Article

Consciousness & the Thermodynamics of Life

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Abstract

An argument based on the holographic principle and the nature of dark energy discusses the possible connection between consciousness and the thermodynamics of life. The nature of life is discussed in terms of symmetry breaking and the behavior of a biological organism that is far away from thermodynamic equilibrium. Only the holographic principle can address these issues since it tells us the point particle description of the world is at best a thermal average with a limited range of validity. The big mysteries are where does the dark energy come from that gives rise to an observable holographic world animated on and projected from the observer's horizon, and where does the differentiated consciousness of the observer at the central point of view of its world come from when this holographic projection and animation process begins?

Keywords: Consciousness, thermodynamics, entropy, energy, life.

It is important to examine our assumptions when discussing the behavior of a living biological organism in terms of entropy, energy, or any other thermodynamic concept. It is widely accepted that the most fundamental scientific concept we have in physics is the holographic principle. This isn't just a string theory idea. Gerard 't Hooft has expressed open hostility toward string theory and yet he accepts the holographic principle as the most fundamental scientific concept we have (Susskind). There is general agreement among people who work in string theory (Bousso) and most people who work in loop quantum gravity (Smolin) that the holographic principle is our most fundamental principle. This conclusion is quite general and is not dependent on any particular theory. As both 't Hooft and Tom Banks have argued (Gefter), the holographic principle is automatically in effect when non-commutative geometry is applied to a bounding surface of space, which in the sense of relativity theory is an event horizon that arises in an observer's accelerated frame of reference (Madore). String theory, loop quantum gravity and all possible theories of quantum gravity are probably special cases of non-commutative geometry. The only possible way to put the quantum in space-time geometry is to express space-time coordinates as non-commuting variables. These non-commuting space-time coordinates give rise to the bits of information encoded on a bounding surface of space that we call entropy.

This is important when we discuss the entropy of a living biological organism with the ability to express all the complex behaviors we call emotions. Not only is the behavior of a biological organism far away from thermodynamic equilibrium, but that behavior can only arise through

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some kind of critical phenomena or symmetry breaking, like a phase transition. Unlike a physical phase transition, like the freezing of water or melting of ice, which is dependent on the flow of heat in a thermal gradient, biological symmetry breaking is more complex because it also depends on the addition of potential energy to the organism (Kauffman). The flow of heat is nothing more than kinetic energy at a microscopic level, which we tend to conceptualize as the motion of point particles, like the electron and photon. We also conceptualize potential energy as the tendency of particles to bind together under the influence of a fundamental force, like an electron that binds to the composite particle we call a proton under the influence of the electromagnetic force, or the quarks that bind together into a proton under the influence of the strong nuclear force. We then attribute entropy to these point particles, which is the idea of quantum information. The problem is this conceptualization can at best be an approximation of the holographic principle, which tells us that all the fundamental bits of information are really encoded on a bounding surface of space in a binary code of 1's and 0's. Kinetic energy arises from the tendency of bits of information to flip back and forth between 1 and 0, like spin variables that tend to flip back and forth between the up and down spin positions due to their thermal energy, while potential energy arises from the tendency of bits of information to align. This tendency for alignment is a natural consequence of non-commutative geometry, which typically formalizes the n bits of information encoded on a bounding surface of space in terms of the n eigenvalues of an SU(n) matrix (Madore). Since these n bits of information are entangled, they naturally tend to align, like in a spin network (Penrose).

We can understand the complex behavior of living biological organisms as arising through the phenomena of symmetry breaking due to the alignment of these bits of information, but there is always a balance between competing critical phenomena. For example, photosynthesis in a plant involves both the construction of carbohydrate molecules, as the energy of an absorbed photon is converted into a high energy chemical bond, and the burning of carbohydrate molecules, as the energy of that chemical bond is released and utilized to perform useful work, like the plant turning toward the sun so that it can absorb more photons and grow.

The construction of the carbohydrate molecule is an example of biological symmetry breaking that requires the addition of potential energy to the organism, which is obtained through the absorption of the photon. The plant is then able to express a desire to absorb more photons and grow as it burns the carbohydrate molecule and uses some of that released energy to turn toward the sun, which is the performance of useful work in terms of the growth of the plant. The expressed desire to turn toward the sun has a useful purpose for the plant, which is to absorb more photons and grow. That's really the only significant difference between a physical phase transition, which is solely dependent on the flow of heat, and an example of biological symmetry breaking, which always requires the addition of potential energy. The emotional behavior of a living biological organism is complex because there is always a balance between competing critical phenomena, which in the example of the plant is the balance between the construction

and burning of carbohydrate molecules, but this behavior is emotionally directed toward the growth of the plant, which is necessary for the plant's survival. Although we can conceptualize this process in terms the motion and organized behavior of point particles, like electrons and photons, the more fundamental description is in terms of the holographic principle.

The holographic principle tells us the point particle description is at best a thermal average with a limited range of validity. This fundamental principle tells us the n bits of information encoded on a bounding surface of space are specified in terms of the surface area A of the bounding surface as n=A/4(Planck area), where the Planck area is $\ell^2=\hbar G/c^3$. The bounding surface also has an absolute temperature, which for a spherical surface of radius R is given as $kT=\hbar c/2\pi R$. The maximal entropy of everything that can be observed within that bounded space is given as S=kn. Ted Jacobson has shown using the fundamental relation between the flow of heat and a change in entropy, $\Delta Q=T\Delta S$, that the observable space-time geometry of that bounded region of space is described by Einstein's field equations for the space-time metric in the sense of a thermal average or thermodynamic equation of state valid near thermal equilibrium (Jacobson). The reason Einstein's field equations arise from the holographic principle as a thermal average is quite simple.

As heat flows across a bounding surface of space, the maximal entropy of that bounded region of space must change, which implies a change in the surface area of the bounding surface, which implies a change in the space-time geometry of the bounded space. Einstein's field equations for the space-time metric only describe the space-time geometry of that bounded region of space in the sense of a thermal average. The holographic principle is more fundamental than gravity as it implies that gravity only arises as a thermal average. If we apply the usual unification mechanisms of supersymmetry and the Kaluza-Klein mechanism of extra compactified dimensions of space to Einstein's field equations for the metric (Zee), we then end up with a field theory that looks like 11-dimensional super-gravity (Greene), which includes the fundamental forces of gravity, electromagnetism, and the strong and weak nuclear interactions. All the usual quantum fields of the standard model of particle physics are included in this description. The problem is this point particle description is only a thermal average with a limited range of validity, which is a low energy limit. The quantum field for any point particle is understood as an extra component of the space-time metric, and a particle excitation is understood as a wave-packet of field energy. The point particles of electrons and photons, which are the quantums of the Dirac and electromagnetic fields, are in reality no more fundamental than phonons or the quantum of sound waves.

There is a mystery about the holographic principle that we need to address if we really want to understand the complex emotional behaviors of living biological organisms. This mystery is the nature of dark energy, which is the accelerated or exponential expansion of space that always expands relative to the central point of view of an observer (Gefter). Due to the limitation of the

speed of light, which is like the maximal rate of information transfer in three dimensional space, a cosmic horizon surrounds the observer at the central point of view and limits the observer's observations within that bounded space. The cosmic horizon acts as a holographic screen that encodes all the fundamental bits of information for everything the observer at the central point of view can observe in that bounded region of space. Everything the observer can observe in that bounded region of space is like a projection of an image from the holographic screen to the observer's central point of view (Susskind). This holographic projection process can be called a screen output. Not only is the image of every perceivable thing projected from the screen, but those images are also animated over a sequence of screen outputs, just like the animation of a movie on a computer screen. This holographic projection and animation process requires energy.

Fundamentally, this energy must come from dark energy (Gefter), which is the energy that puts the "bang" in the big bang event and creates the observer's world in the first place. In the sense of inflationary cosmology, the normal flow of energy through the observer's world, which animates all projected images, can only arise as dark energy burns away and heat is radiated away to infinity. We understand this burning away of dark energy as an example of symmetry breaking. A non-zero value of dark energy is always defined in a metastable or false vacuum state, and the burning away of dark energy always occurs in a phase transition, as the value of dark energy transitions to a more stable state of lower energy. This is really no different than the burning of a carbohydrate molecule.

The total energy of this dark energy burning process always adds up to zero, since the negative potential energy of gravitational attraction exactly cancels out the dark energy and all other forms of positive energy like mass energy, which is to say the burning process is always in perfect balance. Remarkably, cosmic observations indicate that there is not only a non-zero value for dark energy in the universe, but also that the total energy of the observable universe is exactly zero. In this burning process, heat is radiated away, and the observer's cosmic horizon inflates in size and cools in temperature. This burning process is what gives rise to the thermal gradient that drives the normal flow of energy through the observer's world. The complex emotional behavior of all biological organisms arise due to the normal flow of this animating energy. We really have no good explanation for the nature of these metastable or false vacuum states, except that life and the complex emotional behaviors of living organisms could not occur without them.

Amanda Gefter has argued that ultimate reality must be invariant for all observers. Based on this self-evident axiom she has concluded: *Nothing is ultimately real*. This conclusion is irrefutable in a holographic world where everything an observer can possibly observe arises from configuration states of information encoded on a holographic screen, which is always an observer-dependent event horizon that arises in the observer's accelerated frame of reference. Since the observer's world is ultimately defined on an observer-dependent cosmic horizon that arises with dark energy and the accelerated expansion of space, every possible observable thing

in the observer's world is observer-dependent and depends on the observer's frame of reference. Nothing observable in that world can be invariant for all observers, and therefore *Nothing is ultimately real*. This conclusion is akin to an optical illusion. Either there is no such thing as ultimate reality, or ultimate reality does exist, but can only be described as the primordial nothingness. This primordial nothingness must be infinite and undifferentiated. The big mysteries are: how does dark energy arise from the primordial nothingness in the first place to create the observer's world in a big bang event, and how does the differentiated consciousness of the observer arise at the central point of view in relation to the observer's horizon? The absolutely mysterious thing about the observer's consciousness is that relativity theory tells us the observer's central point of view is the singularity of the big bang event.

Trying to explain reality in terms of the laws of physics is putting the cart before the horse. The laws of physics describe the behavior of the world in a probabilistic sense, but they can only emerge as thermal averages from the holographic principle, which in turn can only come into effect when bits of information are encoded on a bounding surface of space when non-commutative geometry is applied to the surface. This is always an observer-centric description of the world. The bounding surface of space is an event horizon that arises in the observer's accelerated reference frame, which for an observer's world can only be understood as a cosmic horizon that arises with dark energy and the accelerated expansion of space that always expands relative to the central point of view of the observer. Dark energy is the horse and the laws of physics are the cart.

The big mysteries are: how does dark energy arise from the primordial nothingness and create the observer's world in the first place, and how does the differentiated consciousness of the observer at the central point of view of its own world arise from this primordial undifferentiated nothingness as its observable world is holographically constructed on the observer's cosmic horizon? In this sense, the primordial nothingness is the beginning and the end. It is what exists before dark energy is expended and the observer's world appears to come into existence or begin, and it is what exists after all dark energy burns away and the observer's world appears to go out of existence or end.

There is another mystery that needs to be addressed. The observer's holographic screen is always described by a quantum state of potentiality that is like a sum over all possible configuration states of information or ways bits of information can become encoded on the screen. In any screen output, a choice must be made as a particular configuration state of information is chosen from the quantum state. In physics this is called a quantum state reduction. Who chooses? Physics assumes the choices are made randomly or in an unbiased way. Random choice is the only thing that gives the laws of physics their predictability. If bias arises in the way choices are made, then all bets are off and the laws of physics lose their predictability. If we conceptualize the quantum state as a sum over all possible paths through the information configuration space,

then only random choice can give rise to the path of least action as the most likely path in the sense of quantum probability. The path of least action is the classical limit, which is like the shortest distance between two points in a curved space-time geometry. Even the idea of a thermal average relies on random choice.

What if bias arises in the way choices are made? Who would make those biased choices? Only the observer at the central point of view of its own world can make choices with its focus of attention on things. All the bits of information for everything the observer can observe in its world are encoded on the observer's holographic screen. Images of things are projected to the observer's central point of view in a screen output and are animated over a sequence of screen outputs. Each screen output is a choice that chooses a particular configuration state of information from the quantum state. If emotional bias arises in the observer's focus of attention on those observable things, there is the possibility that bias can arise in the way the choices are made. Emotional bias in the observer's focus of attention could give rise to the expression of biased emotions, which like a positive feedback loop could then further bias the observer's focus of attention on things.

Things are more complicated than this scenario, since there is the possibility of information sharing among many observers, like the kind of information sharing we see in a network of screens, like the internet. Each observer's holographic screen can share information with the screens of other observers to the degree those screens overlap in the sense of a Venn diagram. This is possible since every observer is at the central point of view of its own cosmic horizon, and the horizons of many different observers can overlap and share information (Gefter).

The universe is not at thermal equilibrium. We can't even really speak about the universe per se, only about an observer's world (Gefter). Each observer's world is defined on its own holographic screen that encodes all the bits of information that specify the configuration states of everything the observer can observe in its world. The observable images of those things are projected from the observer's screen to the observer's central point of view in a screen output and animated over a sequence of screen outputs, just like the animation of a movie on a computer screen.

The observer itself is only a focal point of perceiving consciousness at the central point of view of its world. Everything the observer can perceive in its world, including the animated image of its character in that world, is projected from its screen. This holographic projection and animation process is only possible because of the flow of energy through the observer's world. That flow of energy naturally arises as dark energy burns away and the observer's cosmic horizon inflates in size, cools in temperature, and encodes more bits of information. This energetic process is not at thermal equilibrium. The burning away of dark energy is actually more like a phase transition. The fact that things are not at thermal equilibrium is obvious when we look towards the hot sun and see the burning of nuclear fuels inside the sun that give rise to

the radiation of hot high energy photons, and then turn around and look at the coldness of cold outer space. The flow of energy through the observer's world is driven by the thermal gradient created as dark energy burns away, just like the flow of sunlight is driven by a thermal gradient. There is no need to violate the second law of thermodynamics with this flow of heat since the observer's cosmic horizon encodes more bits of information as it inflates in size and cools in temperature, which happens naturally as dark energy burns away. The development of coherently organized forms of information in the observer's world, like the biological organism of its observable character, occurs naturally as energy flows in this thermal gradient. Coherent organization of form naturally develops because all the bits of information encoded on the observer's holographic screen are entangled like the eigenvalues of an SU(n) matrix, and those entangled bits of information naturally tend to align.

Everything in the observer's world can only begin when the observer, which is a differentiated point of consciousness, arises at a central point of view in relation to a holographic screen, which is an event horizon that encodes all the bits of information for everything observable in the observer's world and projects all the animated images of things in the observer's world like images of a movie. This holographic projection and animation process requires energy, which is what we perceive as animating emotional energy. At the center of this animating emotional energy is the projected image of a central character, just like the central character of a movie. This central character is a biological organism that arises from the way bits of information encoded on the holographic screen are coherently organized into form with the potential to self-replicate their forms over an animated sequence of screen outputs. All of these perceivable images are projected to the central point of view of the observer, which not only observes the images of things, but also perceives the flow of emotional energy that animates those things. The observer not only perceives the animated form of the organism but also "feels" the emotional feelings expressed by the biological organism as the animation process goes forward. The animation of "inanimate objects" like a rock is limited to the flow of heat, which is kinetic energy at a microscopic level, while the biological organism also has the ability to add potential energy to its form. The addition of potential energy not only occurs when we eat something, but also when we learn something. All knowledge is based on the organization of information, and that organizing process requires the addition of potential energy.

The animated form of biological organisms are characterized by the ability to express emotions, which are desires to add potential energy to their forms. This expression of emotions by the organism is what makes the observer "feel" self-limited to the form of the organism as the observer perceives the flow of animating emotional energy through that form. This feeling of self-limitation allows the observer to emotionally identify itself with the form, which leads to emotional bias in the observer's focus of attention, which leads to the expression of biased emotions, which leads to a vicious cycle of self-identification of the observer with its character

and self-defense of the animated form of the character with the expression of biased emotions, which is the emotional expression of ego that can be called the self-identified state (Damasio).

The emotional bias of the self-identified state creates feelings of self-limitation, which is a state of emotional bondage created as the observer identifies itself with its character. This self-limited state of emotional bondage is why Plato called an observer that emotionally identifies itself with the emotionally animated form of its character, like a shadow projected on a wall, a prisoner.

There is another possible way to live, which is free of the emotional bias of ego. This possibility can be called the integrated state. To live an integrated life requires surrender and the willingness to come into alignment with the normal flow of things. Surrender leads directly to the integrated state, as the animating flow of energy through one's character comes into alignment with the normal flow of energy through one's world, which leads to feelings of connection, expressions of creativity and correctness of actions. Surrender is not really possible unless we become aware of the true nature of what we really are, which is consciousness (Nisargadatta). As long as we live in a fearful state of self-identification with character, we won't surrender.

The big mystery is where does the differentiated consciousness of the observer at the central point of view of its world come from when this whole holographic projection and animation process begins? Where does the dark energy come from that puts the "bang" in the big bang event and that creates the observer's world in the first place? The value in thinking about things in a logically consistent way is it drives us to these fundamental questions. These questions don't really have answers in the conventional scientific sense. To really answer these questions requires that we go beyond what we call knowledge and beyond what we call information, to consciousness itself. Only the consciousness of the observer at the central point of view of its own world can know about the meaning of the knowledge energetically constructed out of information in that world. Only the observer can know what it all means. This journey to consciousness itself always requires a shift in the observer's focus of attention away from its observable world and onto its own sense of being present for that world (Nisargadatta). The journey to consciousness itself, which is a journey beyond all possible knowledge to the true nature of what we are, is the real mystery.

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