same conditions: their actual, effective magnitude, however, depends on the energy of the interaction.

To summarize: if in a selfcreating universe particles, particle properties must be as much the cause as the effect of their interactions, then this has some far-reaching consequences:

- the communication between particles and hence the transmission of light then is instantaneous, not over any space distance but over any spacetime distance.
- as a SCU contains, produces all time inside of it so time cannot be observed to pass at the same pace at all distances, past, present and future are relative, observer dependent notions.
- a particle then cannot have an infinitely sharp, fundamental boundary separating it, its properties from spacetime, where the particle ends and its environment begins.
- if the energy of a particle varies in wavelike manner within every cycle of its oscillation, then so does the indefiniteness in the position it acts from, from which its energy curves spacetime: a particle is a modulation in and of spacetime itself, an excitation, a quantum of the associated field.
- if any kind of charge contributes to, is an expression of the energy of particles and the energy involved in one interaction, associated with one kind of charge, one force, powers and is powered by all other interactions a particle is simultaneously involved in due other kinds of charge, then what seem to be unrelated, qualitatively different kinds of charge are different expressions of a single quantity, of their energy.
- if their properties are as much the cause as the effect of their interactions, of forces between them, then a force cannot be either attractive or repulsive, of itself, agreeing with Newton's 3rd law according to which the force between two particles only can be as strong as the counterforce, the opposition to it they are able to evoke.

- only if their properties are cause and effect of their interactions, of forces between them can particles evolve: by adjusting their behavior and with it the expression, the effective magnitude of the different kinds of charge powering opposite forces to circumstances can they achieve a stable equilibrium.

If the distance between particles *A* and *B* at equilibrium changes then that is because the distance at which their attraction and repulsion due to different kinds of charge are equal changes when the system *AB* absorbs or emits energy and these forces have a different distance dependence. If their properties would only be the cause and not also, simultaneously, the effect of their interactions, then particles would go sit and stay on top of each other once their attraction due to one kind of charge at some distance overcomes their repulsion due to another kind of charge. Though the UP forbids this as this would correspond to a zero uncertainty in their position, to an infinite energy; if it is the environment which is to supply that energy, then it is the environment –the conditions they find themselves in and create– which determines the distance at which they can be at equilibrium. If particles wouldn't be able to adjust the strength of the different forces between them, the effective magnitude of any kind of charge by adjusting their distance or relative motion –if their communication wouldn't be instant over any spacetime distance– then they wouldn't be able to achieve a stable equilibrium, form stable matter and the UP wouldn't then apply.

If the energy of a particle, its rate of change in space and time varies in a wavelike manner within every cycle of its oscillation and it is its energy which makes positions at different distances physically different, then so does the curvature of spacetime, the extent to which it is defined, to which the observed pace of clocks and length of rods varies in space and time in the area where it can be localized.
The particle then is itself a modulation of and in spacetime, its energy stored in the extent to which spacetime is curved where it can be localized, its curvature varying with its energy, greater in the phase in which its energy, its rate of change in space and time is higher, as its position is less indefinite so it acts more like a (point) particle, and more like a wave phenomenon in the phase in which the curvature of spacetime smaller, as its energy, its rate of change in space and time is lower, as its position is less definite so acts more equally, more simultaneously and hence weaker from all points within a larger area.

As a particle in a SCU has no infinitely sharp, fundamental boundary separating it, its properties from its environment, as it is its energy which makes positions at different distances physically different and its energy is a dynamic, wavelike quantity, then so is spacetime, meaning that it cannot be devoid of energy. If when the sign and magnitude of its energy varies within every cycle of its oscillation and with it the observed pace of clocks and length of rods in the area where it can be localized, then a particle can be said to alternately move in forward and backward time direction about some zero-time point. If its energy in one phase is as positive as it is negative in the next, then it is as if the particle in one phase tries to undo the effects of its existence in the previous phase –in vain, for the higher its energy is, the faster it tries to undo these effects, the faster it oscillates between opposite states, the higher its energy is and the greater the effects are of its existence.

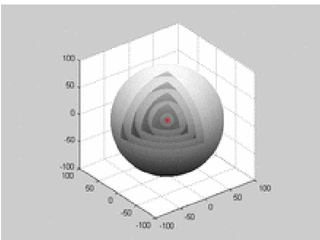
As the exchange of energy, of information between particles only serves to preserve the *status quo*, the world we see, it isn't observable so doesn't seem to occur at all: it only would become observable if we could cut off their communication – in which case they would cease to exist and the universe would vanish like the picture on a TV screen when we pull its plug. As their properties in the classical view only are the cause of forces so they would keep existing even when prevented to interact, their communication is thought to proceed via the random emission and absorption of force-carrying particles like gravitons and photons to express their mass and charge, messenger particles which mediate the gravitational and electromagnetic force and which if massless move at the speed of light.

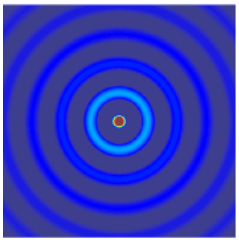
If the emission and absorption of messenger particles is random and their emission (absorption) decreases (increases) the energy of the emitting (absorbing) particle, then the energy, the mass and electric charge of an electron, say, would vary randomly so it could cease to exist if it loses more energy by emitting photons and gravitons than it absorbs –if not for the UP according to which the variation ΔE in its energy may last for a shorter time Δt as it is higher. It is unclear, however, how the particles in its environment can know when to replete a deficit in its energy, when they are to send messenger particles with the right energy at the right time in the right direction for if they move at a finite (light) velocity, then the emitting particles would have to be clairvoyant to predict the position, motion and energy of the electron at any future time to ensure the timely arrival of the photons and gravitons they send toward the electron to replenish its energy. In other words: how can the electron know what mass and charge it ought to have and preserve its mass and charge if the emission and absorption of messenger particles is random and they move at a finite velocity? There obviously is no such problem if particles express and at the same time preserve their existence, their properties by exchanging energy and the exchange is instant over any spacetime distance.

If the rest energy and hence the electric charge of a particle would be a privately owned and hence static quantity, either positive or negative, always, then a finite-sized electron would disintegrate due to the electric repulsion between its parts. As it doesn't, the electron is thought to be a dimensionless point particle, implying an infinite electric charge and bare mass, infinite forces and interaction energies at infinitesimal distances. While these infinities can be circumvented by assuming that the electron is shrouded in a cloud of short-lived virtual electron-positron pairs which are temporally created out of the force fields of the real electron, electric dipoles which by orienting themselves in the electric field of the real electron screen its infinite electric charge, resulting in the finite values observed in experiments; such infinities obviously don't occur if particle properties are cause and effect of their interactions, if their energy –any kind of charge which contributes to, which is an expression of their energy– is a dynamic, wavelike quantity, in one phase is as positive as it is negative in the next, if the energy of a particle is higher as its rate of change in time is higher, as the frequency its energy sign alternates

at is higher, as its rate of change in space, its wavelength, the distance over which its sign flips is shorter.
Though many physicists are unhappy with a trick which turns an infinite into a finite quantity; the assumption that the electric charge of the electron is infinite originates in the belief that particle properties only are the cause of interactions.
Clearly, if when their properties are cause and effect of their interactions, a particle cannot have an infinitely sharp, fundamental boundary separating its properties from its environment, then we cannot think of its mass and charge as residing within a dimensionless point, an infinitesimal volume: to say that it does is to say that space exists, is defined even when devoid of energy.

If the energy of a particle varies within every cycle of its oscillation, then so does the indefiniteness in the position its energy, its charge acts from as does the extent to which spacetime is curved where it can be localized. As a force only can be as strong as the counterforce it meets or is able to evoke, forces between particles only can become infinite if we spend an infinite amount of energy in decreasing (the indefiniteness in) their distance, thereby increasing their energy –and with it any force, the effective magnitude of any kind of charge.
If the sign and magnitude of the energy, of the electric charge of an electron varies in a wavelike manner within every cycle of its oscillation and with it the indefiniteness in the position its energy, its charge acts from, if it has no fundamental boundary where its energy, its charge ends and space begins so its charge doesn't reside within an infinitesimal point but alternately spreads and shrinks over space in a wavelike manner, if the electron is a modulation of and in spacetime itself so the magnitude and sign of any kind of charge varies, alternates in space and time as illustrated in these in these animations, [1]





so the negative areas, phases of the electron wave are separated by its positively charged areas, phases, then the electric repulsion between its like-charged phases is balanced by the attraction between the oppositely charged parts of the electron wave so there is no need for virtual electron-positron pairs to screen what only in the classical view is an infinite mass and electric charge –unless we interpret these virtual electron-positron pairs as the quanta of the electron field.
In other words, the energy, the effective electric charge of particles only can become infinite if we confine it to an infinitesimal space –which would take an infinite energy to accomplish. As the energy to decrease (the indefiniteness in) the distance between particles has to be supplied by the environment, it is the

[1] https://upload.wikimedia.org/wikipedia/commons/7/7e/Spherical_Wave.gif
https://commons.wikimedia.org/wiki/File:Spherical_wave2.gif (20-3-2021)

environment which determines the distance at which they can be at equilibrium, the strength of forces between them, the effective mass and charge they observe each other to have at that distance. If we collide charged particles at higher momentum, they exhibit a greater charge, then that isn't because at a shorter distances the cloud of virtual electron-positron pairs is thinner, less effective in screening their infinite charge, but because by decreasing (the indefiniteness in) their distance at the collision we increase their energy, their electric charge.

4
The 'speed' of light

The fact that light always and everywhere travels at 299,792,458 meter per second is quite remarkable for how can it know at what speed it must move and maintain that exact velocity? Does it have some kind of GPS and cruise control on board? [1]
According to relativity theory the observed pace of a clock is slower as it moves faster relative to the observer, to stop, to freeze at the speed of light: as a particle moving at the speed of light is completely frozen in time, from its own point of view its voyage takes no time at all. If at the speed of light it is completely frozen in time so its state, its energy cannot change as it travels, then it cannot express its energy, its properties in interactions with the objects in the environment it travels through –which is why a particle moving at the speed of light is massless, why a massless particle moves at the speed of light.
However, if at the speed of light it cannot interact with the objects in the environment it travels through so it doesn't exist, has no physical reality to these objects nor the environment to the particle, then its position is completely indefinite as it then doesn't make any sense to specify relative to what it moves, meaning that we shouldn't think of the constant of nature *c* as a velocity.
Though we can predict when we can intercept a photon where if we know when and where it was emitted in what direction; that doesn't mean that we may think of it as a particle which moves through space, in time, the universe growing older as it travels if it only can be said to have a location and velocity if it keeps existing to, interacting, exchanging energy with the object relative to which it moves.
It is because particles in the classical view have an autonomous existence so don't have to keep interacting to keep existing why *c* came to be thought of as a velocity: because we look at it from a mathematical rather than a physical point of view.
As in a universe where particle properties are cause and effect of their interactions, their communication –and hence the transmission of light– is instantaneous over any spacetime distance, it is obvious why nothing goes faster than light.

If in a misty field at night a laser is switched on, its beam perpendicular to our line of sight and some distance above the horizon, and we watch from afar the motion of the front of the light beam as it is reflected by the mist droplets in our direction, then we see the beam front move at a constant velocity away from the laser.

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[1] If we *define* the meter as the distance light covers during 1/ 299,792,458 second and the second as the time it takes light to cover a distance of 299,792,458 meter, then the speed of light obviously is the same everywhere as measured locally.

While this observation can be explained by assuming that time passes at the same pace everywhere and that light moves at a finite velocity through space, in time, the universe growing older as it travels; we see the same if the light is instantly everywhere on its path and, via the mist droplets, in our eyes as soon as the laser is switched on in a universe where time is observed to pass at a slower pace at larger distances, if a clock at the laser is observed to run at a slower pace as it is more distant as measured from the laser via the path of the light toward us.
It is the belief that the universe has a beginning, a definite age, that it is the same time, that time passes at the same pace everywhere, that it lives in a time realm not of its own making why we assume that we can, in principle though not in practice (look from outside the universe in as it is at some particular moment in cosmic time, of itself, without the time delay due to the speed of light), determine what precedes what in an absolute sense, what is cause of what, why light came to be thought of as something which moves through space, in time, the universe growing older as it travels –instead of the property of spacetime it is in a SCU.

If in a space where time passes at the same pace everywhere, there is a light source *S* and two observers *A* and *B* moving at a different velocity relative to *S* in the same plane –in the same time slice 'now'– and light at any time would have a definite location, if it would move at a finite, constant velocity, then *A* and *B* should measure the light *S* emits to move at a different velocity.
The present, not incorrect explication why they nevertheless measure the same light velocity is that the observer sees her path shrink and observes clocks along her path to run at a slower pace as she moves faster. However, the observer only finds the speed of light to be independent from her own motion relative to its source, to the light, if the ratio between the length she observes her path to have when moving and when at rest varies in the same manner with her velocity as the ratio between the pace she observes clocks along her path to run when she is moving and when at rest: if space and time are intrinsically related.
This they only are in a universe where, as it only exists as seen from within, a clock is observed to run at a slower pace as it is more distant even when at rest relative to the observer, a pace which then also should depend on the rate of change of its distance to the observer, not in a universe where it is the same time, where time passes at the same pace everywhere in empty space, where, as its pace isn't related to anything, it is a mystery why there is time at all.

It is because space and time are inseparately related why the value of the constant of nature called the 'speed of light' has nothing to do with the observers, why they find the same value no matter their own motion relative to the light source or the photon: because it doesn't refer to a velocity –which, as it requires that we specify relative to what the photon moves, then should be different to observers moving at a different velocity– but to a property of spacetime. Whether *c* refers to a velocity or a property of spacetime depends on whether the photon can be ascribed a location or not: whether it keeps interacting with the objects relative to which it is supposed to move or not, whether at the speed of light a particle is completely frozen in time or not, whether special relativity theory is correct or not.

As the transmission of a photon between atoms *A* and *B* changes the state, the energy of both atoms, *A* observes *B*'s state to change at the time it emits the photon since as soon as *A*'s energy changes, the world it observes –including *B*– has changed, looks different to *A* after the emission of the photon, whereas *B* observes *A*'s state change at the time it absorbs the photon, as its own state changes due to the absorption of the photon and hence its observation of, its interactions with the objects within its interaction horizon, including *A*. That is, unless we believe that *B*, after absorbing *A*'s photon sends back a message to *A* to confirm the receipt of the photon, a thank-you note informing *A* that it can, as of this moment, the receipt of the note, start to see *B* in its new state, with an increased energy, start to interact differently with *B*.

If the universe only exists as seen from within so contains, produces all time inside of it, time cannot be observed to pass at the same pace at all distances so past, present and future are relative, observer dependent notions, then we cannot ask what in an absolute sense precedes what, what is cause of what, which of the atoms is the cause of the photon transmission. As there is no universal now in a SCU, no single, objective reality all observers and observing particles live in, have in common, nothing outside nor inside the universe relative to which can be determined what precedes what, *A* and *B* are equally right about the time of the transmission, of an event: as they observe it to happen, as they participate in it.
If its transmission is instant over any spacetime distance, then *A* cannot emit a photon without the cooperation of *B*, the atom which is to absorb it –or rather, without the cooperation of all particles within the interaction horizons of *A* and *B*, which are affected by, take part in the transmission. As the photon carries energy and momentum, the energy and momentum of *A* and *B* change due to the photon transmission: as this instantly affects all particles within the interaction horizons of *A* and *B*, they all participate in the transmission, are part of its cause-and-effect, so if they contribute to or absorb some of the photon's energy and momentum as a change of the momentum and energy of *A* and *B* affects their own energy and momentum, then the photon transmission is an event which simultaneously happens everywhere within the interaction horizons of *A* and *B*.
It is because time in a SCU is observed to pass at a slower pace at larger distances which creates the illusion that such change propagates through space, in time, why we came to think of the transmission of light in terms of cause and effect, of the photon as an object which moves through space, in time:

> In QED the photon is introduced as the unit of excitation associated with a quantized mode of the radiation field. As such it is associated with a plane wave of precise momentum, energy and polarization. Because of Bohr's principle of complementarity we know that a state of definite momentum and energy must be completely indefinite in space and time. This points to the first difficulty in conceiving of the photon. If it is a particle, then in what sense does it have a location? This problem is only deepened by the puzzling fact that, unlike other observables in quantum theory, there is no Hermetian operator that straightforwardly corresponds to position for photons. Thus while we can formulate a well-defined quantum-mechanical concept of position for electrons, protons and the like, we lack a parallel concept for the photon … The simple concept of spatiotemporal location must therefore be treated quite

> carefully for photons. We are also accustomed to identifying an object by a unique set of attributes. My height, weight, shoe size, etc. uniquely identify me. Each of these has a well-defined value. Their aggregate is a full description of me. By contrast the single photon can, in some sense, take on multiple directions, energies and polarizations. Single-photon spatial interference and quantum beats require superpositions of these quantum descriptors for single photons. Dirac's refrain "photons interfere with themselves" while not universally true is a reminder of the importance of superposition. Thus the single photon should not be thought of as like a simple plane wave having a unique direction, frequency or polarization. Such states are rare special cases. Rather the superposition state for single photons is the common situation. Upon detection, of course, light appears as if discrete and indivisible possessing well-defined attributes. In transit things are quite otherwise.[1]

What in CM, in BBC are three separate, unrelated events which happen one after the other, the autonomous, spontaneous, random emission of a photon by *A*, its voyage in some random direction and its accidental absorption by *B* –unrelated in the sense that once emitted, there is no communication between the traveling photon and *A* nor with any particle or atom it eventually is to be deflected or absorbed by; in a SCU it is a single event which happens simultaneously everywhere within the entire interaction horizons of *A* and *B*: not over all of space at some particular moment in cosmic time but over all of spacetime.

While the fact that we can switch on a lamp seems to prove that light emerges from the lamp, that its emission causally precedes its arrival elsewhere at later times, that light travels through space, in time; the lamp is a device designed in such way that once supplied with energy, the probability of a photon emission becomes extremely close but not exactly equal to 1. While we can create favorable conditions for a photon transmission to occur; in a SCU the lamp cannot emit a single photon without the cooperation of the environment which is to absorb it. It is because there usually are plenty other objects prepared to absorb the photon why its emission doesn't seem to depend on anything, as if the light source is the autonomous cause of the emission, as if light is something which moves through space, in time, the universe growing older as it travels.

5

Feynman's path integral

John Wheeler about Feynman's path integral –or 'sum-over-histories'– method:

> Back in 1940 or 1941, Feynman had come up with a new way to look at quantum phenomena that I called 'sum-over-histories.' The idea, in brief, is this: In quantum mechanics, if you to want to find out how something at point *A* influences something at point *B*, you can get the answer by pretending that all of the ways that *A might* send a signal to *B* happen *at once*; the actual effect is then a sum of all the 'virtual' effects from all of the different paths. It is as if a baseball pitcher, instead of throwing a single ball toward the batter, could launch simultaneously a thousand balls that

[1] Arthur Zajonc, in *Light reconsidered* (2003) https://www.arthurzajonc.org/wp-content/uploads/2016/06/LIght-Reconsidered.pdf

> travel a thousand different paths through space and time on their way to the batter. Each of these thousand balls has a 'history' as it flies from pitcher's mound plate. What the batter sees and swings at is the result of all these histories combined. A mind-bending idea, to be sure, but it's just what happens in the quantum world. [1]

If the pitcher and batter represent atoms *A* and *B* between which a photon (baseball) is transmitted and *A* would autonomously emit the photon –independent from what is and happens in its environment, from the presence or absence of atoms to absorb it– then the photon should follow a single path, not split into a thousand photons which follow simultaneously thousand different paths, including detours via Sirius. While they may all depart at the same time at *A*; as paths of different lengths take different times to travel if light moves at a finite, constant velocity, they cannot arrive at the same time at *B* –in which case Feynman's 'sum-over-history' method couldn't possibly work. That it works shows that the communication between particles is instant as only then the effects from all thousand paths can be summed, superposed, processed simultaneously into the actual photon transmission –effects associated with the properties, motion and location of all particles within the interaction horizons of *A* and *B*, which, as the transmission changes the energy and momentum *A* and *B* have according to the particles within their IH's so affects their own energy and momentum, participate in the transmission, have to be weighed, represented in the end result: that there is a continuous, instant exchange of energy between particles by means of which they express and at the same time preserve their, each other's properties.
If they are part of its cause-and-effect then the transmission is an event which simultaneously happens everywhere within the IH's of *A* and *B*. It is because time in a SCU is observed to pass at a slower pace at larger distances which creates the illusion that such change propagates at a finite velocity through space, in time.
What Wheeler's thousand balls do is collect and (re)distribute some of the energy and momentum involved in the photon transmission from and between all particles involved in the transmission: to communicate and weigh all physically relevant information between all particles participating in it, to process what classically would be cause into effect.

As any particle in a SCU can consider itself to be (at) the center of its own IH, its own universe, it contains in its own properties, location, state and motion relative to all objects to which it owes its energy and to the energy of which it contributes all relevant information about its environment –not of *the* universe as there is no such thing, but of the universe it observes when we inspect the particle.
Like a hologram fragment contains all information of the entire hologram; if particle properties are cause and effect of their interactions then a particle contains, in its 'own' properties, state, location and motion relative to all other particles all physically relevant information about all other particles, about its entire universe. Like the hologram fragment gives a vaguer, fuzzier picture of the entire hologram as it is smaller; the information a particle represents, contains about its universe is vaguer, less defined, detailed as its rest energy is lower, as its own position is

[1] *Geons, Black Holes, and Quantum Foam* (1998) J.A. Wheeler p 167–168

less definite and the world it observes from that fuzzier, less definite location. The lower its rest energy is, the less definite its position and motion is, the less defined, evolved its own properties are, the lower it observes the energy to be of the objects in its environment, the less definite it observes their position and motion to be, the less definite it observes their properties to be, the earlier the evolutionary phase it observes them, its universe to be in, the earlier the phase it is in itself.
If a particle, like the hologram fragment contains all information about its universe including the observer so she is herself depicted in the fragment she examines, then she cannot but affect what she observes by subjecting it to a measurement.

6

Space, time and spacetime

It takes much more energy to increase the distance between a nail and a magnet from 1 to 2 millimeter than to increase it from 1 to 2 meter, so if we were to define their distance in terms of the energy involved in a change of their distance –if we would define the unit length as the displacement which takes one joule of energy, say– then we would conclude that there is increasingly more space 'contracted' within what to us looks like a small distance, in a smaller volume nearer to the magnet –smaller as inferred from the position of the nail and magnet relative to surrounding objects, as measured with a ruler which isn't affected by the magnet. Similarly, if it takes more energy to increase the distance between two massive objects when they are nearer to each other than the same displacement when farther apart and we define the unit length as the distance increase between a test particle with a mass of one gram and a massive object, a black hole, say, which takes one joule and use this to construct a ruler the distance between any two successive millimeter marks of which when inserted in the gravitational field of the hole, toward the hole, adjusts to the local field strength in such manner that it takes one joule to move the particle from one millimeter mark to the next, then as seen from outside the gravitational field of the hole in, such ruler would shrink nearer the event horizon of the hole, show an increasing number of millimeter marks per millimeter of a rigid meter stick held parallel to the ruler, a meter stick the length of which isn't affected by the gravitational field of the hole. As seen from a position where the field of the hole is negligibly weak, there is increasingly more spacetime 'stored' near the event horizon within what to the observer is a smaller volume, a spacetime which unfolds to a particle penetrating the field.

If we interpret *c* as a velocity and we could observe, from that vantage point, a flashing light move toward the hole at a constant velocity as measured locally and as seen from outside of it, the field is a region of condensed spacetime, then the nearer to the hole's event horizon the flashing light is, the stronger the field is at the flashlight and ruler than it is at the observer, the smaller she observes the distance between the marks of the ruler to be, as if she looks at it from a larger spacetime distance (which she does indeed) and hence the slower she observes the flashlight move toward the hole, the slower the frequency of the light flashes and the farther its light is shifted to red, so as seen from outside the field, a clock is observed to run at an increasingly slower pace at a larger distance from the observer, nearer the hole's event horizon even when at rest relative to the observer.

If as seen from outside of it, a gravitational field is a region of 'condensed' spacetime and a clock is observed to run at a slower pace, a rod look shorter as the field is stronger than it is at the observer, as they are more distant even when at rest relative to the observer and the source of the field, then a clock should also be observed to run at a slower pace, a rod look shorter as they are more distant even in an 'uncondensed' spacetime: if two points only can be observed to be at different distances in space if time is observed to run at a slightly slower pace at the more remote point –slightly because *c* is so large a number.

The gravitational time dilation of relativity in a SCU then can be thought of as a (spacetime–) distance redshift, so if galaxies look shifted farther to red as they are more distant, then it may be a distance rather than the velocity redshift resulting from the expansion of space in time in a BBU. However, if energy in a SCU cannot stop creating itself and its creation *is* the creation of spacetime so the spacetime distance between galaxy clusters increases, then their redshift may have a velocity component.

It was formerly believed that if all material things disappeared out of the universe, time and space would be left. According to relativity theory, however, time and space disappear together with the things. –Albert Einstein[1]

When … we say that a body preserves unchanged its direction and velocity in space, our assertion is nothing more or less than an abbreviated reference to the entire universe. – Ernst Mach [2]

7

Mach's principle

As in BBC going back in time, space shrinks but the energy content of the universe remains unchanged,[3] all energy must have been concentrated within an infinitesimal volume at the big bang, meaning that, like the concept 'energy density of the universe' means that energy and space are thought of as independent quantities, that energy exists, is defined in the absence of space and space exists, is defined even in the absence of energy. As this contradicts Einstein's statement that space and time would disappear along with matter, with (localized) energy, it is curious that he didn't reject the big bang hypothesis, for if energy and space indeed would be unrelated quantities, then energy wouldn't be able to curve nor expand space as energy only can act upon energy.

Though Einstein was inspired to his theory of general relativity by what he came to call Mach's principle –the proposition that the inertia of a body is something it has relative to all other masses in the universe– and

[1] https://www.nature.com/articles/d41586-018-05004-4 (13-11-2020)

[2] *The Science of Mechanics*. p 233 Mach, Ernst (1960). LaSalle, IL: Open Court Pub. Co. LCCN 60010179. Reprint of the English translation by Thomas H. MCormack (first published in 1906) See https://archive.org/details/sciencemechanic00machgoog/page/n260/mode/2up (10–4–2020)

[3] Before observations indicating that the expansion of the universe accelerates.

> The theory of general relativity teaches that the inertia of a given body is greater as there are more ponderable masses in proximity to it; thus it seems very natural to reduce the total inertia of a body to interaction between it and the other bodies in the universe, as indeed, ever since Newton's time, gravity has been completely reduced to interaction between bodies. From the equations of the general theory of relativity it can be deduced that this total reduction of inertia to interaction between masses -as demanded by E. Mach, for example- is possible only if the universe is spatially finite.[1]

on closer examination

> …the general theory of relativity does not fully entail Mach's principle as conceived by Einstein in the sense that the energy tensor unequivocally and completely determines the metric of spacetime. It could be shown that a particle in an otherwise empty universe can possess inertia… Einstein's confidence in the principle gradually waned, so much so that eventually, a year before his death, he declared that "one should no longer speak at all of Mach's principle." [2]

> The observed fact that a gravitational force is *locally* indistinguishable from an inertial force, in that each induces the same acceleration in all bodies, suggested to Einstein that it is the gravitational influence of the whole universe which gives rise to inertia. General relativity was devised to incorporate this idea, but, as emphasized by Einstein, it failed to do so. Einstein showed that his field equations implied that a test-particle in an otherwise empty universe has inertial properties.[3]

Clearly, if the universe would contain only a single particle, then all points in space would be physically identical, indistinguishable to the particle –which is the same as there being no space at all, and, as nothing then can change, there also would exist no time. The idea of an otherwise empty universe presupposes that space exists, is defined even when devoid of energy –if we may ignore the energy of the particle itself –which we can, for if there is nothing relative to which it can be said to exist, nothing it can interact with to express its properties, its existence, then it obviously cannot have energy, exist itself. The fact that we even consider the existence of a single particle in an otherwise empty universe shows how deeply ingrained the classical assumption is that particles have an autonomous existence, that their properties only are the cause of interactions, that they, the universe has been created by some outside intervention.
The Stanford Encyclopedia of Philosophy: [4]

> Imagine we are far out in space, in a rocket ship accelerating at a constant rate g = 9.98 m/s². Things will feel just like they do on the surface of the Earth; we will feel a clear up–down direction, bodies will fall to the floor when released, etc. … There is one key element left out of this success story, however, and it is crucial to understanding why most physicists reject Einstein's claim to have eliminated absolute states of motion in GRT. Going back to our accelerating rocket, we accepted Einstein's claim that we could regard the ship as hovering at rest in a universe-filling gravitational field. But one can see why the Machian interpretation Einstein hoped

[1] A. Einstein, *Geometry and Experience*. Lecture before the Prussian Academy of Sciences, Jan. 27, 1921
[2] *Concepts of Mass in Contemporary Physics and Philosophy* (2002) Max Jammer p. 150.
[3] *On the origin of inertia* (1953) D.W. Sciama 1953MNRAS. 113…34S
[4] *Absolute and Relational Theories of Space and Motion* (2018) Nick Huggett, Carl Hoefer § 9.3 – 9.4

> he could give to the curved spacetimes of his theory fails to be plausible, by considering a few simple 'worlds' permitted by GRT. In the first place, for our hovering rocket ship, if we are to attribute the gravity field it feels to matter, there has got to be all this other matter in the universe. But if we regard the rocket as a mere 'test body' (not itself substantially affecting the gravity present or absent in the universe), then we can note that according to GRT, if we remove all the stars, galaxies, planets etc. from the world, the gravitational field does not disappear. On the contrary, it stays basically the same locally, and globally it takes the form of empty Minkowski spacetime, precisely the quasi-absolute structure Einstein was hoping to eliminate. … physicists do not doubt that something like our accelerating rocket –in otherwise empty space– is possible according to the theory. We see clearly, then, that GRT fails to satisfy Einstein's own understanding of Mach's Principle, according to which, in the absence of matter, space itself should not be able to exist. A second example: GRT allows us to model a single rotating object in an otherwise empty universe (e.g., a neutron star). Relationalism of the Machian variety says that such rotation is impossible, since it can only be understood as rotation relative to some sort of absolute space. In the case of GRT, this is basically right: the rotation is best understood as rotation relative to a 'background' spacetime that is identical to the Minkowski spacetime of SRT, only 'curved' by the presence of matter in the region of the star.

If according to GR 'the inertia of a given body is greater as there are more ponderable masses in proximity to it' and its inertia equals its mass, then there is mass created as particles contract to stars and galaxies, agreeing with the UP according to which the energy of particles is higher as their position is less indefinite, as they contract to clusters, and energy is a source of gravity, acts like mass. As it is localized energy which makes positions at different distances physically different, distinguishable to an observing particle –pace of clocks, length of rods– the creation of energy in a SCU *is* the creation, not of space in time as in BBC, but of spacetime.

it is unclear, however, why the mass of a body equals is inertia.
Wolfgang Rindler:

> Albert Einstein developed his general theory of relativity starting from the assumption that this correspondence between inertial and (passive) gravitational mass is not accidental: that no experiment will ever detect a difference between them. However, in the resulting theory, gravitation is not a force and thus not subject to Newton's third law, so the equality of inertial and active gravitational mass ... remains as puzzling as ever. In general relativity two of Einstein's concerns merged: gravity as an aspect of inertia, and the elimination of the absolute (that is, uninfluenceable) set of extended inertial frames. The new inertial standard is spacetime, and this is directly influenced by active gravitational mass via the field equations. Yet in the total absence of mass and other disturbances like gravitational waves, spacetime would straighten itself out into the old family of extended inertial frames. This would seem to contradict Mach's idea that *all* inertia is caused by cosmic masses. Einstein was eventually equally quite willing to drop that idea, and so shall we. The equality of inertial and *active* gravitational mass then remains as puzzling as ever. It would be nice if the inertial mass of an accelerating particle were simply a back-reaction to its own gravitational field, but that is not the case.[1]

[1] *Relativity: Special, General and Cosmological* (2001),Wolfgang Rindler 2nd edition p 22

If particles have to interact, to exchange energy to express and preserve their, each other's properties, to keep existing, to each other, then their inertia, their opposition to a change of their state of motion originates in the fact that it takes energy to change their relative velocity or direction of motion because it affects the frequency they exchange energy at, the energy, the mass they observe each other to have.
Only if, as in the classical view, particles would have an autonomous existence, if their mass would only be the cause and not, also, simultaneously, the effect of their interactions would the equality of mass and inertia be a mystery.

Though the proposition that the inertia of a body is something it has relative to all other masses in the universe is the first inkling of the insight that particles, particle properties in a selfcreating universe must be as much the cause as the effect of their interactions; if Mach didn't express this explicitly, then that may be because implies, requires their communication to be instantaneous –which is impossible in a universe where, as it lives in a time realm not of its own making, their communication cannot but proceed at a finite velocity.
This is different in a universe where, as it creates all time inside of it, time cannot be observed to pass at the same pace at all distances, where we don't, as in a BBU, see a distant galaxy as it was, of itself, in a distant past, in *the* past, but as it is, to us, as we look at it, in what only to us is the present, in an earlier evolutionary phase as it is more distant –*if* with 'early' we mean a state of lower energy and not an earlier moment in cosmic time as there is no such thing..

A physical entity does not do what it does because it is what it is, but is what it is because it does what it does. –Max Jammer[1]

8
The origin of particle species

In a universe which contains only two particles *A* and *B*, the wavelength they exchange energy in might vary continuously with their distance if not for the fact that to be able to exert force upon each other, to express their energy, to *have* energy, requires (Newton's 3rd law) the existence of particles in opposite directions to act upon *A* and *B*, to oppose the force between *A* and *B*, particles which to exist, to have energy themselves, to be able to provide this service, in turn require the existence of other particles at larger distances and their communication to be instant. As they only can exchange energy at equilibrium when in counterphase –at distances equal to 1/2, 3/2, 5/2 … times the wavelength they exchange energy in– their distance is quantified and with it the energy they emit or absorb as they jump between different equilibrium states, a jump whereby their distance and the wavelength they exchange energy in changes with a discrete amount.

A problem of particle properties as privately owned and hence fixed quantities, as being only the cause of forces, is that they cannot then gain anything by behaving

[1] *The Philosophy of Quantum Mechanics* (1974) Max Jammer p. 54

in some particular manner, by moving apart or toward each other, say, so they wouldn't be able to interact and it wouldn't even be properties, whereas if when their properties would be cause and effect of their interactions and vary continuously with their distance or the circumstances they find themselves in, then it also wouldn't be properties and there similarly would exist no particles, no universe.
It is because energy tends to increase, to keep creating itself (incentive) and their distance, momentum and energy is quantized and their energy exchange is instant (opportunity) which enables them to interact yet preserve their properties in the sense that they can adjust their distance and relative motion to adjust the effective magnitude of the different kinds of charge so the strength of the associated, opposite forces can vary with their energy yet remain equally strong so they can be at equilibrium at different -quantized- energies, form stable matter.

As particles in BBC popped up readymade, all their properties measured off to the last decimal at or shortly into the big bang, their properties, like some kind of DNA, causally precede, predetermine the properties of and processes in the stars and galaxies they eventually contract to –which then don't evolve but develop following a strictly prescribed plan, implying that all events ever to happen have been predetermined to happen to the last detail and decimal [1] at the big bang, implying an improbable fine-tuning of physical constants to create a viable universe, suggesting that it has been created by some outside intervention. Though our universe is thought to accidentally have those properties which enable the evolution of observers to witness its existence; the supposition that there are many different universes –some of which without observers– is at odds with the definition according to which a universe cannot have any particular properties as a whole.

The advantage of an evolution whereby elementary particles, the building bricks of the universe acquire properties, are shaped and baked in the building process as they contract to stars and galaxies, as the edifices take form (including the building plot, spacetime), is that it enables a feedback whereby particles by adjusting their distance and relative motion, the frequency they exchange energy at,[2] can adjust their properties, evolve to elementary particles and with it adjust the properties of, the processes in stars and galaxies to the circumstances they find themselves in and create in a trial and error process –what manages to survive … survives– so can form stable, long-lived galaxies, a feedback which requires the communication between objects in all possible phases of their evolution to be instant –instant like we cannot push an object before it opposes our action with an equally strong counterforce– the phase they are observed to be in depending on their distance and motion relative to the observer or observing particle.

If the different particle species are the result of an evolution which starts as soon they cross the threshold between a zero and an infinitesimal, nonzero energy, as soon they start to interact, to contract to clusters, to what eventually will become stars and galaxies and the energy they observe each other to have, the frequency they exchange energy at is cause and effect of their interactions and any degree

[1] If not for the UP which limits the predictability of events.

[2] Ignoring other things which have to be communicated like their spin and angular momentum.

of freedom, any independent way they can move relative to each other in some more or less stable configuration –a configuration of particles which, as their evolution proceeds, as the conditions (temperature, pressure) they find themselves in (and create) become favorable to the formation of configurations which increasingly resemble the configuration and behavior of subatomic particles in protons and neutrons, in atomic nuclei in star plasma– affects the energy of the configuration in some specific manner, then every degree of freedom, any independent motion can be associated with some conserved quantity, with a different property or kind of charge.

If a particle is a modulation of and in spacetime, if its energy, its rate of change in space and time varies within every cycle of its oscillation and with it the indefiniteness in its position, then its properties are less definite, less defined, evolved as its energy is lower, as its position and hence its motion are less definite. The farther apart two particles are or the lower their energy is in some configuration, the less definite they observe each other's position and motion to be, the less definite, the less evolved they observe each other's properties to be, the less definite or the fuzzier the configuration is they are part of, the less definite or fuzzier their positions and trajectories[1] are, the more they can be thought of as being part of different configurations simultaneously or the more the different configurations coincide, overlap, the less they differ energetically, the less defined their properties are in such configurations, the weaker they interact, the less forcefully they limit each other's freedom of behavior, the less they impose each other some specific behavior, the less related their behavior is, the properties they observe each other to have. The shorter, the less indefinite their distance is, the shorter, the less indefinite the wavelength they exchange energy in, the less indefinite their relative position and motion is, the higher the energy they observe each other to have, the less indefinite they observe each other's properties to be, the greater the effective magnitude is of any kind of charge. The more particles contract within a smaller space, the more they have to coordinate their behavior to fit within that smaller volume, the more they limit each other's freedom of motion, the more forcefully they confine each other to less indefinite distances and trajectories it takes more energy to deviate from, the greater their opposition is to a change of their behavior, of the properties associated with that behavior, the less indefinite, the more evolved the properties they observe each other to have.

The lower the rest energy of a particle is, the less definite the position of its mass center is, the weaker it interacts, the less definite it observes the position to be of the mass center of other particles, of stars and galaxies, the longer, the less definite the wavelength in which it exchanges energy with the objects within its IH, the lower the energy it observes them to have, the earlier the evolutionary phase it observes them –its universe– to be in, the earlier the phase it is in itself.

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[1] Though in quantum mechanics we only can speak about the probability to find a particle somewhere, not of its trajectory; if the evolution of its wavefunction determines how the probability to find it at some particular place and time changes in time, then we can call the collection of its most probable successive position its trajectory even if it doesn't actually visits those positions.

If it matters, energetically to a particle, if it can distinguish whether another particle nears or recedes from it, moves up or down or from the left to the right or the other way around through its 'sky' –relative to the background of all objects within its IH– moving or spinning in this or that manner or direction and each of the different, independent ways they can move relative to each other affects the frequency they in some configuration exchange energy at in some specific manner can be associated with some particular property or kind of charge, then the different forces of nature will have a different distance and motion dependence, as if they are powered by qualitatively different, independent kinds of charge.
However, if when particle properties are cause and effect of their interactions, the energy involved in one interaction, associated with one kind of charge powers and is powered by all other interactions a particle simultaneously is involved in, then the different kinds of charge must be related, be different expressions of the same quantity, of their energy.
If the different forces, kinds of charge arise from the different, independent ways they can move relative to each other, each of which affects the frequency they exchange energy at in a different, specific manner and all interactions each of the particles participates in contributes to their energy within that configuration, to the energy of the configuration, then the different forces, powered by what seem to be qualitatively different, unrelated kinds of charge are balanced, 'unified' in their behavior within that configuration.

Though an equilibrium between particles is a balance between opposite forces powered by different kinds of charge; if it would be fixed quantities, only the cause of forces, then any equilibrium would be unstable since as soon as their attraction due to one kind of charge at some distance overcomes their repulsion due to another kind of charge, they'd go sit and stay on top of each other –in which case the indefiniteness in their position would become zero and their energy infinite.
However, as this energy has to be supplied by the environment, by all particles within their IH, we can as well say that it is the environment which prevents them to stay on top of each other, which determines the distance at which they can be at equilibrium, their energy, the effective magnitude of any kind of charge.
If their properties on earth seem to be fixed, only the cause of forces, then that may be because the conditions in star plasma (pressure, temperature) they were forged in, evolved to elementary particles, were so extreme that we usually don't observe that their properties –and not just their expression– are affected by their interactions: that only happens at high energies.

Only if their properties would be the cause and not also the effect of their interactions would the different kinds of charge be qualitatively different, unrelated quantities, meaning that the energy which powers one kind of charge then would be unrelated to the energy powering other kinds of charge –as if an electron, say, would have two independent 'batteries,' one filled with electric charge and the other with gravitational charge– in which case the different forces associated with these charges cannot be unified even in principle.
As the equality of inertia and active gravitational mass remains a mystery, it is unclear what mass is, how we should define it. If the inertia of a particle originates

in the fact that it takes energy to change its state of motion because it alters the frequency it exchanges energy at with the objects to which it owes its energy, the mass it exhibits in different directions, then all interactions due to every property or kind of charge it simultaneously participates should contribute to its mass.
Though the different forces of nature are calculated to be equally strong at some grand unification energy; that only means that they are equally strong, not that they then are unified, shown to be different manifestations of a single quantity, of the energy of particles. It may be the assumption that the different kinds of charge only are the cause of forces which prevents the unification of gravity with the other forces.

The beauty of such trial and error evolution is that no calculation is needed as to what particle species and properties, what laws and constants of nature might result in a viable universe: it is gravity, the tendency of energy to increase, to keep creating itself which (GTD) by prolonging in time more compact, higher energy (higher according to the particles involved) above less compact, lower-energy configurations, determines which from all possible, temporary random configurations survives, which selects what particle species, properties and associated constants of nature will survive, including the conditions which they can evolve, the circumstances they find themselves in and create.
A SCU is itself a kind of calculator the components of which take form, which materializes as the trial and error calculation/evolution proceeds simultaneously everywhere, a calculation where particles (which observe each other to be) in all possible phases of their evolution, of all objects they form participate in and are the product of, an evolution which cannot but obey the Nix law which defines the universe as a perpetuum mobile, yielding as much as its costs: nothing –which is to say, a universe which has no external reality but only exists as seen from within.

If particles keep creating and uncreating each other in every cycle of their energy exchange with particles at all distances, particles they observe to be in an earlier phase of their evolution, to have less defined properties as they are more distant, then an instant exchange constitutes a feedback from stars and galaxies to instruct particles what behavior, what properties to adopt to eventually evolve to elementary particles and become part of stars and galaxies themselves.
Though galaxies then create themselves the particles, the building blocks they are going to consist of –reminding of Munchhausen saving himself from drowning in the swamp by pulling his hair; if such processes only can proceed within a certain range of conditions, conditions which, as the mass of the black holes at the center of galaxies increases in time, change, then the formation processes in galaxies may eventually fade out. As the evolution of the particles, the atoms and molecules of the body of intelligent observers takes a long time, they cannot observe nearby galaxies in an early phase of their evolution.

It is gravity which, in imposing a direction on events, acts like the ratchet which in a clock prevents its hands to turn counterclockwise, which prevents processes to reverse and enables particles to acquire properties, to evolve, gradually or in fits and starts, to ever-higher energies, to eventually end up in black holes at the center of galaxies, an evolution, a change we experience as the passing of time.

9
The energy of 'empty' space

As according to the UP a field cannot be *and* remain zero, space contains energy in the form of matter and force fields the quanta of which –virtual particle-antiparticle pairs– continually pop up out of the vacuum to annihilate after a time which is shorter as their energy is higher, meaning "that over sufficiently small distances and sufficiently brief intervals of time, the 'very geometry of spacetime fluctuates." As a higher energy of particles corresponds to a higher frequency or smaller wavelength, to a shorter time and distance, empty space is calculated to have a vacuum energy density which is some 120 orders of magnitude greater than would fit observations. As the gravitational effects this energy should have aren't observed, some physicists have started to doubt quantum mechanics itself.[1] Gerard 't Hooft, about his fellow Nobel laureate, Martinus Veltman:

> Veltman was not to be convinced that what we call empty space perhaps is filled to the brim with invisible particles. He would persist for a long time that he thought this incredible. … For shouldn't all these particles in empty space betray their presence by their gravitational field? You can establish a theory in such a manner that this gravitational field exactly is compensated by other invisible particles or by a mysterious contribution of empty space itself. How nature manages to mask the gravitational effects of invisible vacuum particles so completely that we don't notice any effect, is a mystery.[2] The most radical view ... is that space and time only exist as a separate set of points; [that] particles can only be at those points but not in between. … this would be the most logical interpretation, for 'quantum fluctuations' would ensure that all points where particles can be automatically stay at least one Planck length apart. But it isn't that easy, for how do we then explain how these points are related to form the known space and time? [3]

Clearly, if when the energy of a particle varies in a wavelike manner within every cycle of its oscillation and with it the indefiniteness in its position, the position its energy acts from, if it is a modulation of spacetime itself, then we cannot, as in the above quote or, as in quantum loop gravity where space and time are granular, discrete, say that space comes with a regular, fine-meshed grid, that particles only can be at its vertices, think of space as if it comes in minimum building blocks of space, of time as passing in discrete, minimum amounts. The problem with the assumption that time passes in discrete amounts, in jumps, is that it presupposes the existence of a clock relative to which can be quantified how much time passes

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[1] Lee Smolin in *The Trouble with Physics* (2006) p. 319: "Like 't Hooft, much of his [Roger Penrose's] work in the last two decades is motivated by his conviction that quantum mechanics is wrong." Also see: https://spookyactionbook.com/2013/10/07/does-some-deeper-level-of-physics-underlie-quantum-mechanics-an-interview-with-nobelist-gerard-t-hooft/

[2] *De bouwstenen van de schepping* (1st ed. 1992) Gerard 't Hooft, p 197. This quote does *not* appear in the 6th ed. 2002) (*In search of the ultimate building blocks*) Because the observations indicating that the expansion of the universe accelerates had yet to be made?

[3] *De bouwstenen van de schepping* (6th ed. 2002) Gerard 't Hooft, p. 106

per (instantaneous) jump and the duration of the pauses between successive jumps during which time stands still (sic), a clock the dial marks of which are separated by even shorter time intervals. Likewise, to measure a minimum distance requires a ruler the marks of which are separated by even shorter distances. The proposition that space and time are discrete, that the universe comes with a regular three-dimensional fine-meshed grid with Planck-length sized cells is at odds with the fact that the universe by definition cannot have any particular property as a whole. If space and time would be discrete, then they would exist –the length of the meter and duration of the second be defined– even outside the universe and even in the absence of energy.

If when particles only can be at equilibrium at distances equal to 1/2, 3/2, 5/2 … times the wavelength they exchange energy in, then it isn't space which comes in discrete minimum building blocks, but the distance between particles which is quantified. If when the energy of a particle, its rate of change in space and time varies within every cycle of its oscillation and with it the indefiniteness in its position and it is its energy which makes positions at different distances physically different, then the curvature of spacetime in the area where it can be localized varies in tandem with its energy within every cycle of its oscillation.
The farther apart particles are or the lower the energy they observe each other to have, the longer, the less definite the wavelength they exchange energy in at equilibrium, the less energy is involved in a jump between successive equilibria, the less it matters, energetically, how large it exactly is, the less definite, the less discrete their equilibrium distance is, whereas the shorter their distance or the higher their rest energy is, the shorter, the less indefinite the wavelength they exchange energy in but the smaller, the less indefinite, the more discrete, so to say, the length of a jump to the next equilibrium distance is.

Though

> … the whole of spacetime is occupied by the fields of the elementary particles. Even in the absence of matter, the fields of the *virtual* particles constitutes an all-pervasive background which can in no way be eliminated. In fact, matter is only a small perturbation of it. This background … can be looked upon as a modern ether. Since it possesses no net energy it makes no contribution to curvature ... but it does suggest the *a priori* existence of spacetime, which matter merely modifies and does not create.[1]

if a SCU cannot have any particular property, then we cannot think of space as uniformly filled with virtual particles, with a vacuum energy density which is the same everywhere, think of space as some rarefied, homogenous substance, something you can buy per cubic meter at your DIY, so to say, a background spacetime which only is warped near masses. If (UP) the energy of particles is higher as their position is less indefinite, then the vacuum energy density somewhere should, like the price of real estate, depend on where they pop up, be lower where their position is less definite, which it is farther from masses and higher near masses.

[1] *Relativity: Special, General and Cosmological* (2001),Wolfgang Rindler 2nd edition p 244.

Instead of considering the energy of these virtual particles to be only the cause of whatever effects we want them to explain, to think of the vacuum energy density of empty space as an intrinsic a property of space, the same everywhere, always, something which doesn't depend on where they pop up and task it to drive what seems to be the accelerating expansion of the universe, we ought to ask to what these particles owe their energy, relative to what they exist, have energy.
If real particles indeed can be thought of as virtual particles which managed to set up a continuous energy exchange by means of which they force each other to re-appear after every disappearance as their lifetime as given by the UP is up, to express and preserve their, each other's properties so their energy varies in a wave-like manner within every cycle of their oscillation and with it the indefiniteness in their position, then the virtual particles of empty space can be thought of as the volatile interference products of the real particles of stars and galaxies, constituting their gravitational field. If so, then the effects of the presence of the virtual particles of the vacuum already is accounted for in the existence of all particles to the energy of which they contribute and to which they owe their energy, including the real particles of stars and galaxies –in which case they don't have any excess energy to drive the accelerating expansion of space.

The problem is that in speaking about the energy density of the vacuum, BBC defines energy and space as unrelated quantities –in which case energy wouldn't be able to cause space to curve or expand as energy only can act upon energy.
If energy in a SCU tends to increase, to keep creating itself and it is energy which makes positions at different distances physically different so the creation of energy *is* the creation of spacetime, if particles, real and virtual, are modulations of and in spacetime, then space isn't so much occupied by fields and virtual particles but rather is constructed out of these particles/fields, these modulations.
Only if their properties would be privately owned quantities, only the cause of interactions would a particle have a fundamental boundary separating it, its properties from its environment so in this, classical view, particles are *fremdkörper* in an alien environment, in a space which exists even when devoid of energy.

If when particle properties only would be the cause and not, also, the effect of their interactions so would keep existing even when prevented to interact, then information about each other's existence, properties, state, location and motion would have to be transmitted explicitly, requiring the existence of force-carrying particles like photons and gravitons, messenger particles which if massless move at a finite (light) velocity so the information they transport would be outdated for a time proportional to their distance. By contrast, as particles in a SCU express and at the same time preserve their, each other's properties by exchanging energy, there is a continuous, instant exchange of information between them about each other, information which is refreshed in every cycle of their energy exchange.
That is, whereas if it is the same time, if time passes at the same pace everywhere, we can distinguish what in an absolute sense precedes what (in principle though not in practice, as 'seen' by an imaginary observer outside the universe who without any time delay due to the speed of light, can observe the entire universe as it is at some particular moment in cosmic time), what is what is cause of what; as a

universe which only exists as seen from within creates all time inside of it so time cannot be observed to pass at the same pace at all distances and there is no universal 'now' so past, present and future are relative notions, the communication, the energy/information exchange is instant in the sense that all observers and observing particles are equally right about the time some event happens: when they observe it to happen, as they participate in it.

If when the energy of particles, real and virtual, varies within every cycle of their oscillation, then so does the indefiniteness in their position: the lower their energy is, its rate of change in space and time in one phase, the less definite the position and hence their motion is, the behavior from which their properties can be inferred, the less defined, evolved their properties are in that phase, then particles in some sense repeat their evolution to elementary particles in every cycle of their oscillation. The virtual particles of empty space then can be thought of as the offspring *and* predecessors of the real particles of matter, particles which in appropriate circumstances may evolve to elementary particles, to the particles of stars and galaxies –in which case galaxies create themselves the particles, the building blocks they are going to consist of. If particles are modulations in and of spacetime, areas where the curvature of spacetime –the observed pace of time and length of rods– varies within every cycle of their oscillation, then it is their continuous creation and 'uncreation' which produces, maintains what we observe as spacetime.
Carlo Rovelli:

> In Newtonian physics, if we take away the dynamical entities [particles, fields] what remains is space and time. In relativistic physics, if we take away the dynamical entities, nothing remains. The space and time of Newton and Minkowski are reinterpreted as a configuration of one of the fields, the gravitational field. … The world is made by fields. Physically, these do not live on spacetime. They live, so to say, on one another. Not anymore fields on spacetime, just fields on fields. … In prerelativistic physics, spacetime is a fixed nondynamical entity over which physics happens. It is a sort of structured container which is the home of the world. In relativistic physics, there is nothing of the sort. There are only interacting fields and particles: the only notion of localization which is present in the theory is relative: dynamical objects can be localized only with respect to one another. … Einstein's discovery is that Newtonian spacetime and the gravitational field, are the same entity. This can be expressed in two equivalent manners. One is that there is no space-time: there only is the gravitational field. The second is that there is no gravitational field: it is spacetime that has dynamical properties. [1] … One consequence is that the quanta of the field cannot live in spacetime: they must build "spacetime" themselves.[2]

[1] *Quantum Gravity* (Dec. 30, 2003) Carlo Rovelli p. 53 – 55 http://www.cpt.univ–mrs.fr/~rovelli/book.pdf
[2] Ibid, p. 7

10

Why quantum mechanics works

The double-slit experiment

In the basic version of the double-slit experiment [1]

> … a coherent light source, such as a laser beam, illuminates a plate pierced by two parallel slits, and the light passing through the slits is observed on a screen behind the plate. The wave nature of light causes the light waves passing through the two slits to interfere, producing bright and dark bands on the screen –a result that would not be expected if light consisted of classical particles. However, the light is always found to be absorbed at the screen at discrete points, as individual particles (not waves), the interference pattern appearing via the varying density of these particle hits on the screen. … The particles do not arrive at the screen in a predictable order, so knowing where all the previous particles appeared on the screen and in what order tells nothing about where a future particle will be detected. If there is a cancellation of waves at some point, that does not mean that a particle disappears; it will appear somewhere else. Ever since the origination of quantum mechanics, some theorists have searched for ways to incorporate additional determinants or "hidden variables" that, were they … known, would account for the location of each individual impact with the target. … electrons are found to exhibit the same behavior when fired towards a double slit.

If we find a similar interference pattern if we use electrons and even if we shoot them one at a time, then that must mean that each electron goes through both slits, so the experiment shows that an electron has no infinitely sharp, fundamental boundary where it, its properties end and its environment begins. Such interference obviously is impossible if its properties would be privately owned and hence fixed quantities, only the cause of interactions.

As its energy, its rate of change in space and time varies within every cycle of its oscillation, so does the indefiniteness in its position, so if this indefiniteness twice in every cycle exceeds the distance between the slits, then it goes through both slits simultaneously and interferes with itself from both splits. As it has to keep exchanging energy with all particles within its IH to keep existing, from the point of view of the electron its environment splits into two slightly different worlds as it nears the slits, worlds which from both splits and both sides of the plate exchange energy with, act upon the electron.

It acts more like a point particle at the times in its cycle when its energy is maximal, as the indefiniteness in its position is minimal and more like a wave phenomenon at the times in its cycle when its energy, its rate of change in space and time is lower, as its position less definite, as its energy, its charge acts weaker, more simultaneously and more equally from all points within a larger region, a region which twice in every cycle comprises both slits and both sides of the plate.

[1] https://en.wikipedia.org/wiki/Double–slit_experiment (2–10–2019)

It was Werner Heisenberg who first realized the need to free ourselves from the belief that, say, an electron has a well determined position at every time. When it is not interacting with an external system that can detect its position, the electron can be "spread out" over different positions. … [he] first recognized that the electron does not have a well-defined position when it is not interacting.[1]

Schrödinger's cat

As an electron in a SCU has to keep interacting, exchange energy with the particles within its IH to keep existing to these particles so its energy, its rate of change in space and time varies in a wavelike manner within every cycle of its oscillation and with it the indefiniteness in its position relative to these particles, it isn't so that it has no well-defined position until we measure it: if there is nobody to hear a tree falling in the woods, then that doesn't mean that it makes no noise. The electron only assumes a well-defined position relative to the measurement device –the external system– when it is subjected to a measurement interaction.
If the electron could be at two places at once, then so would its mass:

> According to the standard model, the electron … can be in two places at once because it is described by a wave function. And according to general relativity, the mass of the electron curves space-time around it. But around which location? General relativity cannot answer this question, since a curvature doesn't have quantum properties and can't be in two places at once. … after a measurement of its position, the wave function must be updated so that the measured state now has a probability of 1. This update -sometimes referred to as "collapse" or "reduction"- is instantaneous; it happens at the same moment for the entire wave function, regardless of how far the wave function was spread out. [2]

If it could be at two places at once with all of its energy and electric charge, then this would violate conservation laws so if this is impossible, then it cannot actually be at, interact from two places at once with 100 % of its energy and electric charge. If its energy is a dynamic, wavelike quantity so the indefiniteness in its position varies within every cycle of its oscillation then it alternates between a phase in which it acts more like a point-particle and a phase in which it acts more like a wave phenomenon: the lower its energy, its rate of change is in some phase, the more equally and more simultaneously and weaker it acts from all points within a larger region, the more it is "spread out." Though the idea that it can be at two places at once is problematic in a universe where it isn't the same time everywhere; it can be said to be present everywhere it affects, participates in events.
If the rest energy of a particle, its rate of change in space and time varies within every cycle of its oscillation, then so does the curvature of the area where it can be localized: as it is a modulation of and in spacetime itself, the curvature of spacetime in the area where it can be localized follows the rate of change of its energy in space and time. As seen from outside its gravitational field, the curvature in the area where it can be localized, the extent to which adjoining points differ physically from each other –the observed pace of clocks and length of rods in that area– then varies in tandem with its energy.

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[1] https://plato.stanford.edu/entries/qm–relational/ (7–10–2019)

[2] *Lost in math* (2018) Sabine Hossenfelder, p 179 and p 120

The higher its rest energy is, the greater its rate of change in space and time, the higher the frequency at which its sign and magnitude alternates, the more curved spacetime is, the faster its curvature alternately increases and decreases. If it is its energy which makes positions at different distances physically different so a particle is itself a modulation of spacetime so spacetime itself has a dynamic, wavelike character, then there obviously exists no space nor time in the absence of energy. To speak about the energy density of the universe, to say that energy causes space to curve or expand is to state that space and time exist, are defined even when devoid of energy, that energy, space and time are mutually unrelated quantities.

The supposition that an atom can be in different states or at different places at once –that its particles can be part of different configurations simultaneously– or that its state or position is indeterminate until it by some measurement interaction is forced to choose between either one of its possible states or configurations or locations– inspired Erwin Schrödinger to his famous thought experiment.
A cat sits in a closed box along with a radioactive atom and a device which releases poison gas when it detects the radiation the atom emits when it decays –and the cat dies. The supposition is that as long as we don't look in the box, interact with what's inside of it, the atom and cat are in a mixed state: that the atom is neither decayed nor undecayed, the cat dead *and* alive, and that it is the act of looking into the box which nudges the atom into a single state, either decayed *or* undecayed and causes the cat to die *or* leave it be alive. While we cannot predict when the atom will decay; in a universe where particles have to keep interacting to keep existing to each other –the particles in the box, of the box and of the world outside of it– its decay is not an event which is unrelated to what is and happens outside the box, especially if their communication is instant.

The flaw of this thought experiment, then, is that if the box would actually isolate its content completely from interactions with the world outside of it, then the atom, device, poison and cat would cease to exist, be no longer be part of the universe outside the box, of the world of the observer so it would make no sense to ask after the health of the cat or even say that time passes inside the box. The point is that the radioactive atom cannot be decayed and undecayed at the same time in a universe where particles, particle properties only are the cause, but not also the effect of their interactions.

Quantum entanglement: the EPR paradox

As Einstein believed that there is an objective reality at the origin of our observations, he couldn't accept the indeterminacy implied in the UP according to which a particle cannot have both an exact position and momentum at the same time, so to show the absurdity of this he proposed, together with Boris Podolsky and Nathan Rosen a thought experiment showing that such indeterminacy would imply action at a distance –which special relativity forbids.

In the EPR paper Einstein, Podolski and Rosen suppose that [1]

> we have two systems, I and II, which we permit to interact from the time $t = 0$ to $t = T$, after which time we suppose that there is no longer interaction between the two parts.

Systems I and II can be a pair of two spin ½ particles into which a spin-zero particle can decay, particles which become entangled at their creation.

> Since the total spin before and after this decay must be zero (conservation of angular momentum), whenever the first particle is measured to be spin up on some axis, the other, when measured on the same axis, is always found to be spin down. (This is called the spin anti-correlated case; and if the prior probabilities for measuring each spin are equal, the pair is said to be in the singlet state.) …. The paradox is that a measurement made on either of the particles apparently collapses the state of the entire entangled system—and does so instantaneously, before any information about the measurement result could have been communicated to the other particle (assuming that information cannot travel faster than light) and hence assured the "proper" outcome of the measurement of the other part of the entangled pair. In the Copenhagen interpretation, the result of a spin measurement on one of the particles is a collapse into a state in which each particle has a definite spin (either up or down) along the axis of measurement. The outcome is taken to be random, with each possibility having a probability of 50%. However, if both spins are measured along the same axis, they are found to be anti-correlated. This means that the random outcome of the measurement made on one particle seems to have been transmitted to the other, so that it can make the "right choice" when it too is measured. The distance and timing of the measurements can be chosen so as to make the interval between the two measurements spacelike, hence, any causal effect connecting the events would have to travel faster than light. [2]

Clearly, to say that after the creation of the particles "there is no longer interaction between the two parts" is to deny that they are entangled. To assume that there is no communication between them is to assume that particles, particle properties only are the cause and not also, simultaneously, the effect of their interactions.
If particles in a SDCU have to keep interacting, to exchange energy to keep existing, to express and at the same time preserve their, each other's properties, then all particles within each other's IH to some extent are entangled. As this implies an instant two-way communication but special relativity forbids action at a (space) distance, their communication must be instant over any spacetime distance, so entanglement experiments show that we don't live in a universe where it is the same time everywhere, but in a universe where, as it contains, produces all time inside of it, time cannot be observed to pass at the same pace at all distances.

Though to explain such 'spooky action at a distance' away, to be able to hold on to causality, to determinism, to the assumption that we live in a universe where it is the same time, where time passes at the same pace everywhere, the existence of hidden variables was proposed so the spin direction of the particles isn't indeterminate:

[1] http://www.drchinese.com/David/EPR.pdf p 779

[2] https://en.wikipedia.org/wiki/Quantum_entanglement (22-5-2021)

> A possible resolution to the paradox is to assume that quantum theory is incomplete, and the result of measurements depends on predetermined "hidden variables." The state of the particles being measured contains some hidden variables, whose values effectively determine, right from the moment of separation, what the outcomes of the spin measurements are going to be. This would mean that each particle carries all the required information with it, and nothing needs to be transmitted from one particle to the other at the time of measurement. [1]

experiments[2] show that it *is* indeterminate –neither up nor down along some axis– before the measurement, that we don't measure the state they already are in, but that it is the measurement which forces them to adopt either one of the possible directions, information which then needs to be instantly[3] communicated between them.If the measurement of one particle forces it to adopt an up spin as measured along some axis wouldn't be communicated instantly to its entangled partner and force it to adopt a down spin along the same axis, then this would violate the law of conservation of angular momentum for the time it takes the information to travel at the speed of light from one particle to the other. If this is impossible, then we shouldn't think of the speed of light as a velocity but as a property of space-time: that we don't live in a universe where it is the same time, where time passes at the same pace anywhere but in a universe which creates all time inside of it.

The answer to the question the EPR paper asks –whether the quantum mechanical description of physical reality is complete– of course depends on whether or not there *exists* a completely knowable reality at the origin of our observations, causally preceding its observation: whether we live in a BBU or a SCU. As there is no universe-wide 'now' in a SCU, there also exists no single, objective, universe-wide completely knowable reality at the origin of our observations. It is because particles, particle properties are as much the cause as the effect of their interactions why their behavior isn't deterministic, their communication instantaneous, why a measurement cannot but affect what is measured –instantaneous because there is nothing inside nor outside the universe relative to which can be determined what in an absolute sense precedes what, what is cause of what: because the universe only exists as seen from within.
Though when observer *A* measures the spin of particle I to be up, say, observer *B* should instantly find particle II to have adopted a down spin, it still takes time for *B*'s result to be communicated back to *A*: in a BBU due to what in this universe is a finite light velocity and in a SCU because *A* and *B* observe time to pass at a slower pace at larger distances, at the other observer, at the other particle.

If in quantum mechanics we only can speak about the probabilities of the different possible outcomes of an experiment in which two particles collide, say, then that is because if they exchange energy with all other particles to express and preserve their properties and their communication is instant, they affect the behavior of

[1] https://en.wikipedia.org/wiki/Quantum_entanglement (1–4–2021)

[2] https://en.wikipedia.org/wiki/Bell%27s_theorem#Testing_by_practical_experiments (26-3-2021)
https://arxiv.org/ftp/arxiv/papers/0811/0811.3129.pdf

[3] *Relational EPR* (2007) Matteo Smerlak, Carlo Rovelli, https://arxiv.org/pdf/quant-ph/0604064v3.pdf

the particles in the experiment, participate in it, so the result of the experiment also depends on the events *they* are involved in at the time of the collision. Alternatively, as their energy varies within every cycle of their oscillation and we cannot know in what phase they are as they collide, we cannot predict the outcome of any single collision even though the equations of QM predict the probability of each of the possible result if we repeat the experiment many times.

While it is gravity, the tendency of energy to increase, to keep creating itself which drives the changes we experience as the passing of time, which in imposing a direction on events seems to enable us to distinguish cause from effect, what precedes what in an absolute sense;[1] as the energy involved in the (de)composition of a macroscopic object out of (into) atoms is less than a billionth of the energy as contained in its mass ($E = mc^2$), its particles don't really notice what macroscopic object they are temporarily part of, a rock, an apple or a cat, of events they are involved in, of the macroscopic world they are the building blocks of, of a reality which is objective and obeys causality only at this, macroscopic, secondary level. If the world at macroscopic level obeys causality, then that doesn't mean that the world at primary level, at quantum level also has to be causal.

At this time, the Big Bang, all the matter in the universe, would have been on top of itself. The density would have been infinite. It would have been what is called, a singularity. At a singularity, all the laws of physics would have broken down. Stephen Hawking.[2]

11
The second law of thermodynamics

The observation that the pigment particles in a drop of ink disperse in water or that temperature or density differences in a gas in a closed container decrease in the course of time –that an inequilibrium[3] in a closed, isolated system tends to turn into an equilibrium state– led to the formulation of the second law of thermodynamics which says that the entropy of a perfectly isolated system only can increase in time. Entropy is a measure of the information needed to specify the state of a system, of the disorder, indefiniteness or randomness of the system, its lack of information: the more homogeneous the distribution of the ink particles in a glass of water, of gas molecules in a container is or the smaller differences in temperature or pressure are, the higher its entropy is:[4]

> … entropy is a measure of the number of microscopic configurations corresponding to a macroscopic state. Because thermodynamic equilibrium corresponds to a vastly greater number of microscopic configurations than any non-equilibrium state, it has the maximum entropy, and the second law follows because random chance alone practically guarantees that the system will evolve towards such thermodynamic

[1] As seen by a hypothetical observer outside the universe who could, without any time delay due to the speed of light, observe the entire universe as it is at some particular moment in cosmic time.
[2] https://www.hawking.org.uk/the-beginning-of-time.html (16-7-2018)
[3] Let's introduce a new English word: "inequilibrium," meaning the opposite of "equilibrium."
[4] https://en.wikipedia.org/wiki/Arrow_of_time (22–3–2019)

> equilibrium.[1] … Entropy can be thought of as a measure of microscopic disorder; thus the Second Law implies that time is asymmetrical with respect to the amount of order in an isolated system: as a system advances through time, it becomes more statistically disordered. This … can be used empirically to distinguish between future and past.

As a SCU is self-contained, as by definition there is nothing outside of it so nothing can leaver or enter it, it is a perfectly closed, isolated system. However, the supposition that there is a thermodynamic arrow of time according to which time passes in the direction whereby the entropy of the universe increases of course makes no sense if it cannot have any particular property –any particular entropy– nor be in any single particular state as a whole. As there is no cosmic time, no universal now in a SCU so we cannot even specify at what time its entropy is to be measured, the 2nd law of thermodynamics doesn't apply to a SCU.
Only if particles would have an autonomous existence so would keep existing even when isolated from interactions can we put a drop of ink in a glass water and isolate it completely from the world outside of it by putting it in the box Schrödinger proposes to put his cat in, for example, can we ask what the entropy inside the box is and how it changes in time –if not for the problem that if its content indeed would be completely isolated from the world outside of it so no interaction, no communication would be possible between the content of the box and the world outside of it, then the ink and water wouldn't exist, have no physical reality to the observer outside the box. As they wouldn't then be part of the universe of the observer, it doesn't make any sense to ask from outside a perfectly isolated system what the entropy inside of it is and how it changes in time or even say that time passes inside of it. If we only can ask what the entropy inside the box is if its content keeps interacting with, existing to the world outside of it so a different entropy inside of it would make the world outside of it slightly different and vice versa, then the entropy of a system only can change if it is *not* perfectly isolated.

If we nevertheless assume that a big bang universe is a perfectly isolated system which can have a definite entropy, an entropy which only can increase in time, then its entropy must have been minimal at the big bang, its initial state be a state of maximal inequilibrium. Now if we *define* the entropy of a system to be lower as it is farther out of equilibrium but a state only can be unstable, out of equilibrium, be a state of low entropy if there are laws operational by means of which the initial state can, *must* convert into a state which is less far out of equilibrium, then this begs the question where the information as contained in these laws and initial conditions comes from, who or what determined its initial conditions and installed the laws prescribing how one state is to transform into the next. If the initial state is specified by the physical laws which prescribe how it is to change, to transform into another state which is less far out of equilibrium, with a higher entropy, if an initial state only becomes defined, unstable as soon as the laws become operational which force it to transform into a state which is less far out of equilibrium – if these laws determine the nature of all consecutive states, each next state closer

[1] https://en.wikipedia.org/wiki/Entropy (22–3–2019)

to the final equilibrium state of maximal entropy– but a state only can convert into the next if the information as contained in the later state already is present in the previous state (like the chicken in some sense is present, preordained in the egg) so all later consecutive states already are present, predetermined in its initial state –which then contains, *in potentia*, all information universe ever will contain– then how can the transition from one state to the next increase the entropy, the information content of the universe?

Moreover, if a state only can be out of equilibrium when such laws are operational, then shouldn't they prevent the creation of any initial inequilibrium state –of a big bang– in the first place? Though this doesn't mean that ink particles in a glass of water collect just as easily to a drop of ink as they disperse or an egg becomes as easily unbroken as it breaks; the evolution of the chicken in some sense does constitute an entropy decrease as it unbroke the egg. In a universe where particles in a trial and error process evolve together with the associated laws and constants of nature, with the stars and galaxies they form, where its building blocks only acquire properties, are shaped and baked in the building process, as they form stars and galaxies, there obviously is no initial state, no initial minimum entropy which only can increase in time, not to mention that as there is no cosmic time in a SCU, no universe-wide now, we cannot even speak about the entropy of the universe at some particular time.

12
Big bang cosmology

The observational evidence for a big bang consists of the redshift of galaxies, the cosmic microwave background radiation (CMB), the relative abundances of light elements, the distribution of quasars, the metallicity of stars and nebulae and the evolution and large scale structure of the universe. Though the evidence for a big bang seems so overwhelming that almost all cosmologists take it for a fact; it only is evidence if the constant of nature called 'the speed of light' refers to a velocity, and not, as in a SCU, to a property of spacetime.
Despite all effort to gather observational evidence for a big bang, BBC still has no answer to –and therefore completely ignores– the question how if the universe can create itself, it always could, it can have a beginning: whether if it has a beginning, it must have been created by some outside intervention.

One observation which remains unexplained is the isotropy of the CMB, which in BBC is a relic radiation emitted some 380,000 years after the big bang, originating from the time when the universe was cooled enough for electrons and protons to form electrically neutral hydrogen so photons could travel freely without being immediately (re)absorbed by free electrons and protons as a result of which the universe became transparent to radiation –a radiation Fred Hoyle explained as produced by the fusion of hydrogen to helium in his steady state universe.
Due to the expansion of space the wavelength of the photons which existed at the time became stretched, redshifted to its present value, corresponding to a

temperature of $\pm$ 2.72⁰ Kelvin. As an expanding universe implies that regions which are sufficiently far apart recede from each other faster than the speed of light, what happens in one region cannot affect what in happens in the other.
As with the passing of time the region from which we can receive light increases, new areas will come into view. The curious thing, now, is that these new regions look no different from other regions: they have a CMB which is isotropic to about one part in 100,000.
This is the horizon problem: how came these regions to have the same temperature if they are too far apart to ever have been able to interact, communicate and smooth out temperature differences? To explain how the universe came to look as it does today, it would have to have started from improbably fine–tuned initial conditions at the big bang. Another problem, the flatness problem, arises from the fact that for the universe to look flat today

> … some of the initial conditions of the universe … [must have been] be fine-tuned to very 'special' values, and that small deviations from these values would have extreme effects on the appearance of the universe at the current time. In the case of the flatness problem, the parameter which appears fine-tuned is the density of matter and energy in the universe. This value affects the curvature of space-time, with a very specific critical value being required for a flat universe. … The ratio of the actual density to this critical value is called Ω, and its difference from 1 determines the geometry of the universe: Ω > 1 corresponds to a greater than critical density $\rho > \rho_c$ and hence a closed universe, Ω < 1 gives a low density open universe, and Ω equal to exactly 1 gives a flat universe. … The current density of the universe is observed to be very close to this critical value. Since the total density departs rapidly from the critical value over cosmic time, the early universe must have had a density even closer to the critical density, departing from it by one part in 10^{62} or less. … a very small departure of Ω from 1 in the early universe would have been magnified during billions of years of expansion … In the case of an overdensity [Ω > 1] this would lead to a universe so dense it would cease expanding and collapse into a Big Crunch in a few years or less; in the case of an underdensity [Ω < 1] it would expand so quickly and become so sparse it would soon seem essentially empty, and gravity would not be strong enough by comparison to cause matter to collapse and form galaxies.[1]

To spirit these fine-tuning problems away, the universe is proposed to have undergone a rapid exponential expansion[2] from 10^{-36} second after the big bang whereby nearby regions with different energy density were separated so fast that they disappeared beyond each other's interaction horizon, an inflation which, to fit observations, must have ended sometime between 10^{-33} and 10^{-32} seconds after the big bang after which space started to expand at its normal rate –whatever 'normal' may mean if its rate cannot be inferred from first principle.
Inflation is thought to be caused by a hypothetical inflaton field which permeates all of space and has a huge potential energy which, as the field goes to its ground state, is released and drives the expansion of space.
As the new regions which come into view today

[1] https://en.wikipedia.org/wiki/Flatness_problem (13–9–2019)

[2] That is, a –the scale factor, the 'size' of the universe– grows as $e^{\lambda t}$ with time t, and λ a constant

> … are exactly the same regions that were pushed out of the horizon during inflation … they are at nearly the same temperature and curvature, because they come from the same originally small patch of space. The theory of inflation thus explains why the temperatures and curvatures of different regions are so nearly equal. It also predicts that the total curvature of a space–slice at constant global time is zero. This prediction implies that the total ordinary matter, dark matter and residual vacuum energy in the Universe have to add up to the critical density … [1]

The idea is that however inhomogeneous the universe may have been initially, we always can choose areas sufficiently small that each of these original patches of space was almost completely homogeneous and that our present observable universe consists of one of these tiny, since that time inflated and expanded patches of space and that our present observation horizon hasn't yet exceeded the boundary of this original, homogeneous patch of space –and, if the expansion of the universe continues to accelerate, never will.
As to the flatness problem, the inflaton field

> … contains a certain energy density, but unlike the density of the matter or radiation present in the late universe, which decrease over time, the density of the inflationary field remains roughly constant as space expands. Therefore, the term ρa^2 increases extremely rapidly as the scale factor a grows exponentially. Recalling the Friedmann equation $(\Omega^{-1} - 1)\,\rho a^2 = -3kc^2 / 8\pi G$ and the fact that the right–hand side of this expression is constant, the term $|\Omega^{-1} - 1|$ must therefore decrease with time. Thus if $|\Omega^{-1} - 1|$ initially takes any arbitrary value, a period of inflation can force it down towards 0 and leave it extremely small – around 10^{-62} as required … Subsequent evolution of the universe will cause the value to grow, bringing it to the currently observed value of around 0.01. Thus the sensitive dependence on the initial value of Ω has been removed: a large and therefore 'unsurprising' starting value need not become amplified and lead to a very curved universe with no opportunity to form galaxies and other structures. [2]

While it is nice to decrease $|\Omega^{-1} - 1|$ so that whatever the initial energy distribution and density of the universe may have been before inflation doesn't in any way affect how the universe looks today; its credibility is further undermined by the fact that all relevant factors –the times to start and stop inflating and the energy density of the hypothetic inflaton field, i.e., the rate of inflation– don't follow from first principle but are chosen to fit observations.
Because the exponential, accelerating expansion of space

> … stretches out any initial variations in density or temperature to very large length scales, an essential feature of inflation is that it smooths out inhomogeneities, anisotropies and reduces the curvature of space. This pushes the Universe into a very simple state in which it is completely dominated by the inflaton field and the only significant inhomogeneities are tiny quantum fluctuations … [which] form the primordial seeds for all structure created in the later universe. … During inflation, the energy density in the inflaton field is roughly constant. However, the energy density in everything else, including inhomogeneities, curvature, anisotropies, exotic particles, and standard–model particles is falling, and through sufficient inflation these all become negligible. This leaves the Universe flat and symmetric, and (apart from the

[1] https://en.wikipedia.org/wiki/Inflation_(cosmology) (21–10–2019)
[2] https://en.wikipedia.org/wiki/Flatness_problem (16–12–2018)

homogeneous inflaton field) mostly empty, at the moment inflation ends. … The nature of the inflaton field is currently not known.[1]

Inflation increased

… the linear dimensions of the early universe by a factor of at least 10^{26} (and possibly a much larger factor), and so increased its volume by a factor of at least 10^{78}. Expansion by a factor of 10^{26} is equivalent to expanding an object 1 nanometer (10^{-9} m)… in length to one approximately 10.6 light years (about 62 trillion miles) long. … It is not known exactly when the inflationary epoch ended, but it is thought to have been between 10^{-33} and 10^{-32} seconds after the Big Bang.[2]
Inflation is a period of supercooled expansion, when the temperature drops by a factor of 100,000 or so. … This relatively low temperature is maintained during the inflationary phase. When inflation ends the temperature returns to the pre-inflationary temperature; this is called reheating … because the large potential energy of the inflaton field decays into particles and fills the Universe with Standard Model particles, including electro-magnetic radiation, starting the radiation dominated phase of the Universe. Because the nature of the inflation is not known, this process is still poorly understood …[3]

As the expansion exhausts the potential energy of the inflaton field, space only can keep inflating if the newly created space comes with the same energy density:

In standard cosmology, there are three components of the universe: matter, radiation, and dark energy. Matter is anything whose energy density scales with the inverse cube of the scale factor, i.e., $\rho \propto a^{-3}$, while radiation is anything which scales to the inverse fourth power of the scale factor ($\rho \propto a^{-4}$). … For radiation, the decrease in energy density is greater, because an increase in spatial distance also causes a redshift. The final component, dark energy, is an intrinsic property of space, and so has a constant energy density regardless of the volume under consideration ($\rho \propto a^{0}$). Thus, unlike ordinary matter, it does not get diluted with the expansion of space.[4] …
A cosmological constant due to a vacuum energy density has the effect of adding a repulsive force between objects which is proportional … to distance. Unlike inertia it actively "pulls" on objects which have clumped together under the influence of gravity … As the universe expands and the matter in it thins, the gravitational attraction decreases (since it is proportional to the density), while the cosmological repulsion increases; thus the ultimate fate of the ΛCDM universe is a near vacuum expanding at an ever-increasing rate under the influence of the cosmological constant.[5] …
The simplest explanation for dark energy is that it is an intrinsic, fundamental energy of space. This is the cosmological constant … Since energy and mass are related according to the equation $E = mc^2$, … this energy will have a gravitational effect. It is sometimes called a vacuum energy because it is the energy density of empty vacuum. The cosmological constant has negative pressure equal to its energy density and so causes the expansion of the universe to accelerate. The reason a cosmological constant has negative pressure can be seen from classical thermodynamics. In general, energy must be lost from inside a container (the container must do work on its environment) in order for the volume to increase. Specifically, a change in volume

[1] https://en.wikipedia.org/wiki/Inflation_(cosmology) (13–12–2018)
[2] https://en.wikipedia.org/wiki/Inflationary_epoch (10–12–2018)
[3] https://en.wikipedia.org/wiki/Inflation_(cosmology)#Reheating (16–12–2018)
[4] https://en.wikipedia.org/wiki/Dark_energy#Technical_definition (19–3–2019)
[5] https://en.wikipedia.org/wiki/Expansion_of_the_universe (28-7-2020)

dV requires work done equal to a change of energy $-P\,dV$, where P is the pressure. But the amount of energy in a container full of vacuum actually increases when the volume increases, because the energy is equal to ρV, where ρ is the energy density of the cosmological constant. Therefore, P is negative and, in fact, $P = -\rho$. [1]

However, as it is unclear how the density of the energy to drive the inflation came to have the right value to produce the desired expansion rate, how every point of space could know when to start and stop inflating at what rate, as if all points in space come with a clock and instructions when to start and stop inflating at what rate, how this energy knew when to stop expanding space and instead start to convert itself into (a *finite* quantity of) elementary particles and how they knew what properties to be created with, inflation only replaces the improbability of an isotropic and flat universe without inflation with the improbability that all relevant factors of the inflation have the right values[2] to produce the observed isotropy and flatness,[3] inflation doesn't explain anything but is a far-fetched *ad hoc* invention to save the big bang tale.
The problem isn't just that if the vacuum energy density of space aka cosmological constant which is to drive the expansion of space is different in different epochs – huge during inflation, zero thereafter until some 5 billion years ago when it assumed a small value– it cannot be an intrinsic property of space; it also would mean that as soon as this energy stops inflating space and starts to convert itself into elementary particles so space has exhausted the vacuum energy to drive its inflation, it no longer ought to contain the vacuum energy the UP implies space to contain –which of course is impossible. It isn't surprising, then, that the calculated value of the vacuum energy aka cosmological 'constant' is some 120 orders of magnitude greater than would fit observations.

The isotropy of the CMB only is incomprehensible if particle properties would only be the cause and not also the effect of their interactions –in which case their distribution would be more or less random and the CMB be anisotropic.
The observed isotropy suggests that the communication between particles is instant over any spacetime distance, that we live in a SCU. Moreover, if particles only can contract to clusters (and clusters of clusters) if they do so everywhere in concert if their energy is cause and effect of their interactions, then particles tend to evolve to elementary particles, to higher energies at places where forces are equal from all directions, then this automatically produces what in BBC would be a uniform mass[4] distribution but what in a SCU only is an isotropic distribution, though it remains to be seen whether the 2.726 ⁰ K radiation in this universe can be predicted to be isotropic to 1 part in 100,000.

[1] https://en.wikipedia.org/wiki/Dark_energy#Cosmological_constant (19–3–2019)
[2] See, for example, *A Critical Look at Inflationary Cosmology* (1999) Earman J. & Mosterin J. in *Philosophy of Science*, vol. 66, no. 1, 1999, *JSTOR*, www.jstor.org/stable/188736
https://en.wikipedia.org/wiki/Big_Bounce (15-11-21): "In the early 2000s, inflation was found by some theorists to be problematic and unfalsifiable in that its various parameters could be adjusted to fit any observations, so that the properties of the observable universe are a matter of chance."
[3] *A The road to reality* (2004) p 752-759 Roger Penrose.
A critique from one of the architects of inflation (2011) Paul J Steinhardt
http://www.physics.princeton.edu/~steinh/0411036.pdf
[4] In this text, any energy which can be localized, which is a source of gravity is called 'mass.'

If a SCU cannot be in any single evolutionary phase as a whole and the transmission of radiation is instant over any spacetime distance, then the CMB radiation is produced as it is observed, whatever its origin. Though according to Hoyle c.s. who proposed that we live in a steady state universe, this radiation is due to the fusion of hydrogen to helium whereas the light elements were synthesized in stars,

> The energy released in the synthesis of cosmic ^4He from hydrogen is almost exactly equal to the energy contained in the cosmic microwave background radiation. This result strongly suggests that the ^4He was produced by hydrogen burning in stars and not in the early stages of a big bang. In addition, we show that there are good arguments for believing that the other light isotopes, D, ^3He, ^6Li, ^7Li, ^9Be, ^{10}B, and ^{11}B, were also synthesized in processes involving stars. By combining these results with the earlier, much more detailed work of Burbidge et al. and of Cameron, we can finally conclude that *all* of the chemical elements were synthesized from hydrogen in stars over a time of about 10^{11} yr." … "The hot big bang cosmological model is not able to predict the temperature (cf. Turner 1993). But what is remarkable about the result that we have described here is that the energy density of the observed blackbody radiation is extremely close to the energy density expected from the production of helium from hydrogen burning. We showed earlier that this energy is 4.5×10^{-13} erg cm^{-3}, and when this energy is thermalized, the temperature turns out to be T = 2.76 K. While the value of the baryonic density in galaxies and their environs is not known with anything like the precision with which the blackbody temperature is measured, it is clearly not very different from $\rho = 3\ 10^{-31}$ g cm^{-3} (H_0 = 60 km s^{-1} Mpc^{-1}, and dark/luminous matter ratio ≈ 10) and, of course, the calculated temperature is only proportional to $\rho = ^{-1/4}$. [1]

as the steady state model predicts that bright radio sources (quasars and radio galaxies) should occur at all distances but were only found at large distances so could only have existed in a distant past, the steady state universe had to be rejected, this explanation of the origin of the CMB and the abundances of light elements was discarded. By contrast, as the transmission of radiation in a SCU is instant so we don't see a distant galaxy as it was in a distant past, in *the* past, but as it is to us at what only to us is the present, the observation that radio sources only are found at large distances and that the metallicity of stars and nebulae is lower as they are more distant doesn't disqualify a selfcreating universe.
As evolution of elementary particles and their combination to the atoms and molecules of our body took a long time, we cannot observe nearby galaxies in an earlier phase of their evolution than corresponds to that time. Whereas there should be galaxies at all ages at all distances in a steady state universe; as time in a SCU is observed to pass at a slower pace at larger distances, any observer anywhere observes a galaxy to be in an earlier phase of its evolution as it is more distant, the difference with a BBU being that we don't see a distant galaxy as it was in a distant past, in *the* past, but as it is as we look at it, in what only to us is the present.

Though it remains to be seen whether or to what extent a SCU can explain, predict the observations which as yet are taken as evidence for a big bang; as the universe

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[1] *The Origin of Helium and Other elements* Burbidge G. and Hoyle F. The Astrophysical Journal, 509:L1–L3, 1998 December 10 (Turner, M. 1993, Science, 262, 861)

by definition cannot have particular properties nor be in any particular state, big bang cosmology cannot be a valid description of the universe.
Though a relationalist like Rovelli agrees that

> The physical world can be described as a net of interacting components, when there is no meaning to "the state of an isolated system." The state of a physical system is the net of the relations it entertains with the surrounding systems. The physical structure of the world is identified with this net of relationships.[1]

he still hasn't concluded that big bang cosmology then cannot make sense.
Though relationalism points in the right direction in that it emphasizes the importance of relations between objects –the exchange of energy, of information by means of which particles express and at the same time preserve their, each other's properties, their existence; its proponents have yet to realize that causality is an unsurmountable obstruction to their case. In assuming that the rest energy of particles only is the cause of interactions, we treat it as an absolute, objective quantity,[2] as if it is something which only for practical difficulties cannot be measured from outside the universe. If their energy is cause and effect of their interactions, then it similarly is a relative, a relational quantity, different to different particles. Though to quantify things, we have to distinguish between the rest energy of an object, its distance and motion relative to the observer or observing particle; this approach presumes that energy and space are independent quantities, that space exists, is defined even in the absence of energy, implying that energy causes space to curve –which is impossible if energy only can act upon energy.

If the noncausality of quantum mechanics proves that we live in a selfcreating universe, then general relativity only can be unified with quantum mechanics if we let go of causality, if we realize that it is localized energy which makes positions at different distances physically different, which turns an abstract space where time passes at the same pace everywhere into a real, physical spacetime, where two points only can be observed to be spatially separated if time is observed to pass at a slightly slower pace at the more remote point.

The problem is that big bang cosmology tries to explain causally what only can be understood rationally as causality ultimately implies a primal cause, a creator.

[1] *Quantum Gravity* (Dec. 30, 2003) Carlo Rovelli p. 154 http://www.cpt.univ–mrs.fr/~rovelli/book.pdf

[2] "The properties I am referring to are those that are variables: that is, those described by functions on the phase space, not the invariant properties such as the non-relativistic mass of a particle." *Helgoland* (2021) Carlo Rovelli, P. 175, note 5.