A Complex Conjugate Bit and It

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Abstract: *We are perceptually contained in a virtual world projected by our brain. The problem is that a solely epistemological world invalidates all classical notions of reality as the basis of knowledge. If there is an ontological component underlying being, how can we determine whether or not it exists? I propose that the entropies from contracting and expanding space have to be considering on different terms. The "it" and "bit" are actually reciprocal entities that together generate the phenomenal universe.*

> "We have learned that we do not see directly, but mediately, and that we have no means of correcting these colored and distorting lenses which we are, or of computing the amount of their error. Perhaps these subject-lenses have a creative power, perhaps there are no objects."
>
> – Ralph Waldo Emerson[1]

1. The Bubble of Perception

> "It from bit. Otherwise put, every 'it'—every particle, every field of force, even the spacetime continuum itself—derives its function, its meaning, its very existence entirely—even if in some contexts indirectly—from the apparatus-elicited answers to yes-or-no questions, binary choices, bits."
>
> — John Wheeler[2]

Wheeler's idea—that the world is made up of information—is very much reflected the way we experience reality.

Information: "(In its most restricted technical sense) a sequence of symbols that can be interpreted as a message. (From Latin, verb *'informare*' (to inform) in the sense of 'to give form to the mind')." (*Wikipedia*)

The purpose of our brain is to coordinate our movement in the world[3]. From perceptual input, our brain gives us a sense of position and movement (the cerebellum), a sense of orientation in space (the pons), and a memory of location (the hippocampus). Thus, an internal representation of the world—the form given to the mind—is built up and mapped onto the cortex.[4]

Consciousness: "A notion of self in space[5]." "(From Latin *conscius* 'knowing with others or in oneself')". (*Oxford Dictionary*)

The temporoparietal junction in the brain gives us the sense of owning and being in a body—our self consciousness[6]. The richness of our conscious experience depends upon the amount of neural connectivity in our brain, which wires us into a single, integrated entity[7].

Information is contextual. The brain converts sensory data into symbols, such lines, edges and shapes, then weaves them together into meaningful patterns. Without context, and without a relative observer to provide such context, notions such as space and time collapse into incoherence.

Our conscious experience of the world is time-delayed, however. Impulses travelling down the optic nerve to the brain take several hundred milliseconds, and movement initiated in the supplementary motor area may take up to several seconds before it comes to our attention[8]. Events often happen so quickly that the brain cannot process and respond fast enough to be effective in real time. As a consequence, the brain must make predictions about what is to happen and update them on-the-fly.

What we consciously perceive, then, is an after the fact, probabilistic simulation of the world. This includes the self that does the projecting—a transient, self-referential loop[9] between internal brain states and external sensory data. We each live in a bubble of perception and see ourself reflected on its inner walls.

The world of classical physics is considered to be ontological—existing prior to and independent from our knowledge of it. Yet, our world view appears epistemological in nature: in quantum measurements, we bring the world into being through our observation of it[10]. The question then, is how can we, as illusory projections within an illusion, comprehend the basic nature of reality—discern the bit from the it?

2. The Phase Dimension

Besides context, information is dependent upon scale. This is obvious in thermodynamics when temperature emerges from coarse graining the kinetic energy of microscopic particles.

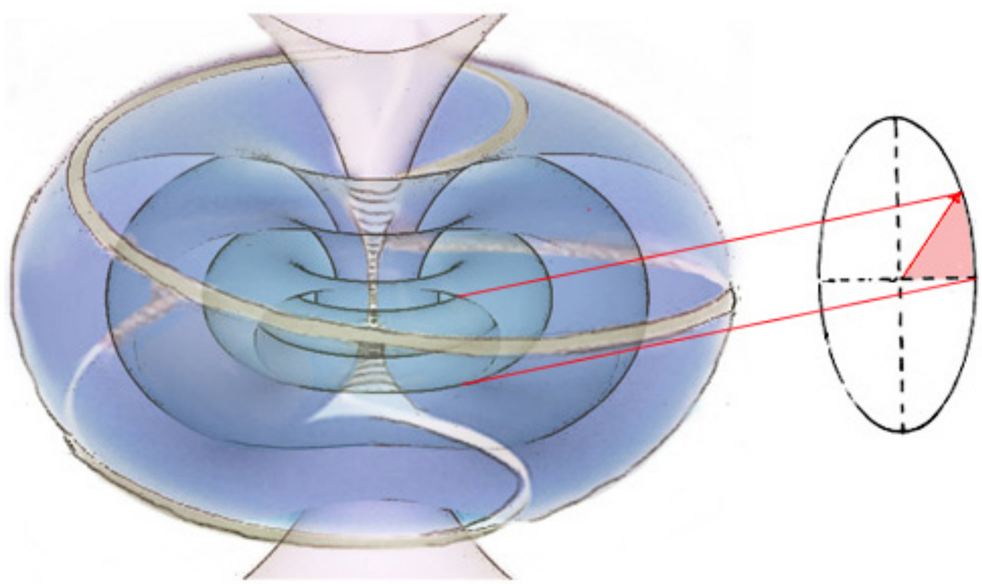
Sir Arthur Eddington introduced the idea of the phase dimension, which measures the scale between an elementary particle and the observable universe as quantum uncertainty[11]. The phase dimension is a 2D complex space with the phase coordinate normal to 3D flat spacetime. (5-D is the geometry of curved spacetime.) Topologically, this is a hypersphere (the "Einstein universe"), which is the same as a torus (donut-shape, $2\pi^2R^3$) with an infinitely small hole. According to this model, the topology of an elementary particle and the universe is the same.

According to Heisenberg's Uncertainty Principle, position (*x*) and momentum (*p*) of the Cartesian coordinate system are reciprocal vectors with a related standard deviation of:

$$\boldsymbol{\delta_x \, \delta_p \geq \hbar/2}$$

where $\hbar$, the reduced Planck constant, represents the internal angular momentum as the spin 1/2 value for an elementary particle such as a proton.

The phase dimension measures the scale of *p* as angular momentum on the complex plane, with the corresponding phase coordinate as an angle. The smaller the angle, the greater the resolving power of the Heisenberg microscope to define *x*. As the angle widens counterclockwise from 0 degrees to 2π, the 5D component diminishes to the limit of uncertainty and becomes flat Euclidean 4-space. The probability distribution for *x* becomes increasingly blurred—uniform and uncertain. Essentially, the scale factor plays the role of time in an expanding universe with a decreasing energy density.



Hypersphere with scale indicated by phase dimension

At the maximum angle, the scale corresponds to the size of the observable universe, **U**. The ratio between the volume of the universe V_u: 3.5 ×10^{80} m^3 and the volume of a proton v_p: 2.5 x 10^{-45} m^3 gives *N*, the number of yes/no locations that a proton could occupy—the entropy for *x*:

$$\boldsymbol{N = V_u/v_p = 1.4 \times 10^{125}} \,.$$

The reciprocal entropy for *p* at this scale is $\mathbf{10^{-125}}$. This value, within the bounds of error, is equivalent to the cosmological constant Λ, which uses area to measure the energy density of empty space.

Λ is calculated using the Shannon formula (***S*** = *k* ln2 where *k* = the Boltzmann constant), which converts thermal radiation into bits of information. (The phase dimension can be scaled logarithmically for this purpose.) According to the Bekenstein bound, the Shannon entropy of the 3D interior of a black hole is encoded on its 2D event horizon as Planck-size bits. Applied to the horizon volume of the expanding universe:

$$\mathbf{\Lambda = (R_u/l_p)^{1/2} = 10^{-123}}$$

where the radius of the observable universe R_u: 4.4 x 10^{26} m and the Planck length l_p: 1.616 x 10^{-35} m. This means that the energy density of the vacuum is extremely low—10^{-47} GeV^4 or or 10^{-29} g/cm^3. Empty space is very still and cold. (The Cosmic Microwave Background from the Big Bang contributes only 2.7° K.)

The inverse value of Λ, $\mathbf{10^{123}}$, gives the total number of bits encoded on the de Sitter horizon, which is the maximum bound for information processing in the universe[12].

3. The Screen

In quantum theory, particles are discrete excited states that arise out of the resonant superposition of waveforms in a continuous field. The action principle $\mathcal{S} = Ht$ *(w*here H is the Hamiltonian energy of the system) determines what path a particle can traverse in the least time. The *total* contribution from all possible paths reaching *x*, *t* from the past is the wave function $\psi(x, t)$.[13]

Using the polar form of the Schrödinger equation:

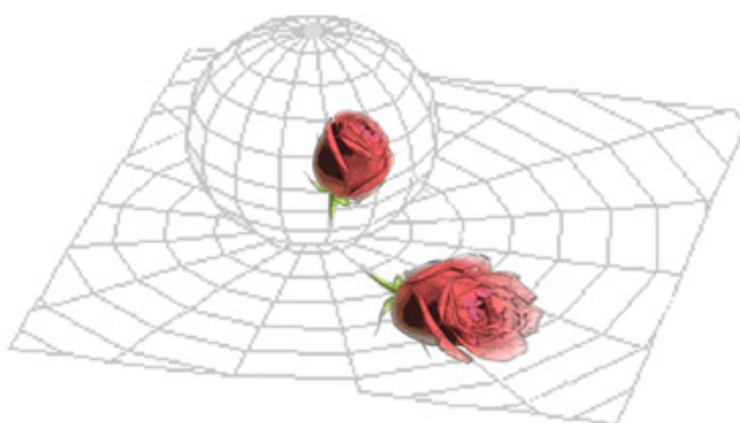
$$\psi = Re^{iS/\hbar}$$

- *R* is the amplitude.
- $\mathcal{S}/\hbar$ for each path is the phase ⟲ ($\partial R/\partial t$), the imaginary part of ψ.
- The energy vector for each path → ($\partial\mathcal{S}/\partial t$) is the real part of ψ. (The rate that $\mathcal{S}$ changes determines the frequency, ν, and therefore the energy of the waveform, $2\pi\hbar\nu$.)

According to the Copenhagen convention, all contributing paths remain in a superposition until a measurement is made. The probability for each path is $|\psi|^2$ and $\mathcal{S}$ is the scale of ψ in the phase dimension. The actual path taken by the particle is the one in which all the phases constructively interfere (the Feynman path integral). Since the action is stationary, the entropy of ψ is zero.

A photon, which carries $\mathcal{S}$, is essentially 2 dimensional. It does not have an oscillating longitudinal axis along its direction of motion[14] (corresponding to a 3rd dimension) and there is zero time at the speed of light. To a hypothetical massless passenger, a photon is instantaneously everywhere. A 2D light front, however, can encode spacetime information, based on the holographic principle associated with the Bekenstein bound (above).

The 2D information surface, called a screen, carries a sum of entropies[14], which can be recorded as an interference pattern. Each photon makes a contribution depending upon its action $\mathcal{S}$. The light front conveys wave information about the non-uniform distribution of matter in different locales at various times. Depending on its frequency, a reference beam, diffracted by the recorded interference pattern, will project a holographic image of the light front history.



The complex plane and the Riemann sphere

Relativistic effects can also be explained from a 2D perspective. As we gaze out into space, we also look back in time. This position/time (***^{x}t***) space can be modelled as a celestial (Riemann) 2-sphere stereographically projected from a 2D complex plane. The restricted Lorentz group preserves the orientation of space and direction of time and acts on the tangent vector space to ***^{x}t*** space[15]. If we move at a relativistic velocity, the 2D coordinates compactify (Möbius transformation), which we view as a Lorentz transformation of the celestial sphere[16]. Of course, from our real world point of view, we are inside the celestial sphere.

According to Brian Greene, the screen is "where the fundamental physical processes actually happen"[17]. If our classical world view is epistemic, does the screen provide an ontic basis for reality or must we look deeper? First of all, we will examine how using the phase dimension scale relates to spacetime dynamics; and secondly, how the paths in light front histories are laid down.

4. Complex Conjugate Space—^{x}t ⟲ ^{p}e

Coordinates and momenta (*x*, *p*) can only be defined consistently in a classical topological background[18]. Momentum (*p*) is a derivative property of *x*, calculated locally and projected as a vector into the immediate future. Because certain properties of a particle—such as mass and charge—are fixed, *p* (as *mv*) is also scale-fixed.

On the other hand, energy can be measured as a density varying in volume, and thus, is scale free. Energy along with time, as action (***et***), varies with a change in scale of the phase dimension. The passing of time corresponds to widening the phase angle and increasing energy density to narrowing the phase angle.

The Lorentz group places the momentum (*p*) and energy (*e*) coordinates of a particle on equal footing as momentum/energy (***^{p}e***) space. A transformation on ***^{x}t*** space induces the same transformation in ***^{p}e*** space[19]. Just as the cosmological constant, Λ, constitutes *maximum* ***^{x}t*** entropy, compactification of 3D ***^{x}t*** space into a 1D singularity represents *minimum* ***^{x}t*** entropy.

Conversely, ***^{p}e*** entropy increases with the compactification of ***^{x}t*** space, reaching maximum density at the Planck scale, $l_p = (G\hbar/c^3)^{1/2}$, where *c* is the speed of light in a vacuum and *G* is the gravitational constant. At l_p, the energy density is 10^{94} g/cm^3, which is approximately 10^{120} times higher that that of Λ (as we can expect from the scale differential).

The Einstein field equations describe gravity as the curvature of spacetime by matter and energy:

$$G_{\mu\upsilon} + g_{\mu\upsilon}\Lambda = (8\pi G/c^4)\, T_{\mu\upsilon}$$

$G_{\mu\upsilon} + g_{\mu\upsilon}\Lambda$ is the Einstein curvature tensor (***^{x}t***), and $T_{\mu\upsilon}$ is the stress-energy tensor (***^{p}e***), which represents the energy due to matter and electromagnetic fields. The equation states that the total entropy of the gravitational (potential) energy of compactification and the kinetic energy of expansion should not decrease. In other words, ***^{x}t*** space and ***^{p}e*** space are approximately balanced in the self-equilibrium of the "Einstein universe" hypersphere.

^{x}t space and ***^{p}e*** space are Fourier conjugates and can be transformed into each other:

$$(i\mathbf{r},\ ct) \longleftrightarrow (i\boldsymbol{\mu}/\hbar,\ E/c\hbar), \qquad [^{x}t \circlearrowleft {}^{p}e]$$ [20]

where **r** is a coordinate and **μ** is momentum. Thus, ***^{x}t*** and ***^{p}e*** form a complex conjugate, which extends the Heisenberg uncertainty principle into the action principle, ***S***, in 5-space geometry.

5. A Bounded Wholeness

"In classical mechanics, the principle of least action can be formulated by the Lagrangian, $\mathcal{L}$:

$$\mathcal{L} = T - V$$

where *T* is the kinetic energy of a system, determined by velocity; and *V* is its potential energy, determined by position. Lagrange's method is to choose a start point and stop point, then calculate—at each instant—all the paths between them. The shortest path is the one in which the action is minimized: $\mathcal{L} = 0$. These results are then mapped back onto x_t space. From the Lagrange point of view, x_t degrees of freedom are regarded as fundamental, and p_e degrees merely as derived quantities.

The key to the Lagrangian is that all the probabilities are bound in time since probabilities can only be assigned to entire paths or histories. These boundaries effectively constrain how paths emerge from p_e space, like resonant wave patterns in a cavity[21].

In the case of x_t space, the stop point boundary is on the Cosmic Event Horizon, and the start point is the Big Bang. Any path is measured to the extent that it is correlated with the boundary conditions at the Big Bang. Because General Relativity is “local” (the speed of information transfer is limited by *c*), a measurement is specific to a place and moment in time, causally unconnected to a distant region of x_t space outside the local light cone.

The Lagrangian can also be derived from the Feynman path integral (from ψ). Because quantum measurements are only instantaneous values, however, there is no way to determine whether a particular measurement will lead back to correlations with the Big Bang. The solution is to consider all of x_t space, and by extension all of $x_t \circlearrowleft p_e$, as one coherent structure in which all the path computations are run at once.

Wheeler and Feynman, in their time symmetric theory[22], theorized that no particle is emitted unless it is absorbed somewhere later in the universe. All electromagnetic field equations are invariant under time-reversal symmetry. Consequently, a wave can be considered going both forward in time from the point of emission (retarded wave) and backward in time from the point of absorption (its conjugate advanced wave). The two-way path is the sum of the amplitudes. In the Wheeler–DeWitt (WDW) equation:

$$\hat{H}_{\text{tot}}\Psi = 0$$

where $\hat{H}_{\text{tot}}$ is the full Hamilton operator for gravity plus matter (p_e entropy), and the wave function Ψ depends on the 3D metric plus all non-gravitational fields (x_t entropy) for the entire universe[23]. Everything exists as a single moment in time, like one gigantic stationary molecule[24].

The iterative process of the Lagrangian is best realized in Cramer's transactional interpretation. In TI, advanced "offer" waves and retarded "confirmation" waves "handshake" with each other and stitch a fractal-like surface back and forth between past and future. This freezes all probabilities into a unique present, which Cramer describes as "the progressive formation of frost crystals on a cold windowpane"[25].

Another way to think about the process is the way ants gather food. Each foraging ant (the offer) performs a random walk and lays down a scent trail as it goes. If the ant successfully locates food (the confirmation), it traverses back along the trail, strengthening the scent. This attracts other ants, which in turn reinforce the scent trail until, eventually, there is a highway that persists as long as the food lasts. Our subjectively experience is like that of an ant. However, from a WDW God's eye perspective, all instances form a continuum. Like a refracted image in a block crystal, what ant paths you see (YES 3 geometries[26]) depends upon your viewing angle.

x_t space, then, can be viewed as a network in which the nodes act are local attractors, turning p_e waves into x_t discrete information. The screen, which encodes p_e waves as an interference pattern, is essentially a spacetime slice across the network. If the probabilities generated in TI are only bounded locally, differently bounded transactions will compete and destructively interfere with path formation. The result would be chaos. The solution is the "big-space" approach in which absolute probabilities are defined for all possible states and settings[27].

This idea of an underlying quantum wholeness is embodied in the Aharonov–Bohm effect[28]. The energy vector of the wave function ψ is determined non-locally when a charged particle, such as an electron, is isolated in a region where the electromagnetic field is negligible. When the field's magnetic potential energy changes, it shifts the phase in the electron's wave function ($\partial S/\partial t$). This alters the electron's momentum and, consequently, its path.

The process that selects the x_t information encoded in p_e waves is measurement. A recent experiment[29] showed that the measured spin state of an atom is correlated with the direction of the path of an emitted photon. Conversely, adjusting the orientation of the observed photon's polarization at the stop point alters the spin states of the atom at the start point, supposedly "after' the photon was emitted.

Suppose an observer knows the complete wavefunction $|\psi\rangle$ at time t_0 (preselected subensemble), and the spectrum of all possible paths at all times (the Hamiltonian). A measurement at t_1 (postselected subensemble) will yield new information. The probabilities estimated for an intermediate measurement at t will differ, however, depending on whether or not a measurement is made at t_1. Thus, the intermediate results depend on both what happens earlier at t_0, and what happens later at t_1. A measurement can be considered a haphazard collection of pre- and postselected sub-ensembles in which the observer discards the results at t_1, thus losing information[30].

According the Stephen Hawking, "we create history by our observation rather than history creating us"[31]. How we create this knowledge by discarding quantum information is the subject of our next section.

6. Knowledge Creation

> "For all is but a woven web of guesses."[32]
> ~ Xenophanes

Dissipative system: "Characterized by the spontaneous appearance of symmetry breaking (anisotropy) and the formation of complex, sometimes chaotic, structures where interacting particles exhibit long range correlations." (*Wikipedia*)

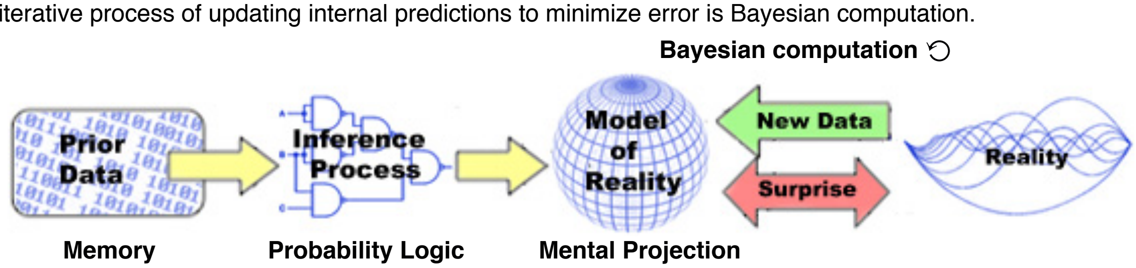
Although quantum wholeness may be conceivable from a God's eye view, in our subjective experience we live on the cusp of a yet-to-be-formed future. In addition, the x_t ⟲ p_e universe is not simply a network of crystallized pathways strung out across flat x_t space. It is a multiply-connected complex of dissipative systems that break the entropic symmetry of x_t space on all scales. From atoms to the stars to superclusters of galaxies; and here on earth, from organic molecules, to the cells in our body, to the biosphere—all reciprocally generate each other.

In this way, systems far from thermodynamic equilibrium can emerge as least action configurations. Computationally, the decrease in x_t entropy—the number of possible logical states (bits)—is offset by a corresponding increase in p_e entropy—the number of physical states (as heat). According to Landauer's principle, to erase N bits of information at least kTN energy should be consumed, generating kN entropy. Note that while any dissipative system constitutes a measurement-like process, only cognitive systems can generate knowledge.

- *Homeostasis*: "the tendency toward a relatively stable equilibrium between interdependent elements" (from Greek *homoios* 'like' + *-stasis 'stoppage'*)." (*Oxford Dictionary*)

Our brain is an expectancy machine[33]. In order to maintain equilibrium with their environment, self-organizing systems, such as ourselves, must minimise their free-energy[34], or "surprise". The neuronal network acts as a cybernetic control system between sensory input and our mental model of the world, which is inferred from compressed x_t information (more entropy per bit) in our memory. Mostly, we operate in a default mode of wakeful rest. However, if a novel stimulus—like a sudden, unexpected movement—perturbs the nervous system, recursive feedback allows our body to make the appropriate motor response. Old memories are altered and new memories are overlaid in order to maintain a consistent model of reality.

The iterative process of updating internal predictions to minimize error is Bayesian computation.



A knowledge generation mechanism[35]

To minimize error is to reduce p_e entropy as the source of uncertainty. In order to understand this better, we can look at the trade-off between entropy and information entanglement in simple pairs of two state systems.

Conditional entropy: ***S*(*A*|*B*)** is the *knowledge* that can be inferred from ***B*** about ***A***. If complete knowledge of ***B***'s state provides complete knowledge ***A***'s state, the conditional entropy is zero. The formula for calculating the conditional entropy of state ***A*** is:

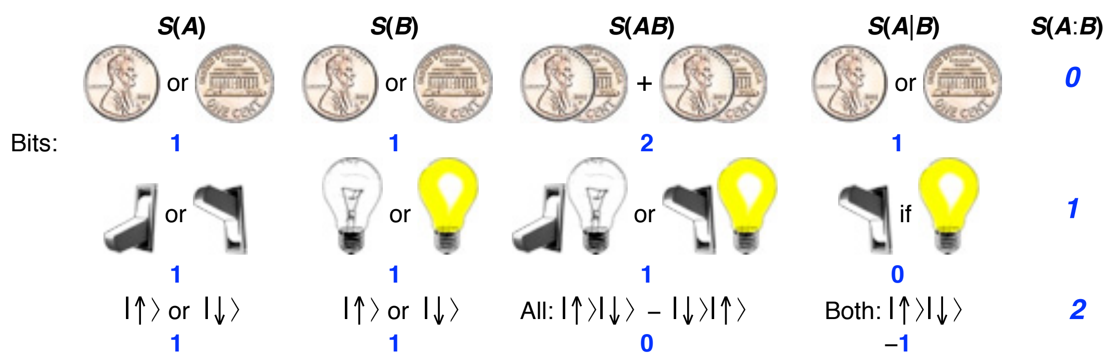
$$S(A|B) = S(AB) - S(B)$$

where ***S*(*AB*)** is the joint, or total, entropy of the system.

Correlation entropy: ***S*(*A*:*B*)** is a measure of how much information about the state of system ***A*** is contained in the state of system ***B***—the total that can possibly be known:

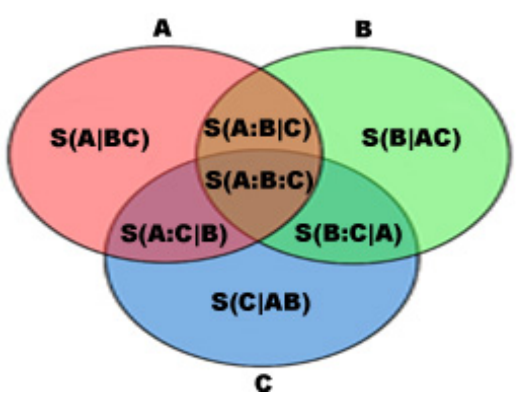
$$S(A{:}B) = S(AB) - S(A|B) - S(B|A) .$$

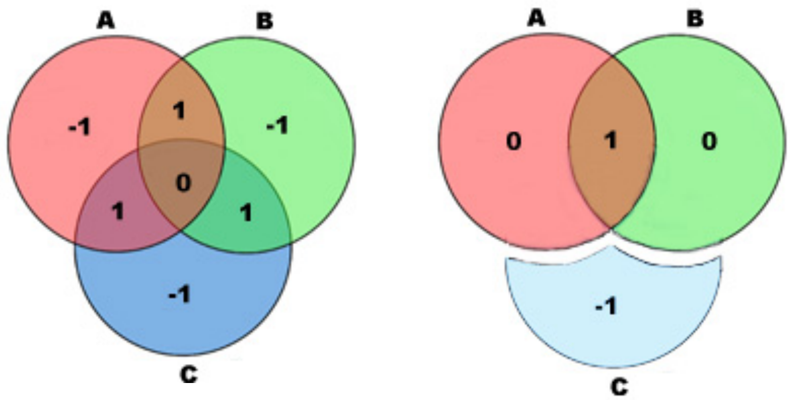
In quantum mechanics, the Shannon formula applies to density matrices rather than classical probability distributions. Correlation entropy is thus a measure of quantum entanglement. For a large number of particles in which the spin states are non-aligned, the density matrix cannot be known with certainty. Such a system is a mixture of correlated and uncorrelated states, neither fully quantum nor classical.



For a quantum entangled system (EPR state), paired particles (i.e., electron ***A*** and electron ***B***) each individually can be either spin state $|\uparrow\rangle$ or spin state $|\downarrow\rangle$, so ***S*(*A*)** = 1 and ***S*(*B*)** = 1. As a qubit, however, ***A*** and ***B*** share opposite spin states. The system is simultaneously in all possible combinations of spin states— $\psi = {}^{1}/\sqrt{2}\,(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle)$— and there is no randomness in the system, so ***S*(*AB*)** = 0. Applying the formula, ***S*(*A*|*B*)** = –1. The spin state of ***A*** , whether $|\uparrow\rangle$ or $|\downarrow\rangle$, can be known with complete certainty by the state of ***B***. Negative information is potential future communication gained[36].

Preparing and measuring the EPR state necessitates a third subsystem ***C***, the observer, who is also entangled (along with all her measuring equipment and everything else) with ***AB***. Fortunately, the result can be generalized to any number of mutually entangled particles[37].





(a) (b)

Entropy diagrams for a system of three mutually entangled particles[38]

a) 'EPR-triplet' in which all entropies are conditional on ***C.***
b) Subsystem ***AB*** unconditional on ***C***, an unentangled mixed state corresponding to a classically correlated system.

ABC is an entangled "triplet" in which ***S*(*ABC*)** = 0 (a "pure" state). ***C*** herself, however, is in a pure state—***S*(*C*)** = 0 (***C*** definitely knows she exists). Consequently, since ***C*** obtains no information about herself, *she* can ignore her own state, and the measurement will still be self consistent.

Measuring the EPR state of ***AB*** is mathematically described as tracing over ***ABC*** ($\mathrm{Tr}_C\,[\rho_{ABC}]$) to yield a classical probability. In doing so, ***C*** erases the p_e entanglement information and takes the system to a pure state—***S*(*A*)** = 0 and ***S*(*B*)** = 0. Now, ***S*(*AB*)** = 1, which corresponds to a classically correlated x_t system (such as the switch and light). ***C*** has gained two bits of information with the expenditure of only one bit's worth of energy, *kT* ln 2—***S(C|AB)*** = −1. Since ***C*** has erased the entanglement information, this process is irreversible unlike the EPR-triplet state.

For us observers then, our classical model of reality is derived from erasing the entanglement information of ourselves and the rest of the universe. x_t entropy is extracted from p_e wave forms in a constant reiterative process of probabilistically matching data against expectation. Erasure of entanglement information also removes p_e initial state information, making energy increasingly uncertain towards the Big Bang. If epistemic states arise from the creation of x_t entropy at the macro scale, what happens at the opposite boundary in p_e space at the micro scale?

7. Down the Rabbit Hole

> *Warning*: the following section becomes increasingly speculative.
> Feel free to bail out when you have passed your comfort zone.

We descend in scale. As the angle of the phase dimension narrows clockwise towards 0 degrees, x_t space compactifies towards the size of a proton. x_t entropy diminishes logarithmically, erasing which-path information. Time is reversed and possible histories now multiply as p_e entanglement grows. Space curves negatively with the increase in energy density and we experience an accelerating anti de Sitter (AdS) contraction equivalent to the force of gravity[39].

Eventually, time and space diminish to the extent that possibilities for motion become very constrained. With the reciprocal growth of p_e entropy, potential energy also increases. At the limit of the Heisenberg uncertainty principle, x_t ⟲ p_e reach counterpoising equilibrium as a spin 1/2 particle. Spin defines a unique inertial frame of reference. Such an elementary particle also possesses the basic units of fixed mass (x_t entropy) and charge (p_e

entropy), both of which are ontic values. For Eddington, the magnitudes of mass, charge (and range in nuclear phenomena) belong to the elementary particle's relations to the rest of the universe[40].

A spin 1/2 particle has 720 degrees of spherical rotation. Consequently, we can continue rotating the phase angle clockwise past 0 degrees for another 360 degrees. What can this signify? A spin 1/2 particle can be represented geometrically by a tetrahedron, a structure which divides into an inside and outside[41]. A complex conjugate, such as $x_t \circlearrowleft p_e$, is not holomorphic, which means that as we enter the proton, we are in for an abrupt transition.

Time and space collapse onto the outer surface of the proton. Inside, from a macro-scale perspective, is a seething soup of quark and gluons. The asymptotic limit that confines the quarks is a quantized version of AdS, the geometry of the interior of a black hole. Conformal field theory (CFT) uses the properties of the quark-gluon plasma to describe geometric conditions near the 'center'—a black hole gas. This AdS/CFT duality is the basis for the Bekenstein bound: entropy = surface area.

The entropy of x_t space is thus encoded on the event horizon, just as a 2D surface can be projected onto a Riemann sphere. However, x_t information is so minimal at this scale, that it is negligible. This would also apply to x_t compactification by a cosmic size black hole. x_t dimensions collapse to 2D surface to a 1D string towards a point singularity. To an external viewer watching her partner fall into a black hole, a slowly fading red shifted image hangs eternally over the event horizon. Meanwhile inside, the hapless traveller is totally erased.

The diminishing x_t entropy acts as gravitational force, which, in turn, is equivalent to the corresponding increase in p_e entropy, measured as Hawking temperature. This entanglement temperature is inversely proportional to the size of the entangling region.[42] In the Lagrangian formulation of path histories, the path taken, called a geodesic, is the one with the least joint x_t and p_e entropies. In this way, as the de Sitter universe expands, the gradient of diminishing p_e entropy (as energy density) provides the quantum potential and $x_t \circlearrowleft p_e$ guides the action $\mathcal{S}$.

With the compactification of x_t space inside the event horizon, the universe becomes increasingly symmetrical as the electroweak and nuclear force become unified. p_e entanglement entropy grows towards the Planck limit, encompassing an ever increasing number of possible histories for the universe. Since we have identified quantum potential as the ontic driver of Lagrangian path formation (p_e entanglement), we are left with a rather startling conclusion. This proliferating multiplicity of histories—*parallel universes,* actually—*is* the ontic reality[43]! On the other hand, since the capability of the universe to process information is bound by the number of Planck bits, all possibilities converge to a finite set of solutions, of which our current reality may be the most probable.

Conclusion

Epistemic knowledge derives from erasing the entangled ontic information produced by quantum potential.

Using Eddington's phase dimension, we have examined the effect of scale on information. Position/time can be put on equal footing with momentum/energy as complex conjugate space: $x_t \circlearrowleft p_e$,. This extends the Heisenberg uncertainty principle into the action principle, $\mathcal{S}$, in 5-space geometry. As the x_t de Sitter universe increases in scale, decreasing p_e entropy as quantum potential drives the global formation of Lagrangian paths. Conversely, x_t entropy increases as which-paths are selected by erasing the p_e entanglement information. Lowering x_t entropy results in compactification of x_t space, corresponding to the gravitational force and Hawking temperature. Least action occurs where x_t and p_e entropies jointly are minimal.

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