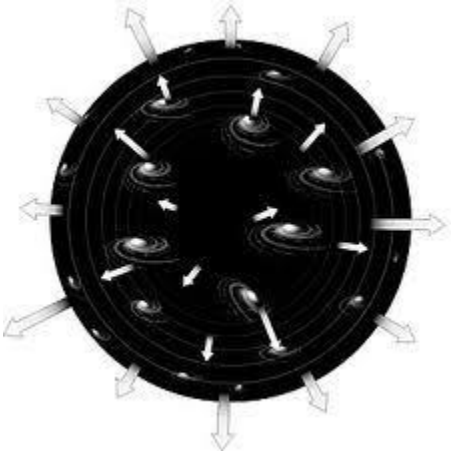
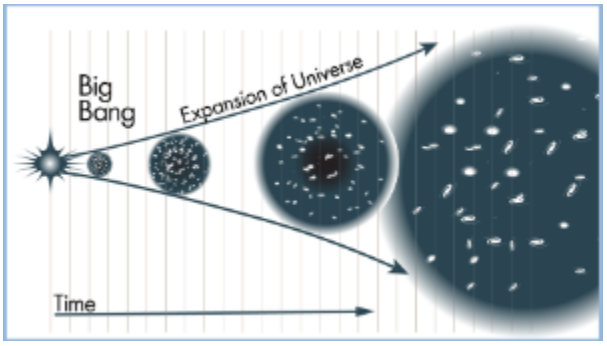
Beyond Computation

Q; Hey you had a blog post a few years ago called the real time traveler and in it you said that you interviewed a student or partner of Leonard Susskind on the holographic principle. Who was this scientist again? I can't find that post again anywhere.

A: Several years ago, I communicated with Amanda Gefter, who interviewed Lenny Susskind about the holographic principle extensively for her book Trespassing on Einstein's Lawn. Gefter's basic idea was that an observer creates in its own holographic world due to the information that's encoded on the observer's de Sitter cosmic horizon that arises from dark energy and the accelerated expansion of space, which in relativity theory is understood as a positive cosmological constant. In relativity theory, the accelerated expansion of space always expands relative to the central point of view of an observer. At the observer's cosmic horizon, space appears to expand away from the observer at the speed of light, and so nothing is observable to the observer beyond the limits of its cosmic horizon.

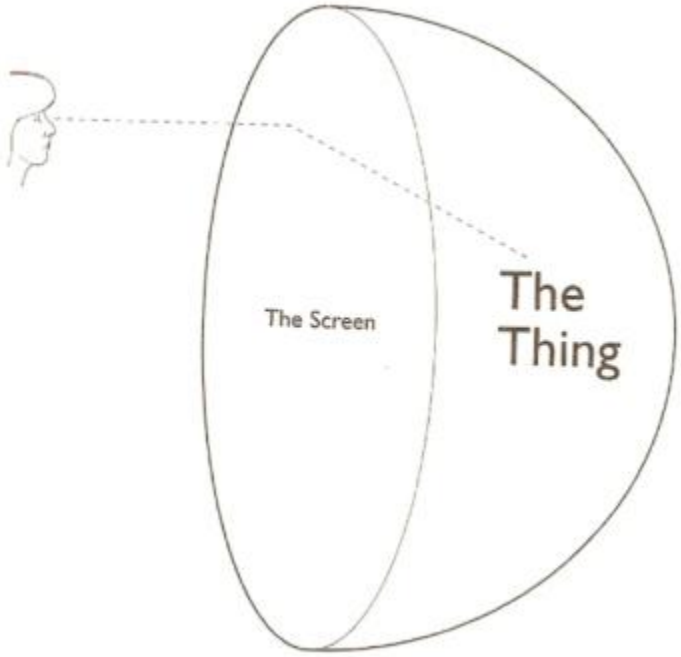


Accelerated Expansion of Space



Accelerated Expansion of the Universe

When the observer's cosmic horizon encodes information for its own holographic world, its horizon becomes its holographic screen. Everything observable in the observer's own holographic world is reducible to information encoded on its holographic screen. Everything observable in the observer's holographic world is like a holographic image projected from its screen to its point of view at the center of its own holographic world.

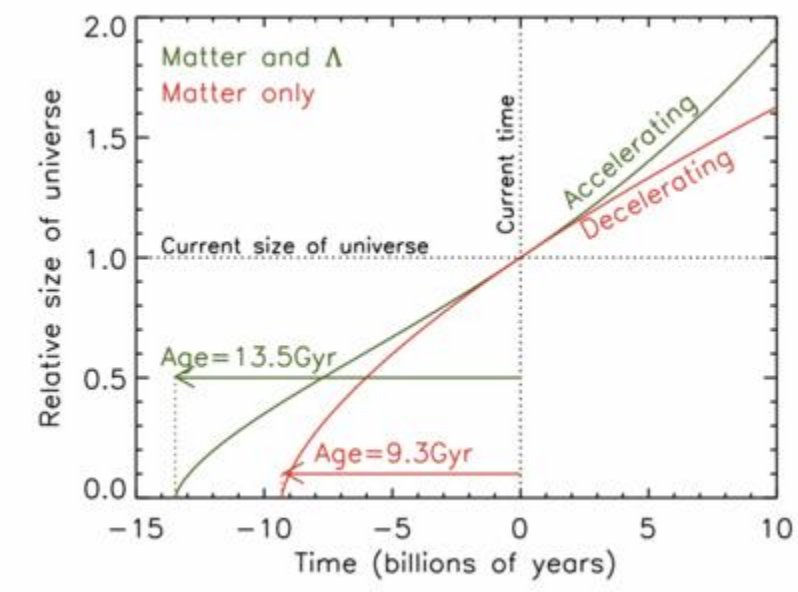


The Observer, the Screen, and the Images of Things in its Holographic World

Susskind actually agrees with this idea, but has found no way to implement the idea in terms of theoretical physics. Due to this impasse, Susskind concentrates all of his efforts on understanding the AdS/CFT correspondence, which is the kind of holographic world created with a negative cosmological constant in anti-de Sitter space, which arises from the accelerated contraction of space. Anti-de Sitter space has a conformal boundary, and information can be encoded on that boundary in terms of an SU(N) conformal field theory. In the large N limit, this information encoded on the conformal boundary of anti-de Sitter space is equivalent to gravity in anti-de Sitter space. The way this works is that the information encoded on the 10-dimensional conformal boundary of anti-de Sitter space by a supersymmetric SU(N) conformal field theory in the large N limit is equivalent to 11-dimensional supergravity in anti-de Sitter space. When we understand the extra dimensions are being compactified, 11-dimensional supergravity explains all the laws of physics in terms of Einstein's field equations for the space-time metric, which is the nature of the gravitational field, along with Maxwell's equations for the electromagnetic field and the Yang-Mills equations for the nuclear fields. The matter fields, as described by Dirac's equation for the electron and quark fields, naturally arise

from supersymmetry. In other words, the laws of physics in 11-dimensional anti-de Sitter space are equivalent to the information encoded by a supersymmetric SU(N) conformal field theory defined on the 10-dimensional conformal boundary of anti-de Sitter space. The AdS/CFT correspondence is an explicit demonstration of the holographic principle.

Unfortunately, we do not live in anti-de Sitter space. We live in an exponentially expanding universe as characterized by de Sitter space and the accelerated expansion of space. This is confirmed by direct observation. When we look out at distant galaxies, the farther away the galaxy, the faster the galaxy appears to accelerate away from us. The limits of our observations are defined by a cosmic horizon at which point galaxies appear to move away from us at the speed of light. The Nobel prize was awarded for this discovery of observational cosmology.



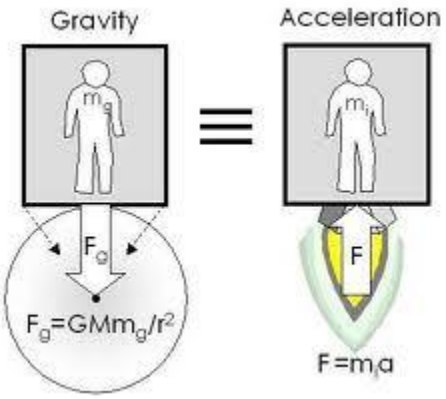
Accelerating Universe

Susskind accepts that the de Sitter cosmic horizon is the nature of the observer's holographic screen that defines its holographic world when information is encoded on its horizon. The stumbling block is to formulate this in terms of theoretical physics. There is no analogue of the AdS/CFT correspondence that generalizes to de Sitter space.

The basic problem comes down to the nature of the observer. In de Sitter space, the observer is always at the central point of view of its own de Sitter cosmic horizon. The observer's holographic world is only defined when its horizon encodes information for everything observable in its holographic world and becomes its holographic screen.

The problem of the observer is the problem that Gefter confronted in her book. Gefter defined the observer as an accelerating frame of reference. In relativity theory, the

observer is defined as the origin or central point of view of a space-time coordinate system, which becomes an accelerating frame of reference when that coordinate system undergoes accelerated motion. In terms of the principle of equivalence, the nature of gravity is understood as arising from the observer's own accelerated motion.



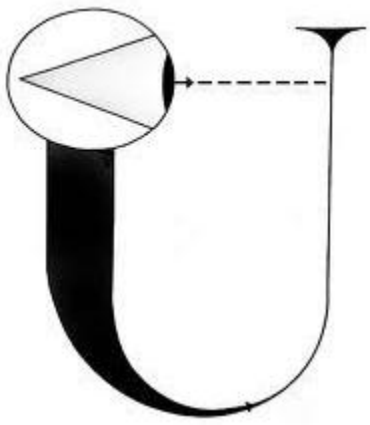
Principle of Equivalence

An accelerating observer always observes events in its own space-time geometry in terms of the curvature of that space-time geometry. The curvature of that space-time geometry is the nature of the gravitational field as formulated by Einstein's field equations for the space-time metric. The situation in de Sitter space is very similar, except the curvature of that space-time geometry is being generated by the accelerated expansion of space. The expression of dark energy in terms of the accelerated expansion of space, like any other expression of mass or energy, is a generator of gravity in terms of the curvature of that space-time geometry. Dark energy generates gravity. The odd thing about this process is that the expression of dark energy is always counterbalanced by the expression of gravity. The negative potential energy of gravity always exactly cancels out the expression of positive dark energy. The negative potential energy of gravitational attraction exactly cancels out the expression of positive dark energy, and so the total energy of this process exactly adds up to zero. This is actually confirmed by observations of the universe. A universe with a total energy of zero is asymptotically flat, which is confirmed by direct observations of the universe.

This is one of the puzzles that Gefter had to confront when she explored the nature of the observer. The observer is best understood as arising at the central point of view of its own holographic world that is defined in terms of information encoded on its own cosmic horizon that arises due to dark energy and the accelerated expansion of space.

The big question that Gefter asked herself is: Where does the observer come from? The answer that Gefter eventually settled on is that the observer and its holographic world are a self-excited circuit. John Wheeler proposed this idea of the observer and the world

it perceives as a self-excited circuit when he tried to scientifically understand the nature of an observer and the world that it perceives in terms of information.



Universal Observer as a Self-Excited Circuit

There is actually a great deal of merit in this idea of the observer and the world that it perceives as a self-excited circuit since perception always occurs in a subject-object relation. The observer is the subject and whatever it perceives in its world is an object of perception. In terms of the holographic principle, the observer always arises at the central point of view of its own holographic world, and whatever it perceives in that world is a form of information that can be reduced to information encoded on its own holographic screen. The observer's holographic screen is an event horizon that arises due to the observer's own accelerated motion, which in the case of the expression of dark energy is the accelerated expansion of space. The observer's event horizon becomes its holographic screen when its horizon encodes information.

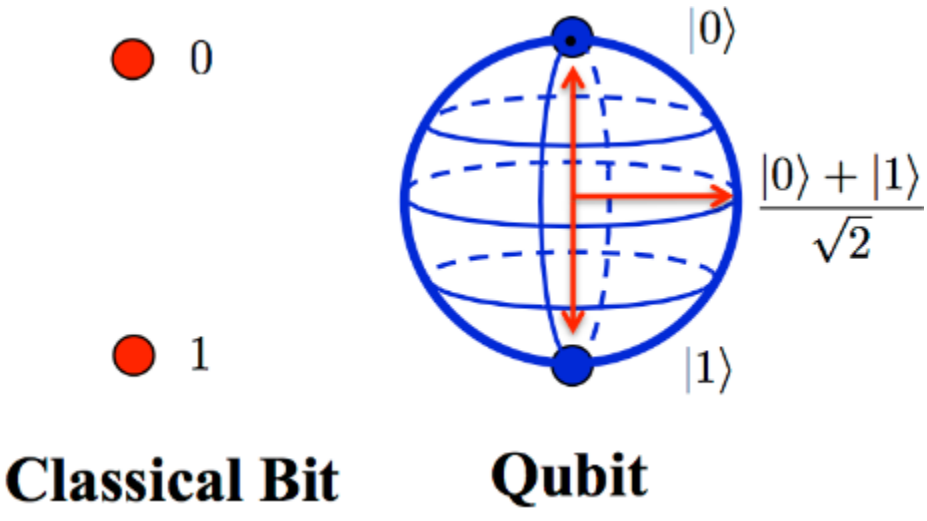
John Wheeler understood this process as similar to what an observer can observe on a computer screen. The computer screen encodes bits of information on pixels. That information is encoded in a binary code of 1's and 0's. Whatever the observer observes is a form of information that can be reduced to bits of information encoded on the computer screen. These forms of information are projected like images from the screen to the observer's point of view outside the screen and are animated in the flow of energy that flows through the computer. Everything the observer can observe is a projected form of information animated in the flow of energy. Wheeler called this idea "It from bit".

The idea of the observer's holographic screen as similar to a computer screen is the essential nature of the holographic principle. Information is encoded on the observer's holographic screen in terms of bits of information. The big question was how this information encoding occurs when the holographic screen is a de Sitter comic horizon.

Gefter began to search for such an explanation and found it in the work of Tom Banks, who initially called the idea matrix theory, and then changed the name to holographic space-time. Banks and Susskind are colleagues, and collaborated on the initial paper on matrix theory before the AdS/CFT correspondence was discovered. Their respective interests then diverged as Banks became focused on de Sitter space while Susskind focused his attention only on anti-de Sitter space.

Banks assumed the observer's holographic screen is ultimately defined on a de Sitter cosmic horizon. This is inherently an observer-centric and observer-dependent formulation of the holographic principle since the observer is at the central point of view of its own holographic world that is defined on its own de Sitter cosmic horizon.

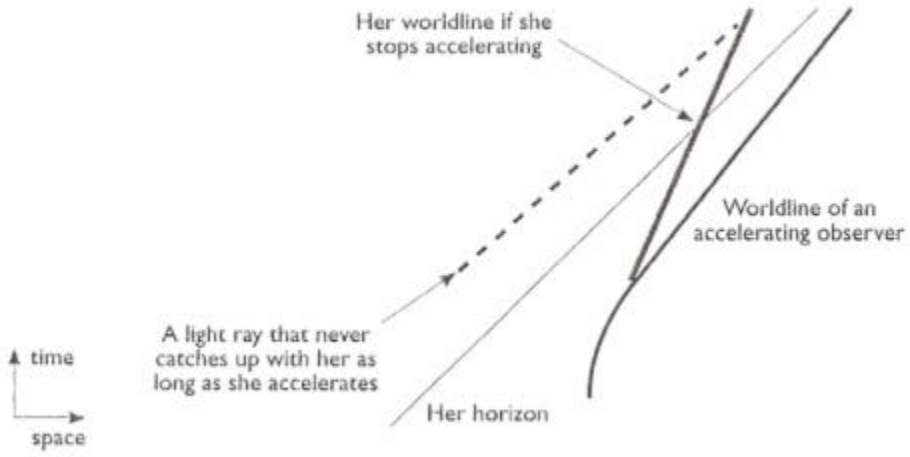
The big question is how is information encoded on the observer's cosmic horizon? The answer is that information is encoded in terms of quantized bits of information called qubits. A qubit is understood to be mathematically represented in terms of a matrix, like a Pauli spin matrix that represents a spin variable that can only be observed in either a spin up or spin down state. The spin variable encodes measurable information in a binary code of 1's and 0's like a computer switch that is either on or off. This measurable information arises from the eigenvalues of the matrix. In quantum theory, the Pauli spin matrix is formulated in terms of an SU(2) matrix, which also gives a mathematical representation of rotational symmetry of the surface of a sphere. The eigenvalues of the matrix, which are the nature of the measurable information encoded by the matrix, are entangled due to quantum entanglement, which is a mathematical reflection of this rotational invariance. At the level of qubits, quantum entanglement is only reflecting that information is being encoded on the surface of a sphere in a rotationally invariant way.



Qubit of Information Encoded on the Surface of a Sphere

This way of encoding quantized bits of information on the surface of a sphere is called a matrix model. The next big question is where does the surface of the sphere come from? The answer the holographic principle gives is that the surface of the sphere arises as an observer's event horizon due to the observer's own accelerated motion.

The idea of qubits of information being the fundamental underlying basis for quantum theory has recently received a great deal of attention, including the award of a Nobel prize for experiments in quantum entanglement. The big question these experiments have not answered is exactly where is this information encoded? The holographic principle answers this question in terms of the surface of an event horizon that arises due to an observer's own accelerated motion. In terms of an observer's cosmic horizon that arises due to the expression of dark energy, that accelerated motion is understood in terms of the accelerated expansion of space. Even without the expression of dark energy, any accelerating observer will have its observations of events in space limited by an event horizon. In the generic case, this event horizon is called a Rindler horizon.



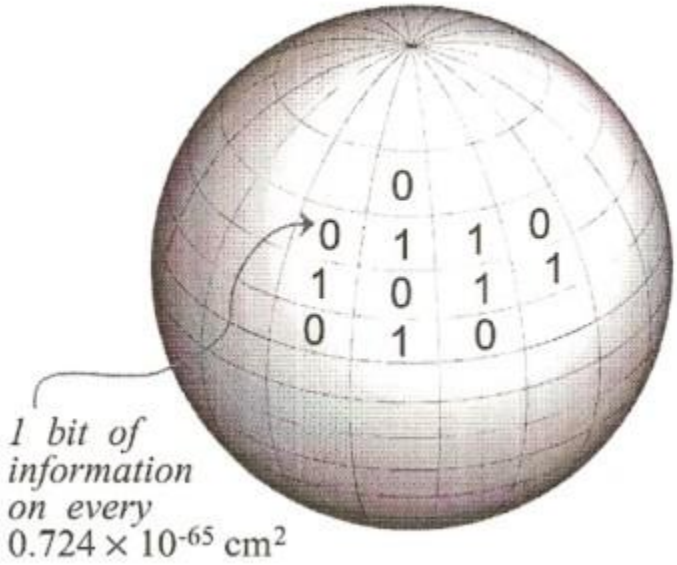
Accelerating Observer's Event Horizon

The nature of an event horizon only requires the idea of an observer that undergoes accelerated motion and the invariance of the speed of light, which is the maximal rate of information transfer in three dimensional space. The speed of light is the maximal rate of information transfer in a computer network. A light ray that originates on the other side of the observer's event horizon can never reach the accelerating observer as long as the observer continues to undergo its accelerated motion. The holographic principle is built on this idea of accelerated motion, whether that accelerated motion arises from the observer's own accelerated motion or the accelerated expansion of space.

The basic idea of the holographic principle is that the observer's event horizon, whether a de Sitter cosmic horizon or a Rindler horizon or some combination of the two,

becomes its holographic screen when qubits of information are encoded on its horizon. The most general way to formulate the holographic principle is in terms of a matrix model, which is the way Tom Banks has formulated the holographic principle. Unlike the AdS/CFT correspondence that only applies in anti-de Sitter space, the idea of a matrix model can also be formulated in de Sitter space.

The upshot is that an observer's event horizon can become its holographic screen when qubits of information are encoded on its horizon, which is mathematically formulated in terms of a matrix model. The way the holographic works is that each qubit of information is encoded on a Planck size area element defined on the surface of the horizon, like bits of information encoded on the pixels of a computer screen. The number of qubits of information encoded on the horizon is given in terms of the surface area, A, of the horizon as $n=A/4\ell^2$, where the Planck area, $\ell^2=\hbar G/c^3$, is given in terms of Planck's constant, the gravitational constant and the speed of light. Since a qubit of information is the smallest amount of measurable information that can be measured, this explains why a Planck-size event horizon, which encodes a single qubit of information, is the smallest possible event horizon. Larger event horizons encode more qubits of information.



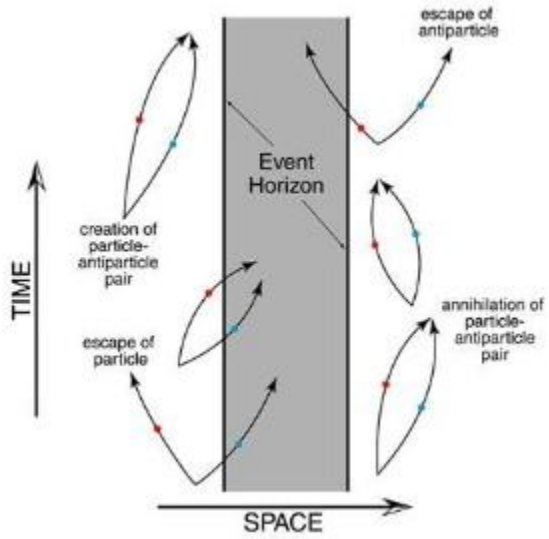
Holographic Principle

The idea Tom Banks had about formulating the holographic principle in de Sitter space in terms of a matrix model, where the observer is at the central point of view of its own holographic world that is defined in terms of qubits of information encoded on its own holographic screen that arises as its cosmic horizon, is a natural extension of the idea that Ted Jacobson had about the thermodynamics of space-time. Jacobson considered an accelerating observer and its Rindler horizon. Jacobson assumed that the observer's

world was defined in terms of qubits of information encoded on the observer's Rindler horizon. In terms of thermodynamics, this way of encoding qubits on the observer's horizon is the nature of holographic entropy. The qubits are the fundamental dynamical degrees of freedom for the observer's world. In terms of qubits as the fundamental basis for quantum theory, a qubit is the nature of entropic information. Holographic entropy is simply given in terms of the number of qubits encoded on the observer's event horizon as S=kn. Jacobson needed one more piece of the puzzle, which is the amount of thermal energy carried by each dynamical degree of freedom at thermal equilibrium.

Thermodynamics tells us that at thermal equilibrium, each dynamical degree of freedom carries the same amount of thermal energy, which is given in terms of temperature as E=kT. In a holographic world, these dynamical degrees of freedom are qubits of information encoded on the observer's event horizon. Jacobson was able to specify this thermal energy in terms of the Unruh temperature of the Rindler horizon, which is simply given in terms of the observer's acceleration, a, as $kT=\hbar a/2\pi c$.

The Unruh temperature is given in terms of the thermal energy of the thermal radiation carried away from the observer's event horizon, E=kT, as observed by the accelerating observer. This emitted thermal radiation is also called Hawking radiation. The Unruh temperature is calculated in quantum field theory in terms of the separation of virtual particle-antiparticle pairs at the event horizon as observed by the accelerating observer. The virtual particle-antiparticle pairs are created out of nothing due to quantum uncertainty in energy, and normally annihilate back into nothing in a short period of time, but at the event horizon they can appear to separate from the point of view of the accelerating observer, which gives the event horizon an apparent temperature due to the horizon's emission of thermal radiation that carries heat toward the observer.



Hawking Radiation

With these values for the holographic entropy and the Unruh temperature of the event horizon, Jacobson was then able to use the laws of thermodynamics, which says that $\Delta E=T\Delta S=kT\Delta n$, to derive Einstein's field equations. Since holographic entropy, $S=kn$, is given in terms of the number of qubits encoded on the surface area of the event horizon as $n=A/4\ell^2$, this simply says that at thermal equilibrium, as the event horizon changes in surface area, the amount of thermal energy inherent in the observer's holographic world also changes since there is a change in the number of qubits of information encoded on the event horizon. At thermal equilibrium, each qubit carries the same amount of thermal energy given in terms of the observer's own acceleration as $E=kT=\hbar a/2\pi c$.

This simple relationship allowed Jacobson to derive Einstein's field equations for the space-time metric from the laws of thermodynamics. As the surface area of the observer's event horizon changes, there is a corresponding change in the amount of energy inherent in the observer's holographic world, which corresponds to a change in the dynamical curvature of the space-time geometry of that holographic world as is specified by Einstein's field equations for the space-time metric.

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} \quad = \quad 8\pi GT_{\mu\nu} - \Lambda g_{\mu\nu}$$

Einstein's Field Equations for the Space-time Metric

Einstein's field equations for the space-time metric are not really fundamental, but are more like a thermodynamic equation of state that describes gravitational events in the observer's holographic world when things are near thermal equilibrium. Once we have Einstein's field equations, we can then deduce all the field equations for the standard model of particle physics using the usual unification mechanisms of supersymmetry and extra compactified dimensions of space. At the level of field theory, the final result of unification looks like 11-dimensional supergravity, just as it does in the AdS/CFT correspondence. All the quantum fields that correspond to particle physics arise from Einstein's field equations as extra components of the space-time metric due to supersymmetry and extra compactified dimensions of space. Just like Einstein's field equations, none of these quantum fields are really fundamental, but instead only have the limited validity of thermodynamic equations of state that describe events in the observer's holographic world when things are near thermal equilibrium.

The holographic principle is telling us that every observer observes events in its own holographic world from the central point of view of that world. Although those events appear to occur in three dimensional space and to be governed by the laws of physics as formulated in three dimensional space, in reality, the information for all those events

is reducible to qubits of information encoded on the observer's own event horizon, which is the two dimensional bounding surface of that space. The observer's event horizon arises due to its own accelerated motion and becomes its holographic screen when its horizon encodes qubits of information. Everything the observer can observe in its own holographic world is a form of information that's reducible to qubits of information encoded on its own holographic screen. Those forms of information are projected like images from the observer's screen to its own point of view at the center of its own holographic world. Even the flow of energy that animates the images can be understood in terms of the energy of the observer's own accelerated motion.

In the sense of the subject-object relation of perception, the observer is the subject and its object of perception is a form of information that is reducible to qubits of information encoded on its holographic screen. Perception only occurs as that form of information is projected like an image from the observer's screen to its central point of view. The observer not only perceives the form of things, but also the flow energy that animates things. There is only an illusion that the form of a person that appears in the observer's world is able to perceive things in that world. The form of a person is only the central form of information that appears in the observer's world, like the form of an avatar that appears in a computer-generated virtual reality world. In reality, there is no person, only the projected images of a virtual reality that appears due to the observer's own motion.

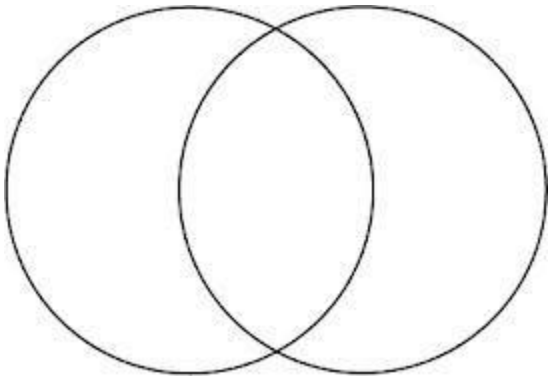
The illusion that the form of a person that appears in the observer's world is able to make local observations of things in that world is why the concept of local realism is not a valid concept. Observation is never really local in nature, but rather is global in nature as an observer makes observations of things in its own holographic world. The observer can only be understood as the central point of view of that world, and the observable form of all things are forms of information projected like images from the observer's own holographic screen to its central point of view. Perception is holographic projection.

There is only an illusion that the central form of a person that appears in the observer's holographic world is able to perceive things in that world. That illusion is created as the observer emotionally identifies itself with that emotionally animated central personal form. The central form of a person is always emotionally animated relative to all other forms that appear in the observer's holographic world. The observer only emotionally identifies itself with that emotionally animated personal form due to its perception of feelings of emotional self-limitation to that emotionally animated personal form as that personal form is emotionally animated relative to all other forms that appear in its world.

In no significant way is this state of affairs different from an observer's perception of the projected and animated images of a computer-generated virtual reality world that's being displayed on a computer screen. In effect, the observer itself creates its own quantum computer that gives rise to the appearance of its own computer-generated

holographic virtual reality world. The quantum computer is created due to the observer's own accelerated motion that gives rise to its event horizon that becomes its holographic screen when qubits of information are encoded on its horizon. The laws of physics for the observer's holographic world are the computational rules that govern the operation of the quantum computer. Even the energy that flows through the quantum computer can be understood as arising from the energy of the observer's own accelerated motion.

If every observer observes events in its own holographic world from the central point of view of that world as events are displayed on its own holographic screen, then how do we explain the nature of a consensual reality shared by many observers? The answer is information sharing. In effect, a computer network is created when holographic screens overlap like a Venn diagram and share information. Every observer is at the central point of view of its own holographic world, but those holographic worlds can share information when their respective holographic screens overlap and share information, which allows many observers to share in a consensual reality.

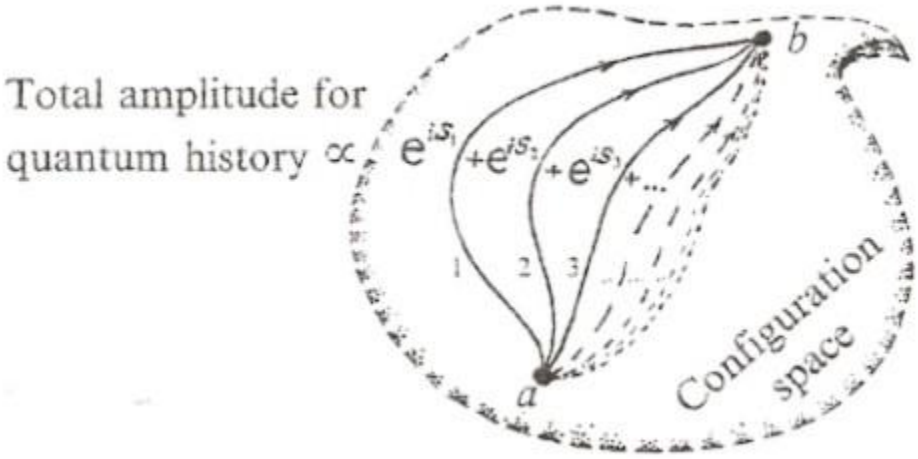


Information Sharing Among Overlapping Holographic Screens

The holographic principle is a way of reformulating quantum theory in terms of the observer. Instead of a wave-function that describes the behavior of point particles in some space-time geometry, the holographic principle reformulates quantum theory in terms of an accelerating observer and its event horizon that becomes its holographic screen when qubits of information are encoded on its horizon. Everything in the observer's holographic world, which not only includes all the point particles of that world, but also the space-time geometry of that world, can be reduced to qubits of information encoded on the screen. Everything is a form of information, and the perception of anything is like an image projected from the screen to the observer's own point of view. Even the perception of the flow of energy, which arises from the observer's own accelerated motion, can be understood in terms of the animation of the images.

In the ordinary quantum theory and quantum field theory of point particles, the quantum state can either be formulated in terms of a wave-function or as a sum over all possible

paths. Each path is weighted with a probability factor that depends on the action for that path, $P=\exp(iA/\hbar)$, where the action is given in terms of kinetic and potential energy as an integral along the path, $A=\int dt(KE-PE)$. This probability factor is the essence of the wave-function and specifies wave motion in terms of Euler's formula $\exp(i\theta)=\cos\theta+i\sin\theta$. The wave-function, $\psi(x,t)$, specifies the quantum probability with which a point particle can be measured at position x at time t as the particle follows its trajectory $x=x(t)$. The most likely path in terms of quantum probability, which is the classical path, is the path of least action, which is like the path that measures the shortest possible distance between two points in a curved space-time geometry. In relative theory, the analogue of the action is called the proper-time, and least action maximizes proper-time.



Quantum State as the Sum over all Possible Paths

Quantum theory, whether formulated in terms of the wave-function or as a sum over all possible paths, allows for the expression of potentiality. A path is never determined, but can only be specified in terms of its quantum probability. Classical physics only seems to be deterministic because it only considers the path of least action. At every decision point, there is always a choice to be made about which path to follow. The expression of potentiality is inherent in the choices we make about which path to follow.

The holographic principle totally reverses this process of quantization. Instead of a wave-function, we start with the idea of an accelerating observer and its event horizon, which becomes its holographic screen when qubits of information are encoded on the horizon. The expression of potentiality arises from quantum entanglement, which is a consequence of the way qubits are defined in terms of the eigenvalues of a matrix that in turn is defined on the surface of the event horizon. By their very nature, entangled qubits allow for the expression of potentiality, which is the essential difference between classical and quantum computing. Fundamentally, quantum theory is based upon the mathematical structure of qubits encoded on an accelerating observer's event horizon.

The wave-function is not fundamental, but is a derived concept that arises from the laws of thermodynamics when things are near thermal equilibrium. Einstein's field equations for the gravitational space-time metric, Maxwell's equations for the electromagnetic field, the Yang-Mills equations for the nuclear fields, and Dirac's equation for the electron and quark fields are all examples of wave-functions, but only have the limited validity of thermodynamic equations of state that describe events in a holographic world.

We have one last important question to answer, which is Gefter's original question: Where does the observer come from? There must be a source of the observer. If we think of the observer as the consciousness present at the central point of view of its own holographic world, then there must be a source of this perceiving consciousness. The really big question is what is the source of the observer's consciousness?

The reason this is a big question is because the perceiving consciousness of the observer cannot arise from something that appears in the holographic world that the observer perceives, like the central form of a person that appears in that world. The source of consciousness cannot be an object in consciousness. Perception always occurs in a subject-object relation, where the observer is the subject and its object of perception is a form of information that appears in its holographic world. That object of perception cannot be the source of the observer's consciousness. To make that assumption would be to create a paradox of self-reference that would make the whole explanation logically inconsistent. Logical consistency of the explanation demands that the observer's consciousness cannot arise from something that it can observe.

The basic problem is that consciousness cannot be computational in nature as Roger Penrose has pointed out. In a holographic world, everything the observer can observe is a form of information that's reducible to qubits of information encoded on the observer's holographic screen. All observable forms of information are computational since they can be reduced to qubits of information encoded on the observer's screen, but the observer's consciousness cannot be computational since it is what perceives the forms of information. The forms must be projected like images from the observer's holographic screen to its point of view outside the screen. Since the observer's consciousness exists outside the screen, it cannot be reduced to qubits of information encoded on the screen without creating a logically inconsistent paradox of self-reference. This is the basic idea underlying the Godel incompleteness theorems. An observer that observes forms of information that are being displayed on a computer screen from its point of view outside the screen cannot be reduced to bits of information encoded on the computer screen, and so the observer's consciousness cannot be computational in nature. The forms of information are all computational in nature, but not the observer's consciousness.

If the source of consciousness cannot arise from something that the observer can perceive in a subject-object relation of perception, then where does the observer's

consciousness come from? If the source of consciousness cannot arise from an object of perception, then where does the observer's consciousness come from? This is the stumbling block that has prevented all real progress in terms of understanding the holographic principle. This is a stumbling block since we have to begin by assuming the *a priori* existence of a source for the observer's consciousness before we can discuss how its holographic world appears to come into existence. That source of the observer's consciousness must exist prior to the apparent existence of its holographic world.

This problem arises from how a holographic world is created. A holographic world only appears to come into existence due to an observer's accelerated motion that gives rise to its event horizon that becomes its holographic screen when qubits of information are encoded on its horizon. The observer itself can only be understood as the perceiving consciousness present at the central point of view of its own holographic world that is able to undergo accelerated motion, which gives rise to its event horizon. To make sense of this scenario, we have to begin with the assumption of the existence of a source for the observer's consciousness. There must be a source of the observer's perceiving consciousness that has an *a priori* existence that exists prior to the apparent existence of its holographic world. Before the observer's holographic world can appear to come into existence, the source of the observer's consciousness must exist.

This is a stumbling block to any real understanding of the holographic principle because the assumption of the *a priori* existence of a source of the observer's consciousness smacks of spiritualism, which is exactly what it is. Virtually everybody that works in the scientific field of the holographic principle is a physicalist, and the idea of a spiritual reality that is beyond physical reality is anathema to the physicalists. Lenny Susskind, Tom Banks and Amanda Gefter are all physicalists, and they all vehemently deny the existence of a spiritual reality that is beyond physical reality. The big problem that they face is that they also accept that physical reality is constructed as a holographic world.

Once you accept that physical reality is constructed as a holographic world, you're in a real pickle when you try to understand the nature of consciousness. The source of consciousness cannot be an object in consciousness. In the sense of a subject-object relation of perception, the source of the observer's perceiving consciousness cannot be an object of perception that appears in its own holographic world, which is understood as a form of information that's reducible to qubits of information encoded on its own holographic screen that arises as an event horizon due to its own accelerated motion as a point of consciousness at the center of its own holographic world. Where does that consciousness come from? It's fine to say that the subject-object relation of perception arises as a self-excited circuit, but we still have to explain the source of consciousness.

The physicalists will never really understand the holographic principle because they deny the existence of a spiritual reality beyond physical reality. That spiritual reality is

the only possible source of consciousness. There is no other possible explanation for the source of consciousness. All other possible explanations suffer from the logical inconsistency of a paradox of self-reference. If we want to maintain logical consistency, we have to assume the existence of a source of consciousness that is beyond physical reality, which is best called spiritual reality. In the words of Sherlock Holmes, when you've eliminated everything that is impossible, whatever remains must be the truth.

What exactly is this spiritual reality beyond physical reality that is the source of the observer's consciousness? The simple answer is that this spiritual reality is the primordial nature of existence. It is what exists when everything else disappears from existence. The observer's holographic world can only disappear from existence when the observer stops accelerating. When the observer's accelerated motion comes to an end, the observer enters into an ultimate state of free-fall. When the observer enters into an ultimate state of free-fall, the observer no longer has an event horizon that encodes qubits of information and becomes its holographic screen. In an ultimate state of free-fall, everything in the observer's holographic world disappears from existence from its own point of view, and nothing remains.

Nothingness

The nothingness that remains when the observer's holographic world disappears from existence is called the void. The void is the source of the observer's consciousness, which is a differentiated state of consciousness that arises at the central point of view of its own holographic world. That holographic world only appears to come into existence from the observer's own point of view due to the observer's own accelerated motion relative to the motionless void. The existence of the void is timeless and unchanging, which is to say it is motionless. The void is unlimited. It has no boundary. The bounding surface of an event horizon can only arise from the point of view of an accelerating observer. The void is also undivided. As the source of the observer's perceiving consciousness, the void can only be understood as undifferentiated consciousness.

In reality, the void cannot be conceptualized except in terms of negation as absolute nothingness, which is unlimited, undivided and unchanging. Only a holographic world that is characterized by limitation, division and change can ever be conceptualized. That conceptualization is the very nature of a holographic world, which is characterized by forms of information and the flow of energy. As absolute nothingness, the void is formless. As absolute nothingness, the void is timeless and motionless. The course of time, like the flow of energy, only appears to exist in an observer's holographic world due to the observer's own accelerated motion relative to the motionless void that gives rise to its event horizon that becomes its holographic screen when qubits of information are encoded on its horizon. In the absolute nothingness of the void, there are no events and nothing ever appears to happen. There is only absolute nothingness.

The void is the primordial, timeless nature of existence. The course of time, like the flow of energy, only appears to exist in an observer's holographic world. Forms of information only appear to exist in an observer's holographic world. The void, as the source of the observer's perceiving consciousness, is the nature of timeless being, which can only be understood as undifferentiated consciousness. The individual consciousness of the observer, present at the central point of view of its own holographic world, is the nature of individual being, which is called *I Am* or the *Self*. As absolute nothingness, the void is the nature of undivided and unlimited timeless being, which is also called *No-self*.

In some mysterious way, the individual consciousness of the observer, present at its own point of view, must separate itself from the undifferentiated consciousness of the void before its holographic world can appear to come into existence. Individual consciousness only refers to the observer's individual point of view. The observer's holographic world only appears to come into existence from its own point of view when the observer begins to undergo accelerated motion relative to the motionless void, which is how its event horizon arises that becomes its holographic screen when qubits of information are encoded on its horizon. When the observer's accelerated motion comes to an end in an ultimate state of free-fall, its holographic world disappears from existence from its own point of view, and only the void remains. In the sense of a dissolution, the individual consciousness of the observer, present at its own point of view at the center of its own holographic world, dissolves back into the nothingness of the undifferentiated consciousness of the void like a drop of water that dissolves back into the ocean. Individual being dissolves back into its source of pure undivided being. This experience of dissolution is called spiritual enlightenment.

There are still a few loose ends that need to be tied together regarding the holographic principle. Just as the undifferentiated consciousness of the void is the source of the individual perceiving consciousness of the observer present at the central point of view of its own holographic world, the void is also the source of the energy that underlies the observer's accelerated motion that gives rise to its event horizon, and the source of the

information encoded on the observer's event horizon that becomes its holographic screen. The void as the source of all these things helps clear up the mystery of the normal flow of thermal energy through the observer's holographic world, which is closely related to the mystery of the cosmological constant and the big bang.

The best theory we have of the big bang is called inflationary cosmology, which assumes that early in the history of the universe the cosmological constant transitions from a higher to a lower value. The value of the cosmological constant sets the size of the observer's holographic world in terms of the radius of its cosmic horizon due to the accelerated expansion of space. The cosmic horizon defines the limits of the observer's own observable world since nothing is observable beyond the limits of its horizon. The larger the value of the cosmological constant, Λ, the smaller the radius, R, of the observer's cosmic horizon, as $(R/\ell)^2=3/\Lambda$. Current observation indicates the value of Λ is about 10^{-123}, which corresponds to a radius of the cosmic horizon of about 40 billion light years. In terms of thermal energy, the smaller the radius of the observer's cosmic horizon, the higher its Unruh temperature, as $kT=\hbar c/2\pi R$.

Early In the history of the big bang, the cosmological constant took on a very high value corresponding to a small radius of the observer's cosmic horizon and a high Unruh temperature. Inflationary cosmology assumes that the cosmological constant transitions from a higher to a lower value, which increases the radius to the observer's cosmic horizon and lowers its Unruh temperature. By this mechanism, the observer's holographic world appears to increase in size. Simultaneously, this allows heat to flow from hotter to colder objects as the Unruh temperature decreases, which explains the normal flow of thermal energy through the observer's holographic world. The normal flow of thermal energy is literally directed in the direction of the accelerated expansion of space as the cosmological constant transitions to a lower value and the observer's holographic world increases in size and cools in temperature.

This expansion also allows entropy to increase as the observer's cosmic horizon increases in radius and surface area, which allows more qubits of information to be encoded on the horizon. This increase in entropy as heat flows in a thermal gradient is the nature of the second law of thermodynamics, which says that forms of information tend to become more disordered due to the randomizing effects of the flow of thermal energy as heat flows from hotter to colder objects. The disorganizing effects of thermal disorder are always counterbalanced by the organizing effects of coherent organization as forms hold together, but eventually thermal disorganization wins out and forms fall apart. The flow of heat in a thermal gradient also explains the nature of *time's arrow* as things tend to become more thermally disordered. *Time's arrow* is literally directed in the direction of the accelerated expansion of space and the expansion of the observer's holographic world. When the cosmological constant transitions to its final value of zero, the radius of the observer's cosmic horizon increases to infinity and its Unruh

temperature cools to absolute zero. When the flow of heat ultimately comes to an end, the course of time also comes to an end, which is called the *heat death* of the universe.

Normal Flow of Thermal Energy through the Observer's Holographic World

There is a big puzzle in this scenario that does not have a scientific explanation. How exactly is the value of the cosmological constant set and what allows for its transition to a lower value? In terms of the holographic principle, there is no scientific answer. In some sense, the value of the cosmological constant is a boundary condition that sets the conditions for the construction of a holographic world. Inflationary cosmology is based on quantum field theory, but quantum field theory cannot explain the nature of the cosmological constant since all field theories only arise in a holographic world as thermodynamic equations of state that only describe events in that world when things are near thermal equilibrium. We have to assume a value for the cosmological constant before we can even construct that holographic world and discuss the laws of physics in that world as formulated in terms of field theories.

In the same way, there is no scientific explanation in terms of the holographic principle for why the cosmological constant transitions to a lower value. Each transition of the cosmological constant would in effect create a new big bang event, which occurs when the universe is far away from thermal equilibrium, and unlike the Unruh temperature, which assumes thermal equilibrium, cannot be calculated in quantum field theory, which is only valid for small fluctuations around thermal equilibrium. Theoretical physics can never explain the value of the cosmological constant or why it transitions to a lower value in terms of the holographic principle since we have to assume a value for the cosmological constant before we can construct a holographic world. In the sense of a boundary condition, the cosmological constant is what sets the radius of the observer's cosmic horizon, which is the bounding surface of space that sets the limits of the observer's own observable holographic world.

Just as the undifferentiated consciousness of the void in some mysterious way is the source of the individual consciousness of the observer at the central point of view of its own holographic world, the void is also the source of the dark energy that's inherent in the cosmological constant, which must take on a non-zero value before the observer's holographic world can even appear to come into existence. The dark energy of the cosmological constant is ultimately what energizes the observer's own holographic world and puts the *bang* in the big bang event. The dark energy of the cosmological constant is also what gives rise to the observer's cosmic horizon that becomes its holographic screen when qubits of information are encoded on the horizon. The void is also the source of this information encoding. In some mysterious way, the whole thing begins as the undifferentiated consciousness of the void differentiates itself into the individual consciousness of the observer at the central point of view of its own holographic world, expresses the dark energy that underlies the accelerated expansion of space that places the observer in an accelerated frame of reference and gives rise to the observer's cosmic horizon, and encodes qubits of information on the observer's cosmic horizon that becomes its holographic screen. It all has to begin with the void. The void is the source of the whole thing. The void is the nature of the spiritual reality that is beyond the physical reality of an observer's holographic world. There is no scientific explanation for the creation of the whole thing other than to call it God's will.

Ultimately, the individual consciousness of the observer must return to its primordial state of undifferentiated consciousness. Individual being must reunite itself with pure undivided being. Individual consciousness, present at the central point of view of its own holographic world, must dissolve back into its source of undifferentiated consciousness like a drop of water that dissolves into the ocean. This dissolution always occurs in an ultimate state of free-fall as the accelerated motion of the observer's own point of view relative to the motionless void comes to an end. In that dissolution, the course of time and the flow of energy come to an end. In that dissolution, the observer's holographic world disappears from existence from its own point of view and nothing remains. That nothingness is the nature of timeless being, which is the primordial nature of existence.

Footnote on String Theory

Why isn't string theory a fundamental description of reality? The answer is string theory is computational, and can only apply to the computational construction of a holographic world. String theory, like field theory, only applies at the level of a holographic world. String theory is closely related to field theory, which is seen in a 10-dimensional supersymmetric SU(N) gauge theory generating string theory in the large N limit, and in the low energy limit of string theory being 11-dimensional supergravity. This connection explains why string theory is holographic. String theory, like field theory, only gives the computational rules that govern events in a holographic world. That computation arises from qubits of information encoded on a holographic screen, which arises as an observer's event horizon due to its own accelerated motion. When that acceleration comes to an end in an ultimate state of free-fall, all computation also comes to an end, and only the void remains. String theory, like field theory, cannot apply in the ultimate reality of the void that is beyond the computational virtual reality of a holographic world. The simple answer is that computation does not apply to the void. The void as the source of a computational holographic virtual reality world is beyond computation.

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