

Black Hole Information Paradox Resolved

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Overview

The Black Hole Information Paradox (BHIP) is a core question in quantum theory. When combined with General Relativity theory, and string theories, these heritage perspectives try to synthesize a “theory of everything” that includes ever elusive quantum gravity. Resolving the so-called BHIP will reveal a new physics paradigm. The fresh analysis herein, along with much improved future telescopes, will help cosmology evolve deep into the 21st century.

Philosophy of Physics

Pure experimental physics starts with ideas and observations, yielding verifiable hypotheses to help build verifiable theories. All theories are subject to challenges, as the scientific method has no pre-determined end. Even the so-called laws of physics can be challenged. In this BHIP case, quantum theories have preceded impossible observations within black hole event horizons, leading to some very strange hybrid physics.¹

In physics and most other sciences there is a divide between experimental and theoretical. Experimental physics is the gold standard, and in fact becomes the only way a Nobel Prize can be

¹ <http://www.pbs.org/wgbh/nova/blogs/physics/2013/12/do-black-holes-destroy-information/>

won, after a theory is verified experimentally. Stephen Hawking never got a Nobel because his popular cosmological ideas could not be experimentally verified. However, Hawking's charisma did get his cremains entombed close to Newton and Darwin.

Theoretical physics is not just a pure exercise in speculative metaphysics, even though some physics math is more ideal than applicable. Metaphysics in general could be everything from pure theology to wild fantasies, all ultimately unverifiable. Theoretical physicists try to go a step beyond generic metaphysics, seeking support through clever maths. Sometimes this all leads to cloud castles.²

Equations with *a priori* elements and concepts try to substitute for cosmological data in models. Theoretical physicists hope to coherently substantiate their ideal derivative models just short of classical causal verification. In some cases historical theories with accessible dimensions have been verified after the right tools and methods appeared, which is the scientific method at its best.

However, there are critical realms of inquiry at the dimensional extremes that can never be verified or described with any human instruments. Our inability to ever experimentally close these open circles of inquiry creates its own delicious dilemmas.

Consider the dimensional known unknowns, as well as the countless unknown unknowns: On the logarithmic scale,³ humans are near the 10^0 m (1 meter) size. Individual atoms are at 10^{-14} m scale, and atomic cores are at 10^{-15} . Electrons are about 10^{-18} . Neutrinos, the smallest detectable particles, are about 10^{-25} . Our finest electron microscopes resolve to about 10^{-18} m, which is impressive. Still, this is rough resolution when compared to the 10^{-39} m dimension of individual, fundamental matter/energy spheres.

² <http://astronomy-links.net/AstrophysicsCloudCastles.pdf>

³ [https://en.wikipedia.org/wiki/Orders_of_magnitude_\(length\)](https://en.wikipedia.org/wiki/Orders_of_magnitude_(length))

Interestingly, *the logarithmic "dimensional distance" between individual human beings and individual atoms is similar in number to the logarithmic difference between individual atoms and individual yin/yang spheres of matter/energy.*

Going from humans outward, the logarithmic dimensional distance between individual humans and the entire visible universe is roughly the same as that between fundamental yin/yang particles and composite individual atoms. Let that sink in.

We might eventually somehow see down toward the beginning Planck dimension, which starts at 10^{-35} m. Below that gateway dimension quantum effects are said to rule, making classical measurements impossible. Nevertheless, within the extremely small dimensions of sub-Planck existence lie the fundamental matter/energy building blocks of nature. Here is a playground where experimentalists cannot play. Both GR and quantum theory have failed to sufficiently grasp the sub-Planck beyond their simple idea of quanta.

There is in math no smallest dimension, down toward zero itself. Yin/yang Coulomb spheres at minus 39 meters appear to be the smallest physical units. However, there is one case where all such spheres inside a BH can transform from matter/energy to nearly pure energy, while shrinking rapidly toward the zero dimension – and that's in the critical stage of another big bang.

Because sub-Planck dimensions have been poorly conceived, all things proximally built from the real fundamental building blocks – including the simultaneity of cause and effect, and the unity of energy and matter – are poorly modeled in current cosmological theory.

"Built things" include every structure and dynamic system up to and including the multiverse itself. Interestingly, pure zero and pure infinity cannot be modeled, which hasn't stopped some

physicists from employing gimmicks like renormalization and regularization of quantum field-theory math.⁴

Science is a major subset of philosophy, as the ancient Greeks understood. Philosophical inquiry looks to minimize variables down to one, and so does science. Proper reduction occurs when unnecessarily complicated hypotheses are superseded by more elegant, parsimonious hypotheses. Any hypothesis that self-contradicts thereby self-negates and eliminates itself. Likewise, whenever any supporting math equations slip into the trap of infinities and zeroes, the results are nonsense.

Nevertheless, there are some ways to compare and evaluate competing paradigms where experimental evidence is not yet (if ever) available. Theoretical physics can thereby become valuable and progressive, not just absurd, as we all seek intellectual efficiency. We remember that much of today's experimental physics once was theoretical physics. Much of yesterday's metaphysics is today's physics. Hopefully, some of this essay's theoretical physics will inspire future experimental physics.

Quantum Theory and the BHIP

The next two very interesting paragraphs are directly taken from the *Wikipedia* article on "CPT Symmetry"⁵:

"Charge, parity, and time reversal symmetry is a fundamental symmetry of physical laws under the simultaneous transformations of charge conjugation (C), parity transformation (P), and time reversal (T). CPT is the only combination of C, P, and T that is observed to be an exact symmetry of nature at the fundamental level."

"The implication of CPT symmetry is that a "mirror-image" of our universe — with all objects having their positions reflected by an

⁴ <https://en.wikipedia.org/wiki/Renormalization>

⁵ https://en.wikipedia.org/wiki/CPT_symmetry

arbitrary plane [*sic*](corresponding to a parity inversion)⁶, all momenta reversed [*sic*] (corresponding to a time inversion)⁷, and with all matter replaced by antimatter [*sic*] (corresponding to a charge inversion)⁸ — would evolve under exactly our physical laws. The CPT transformation turns our universe into its "mirror image" and vice versa. CPT symmetry is recognized to be a fundamental property of physical laws."

Examining the BHIP is a cosmological theory way to test CPT. If quantum CPT survives the maelstrom inside event horizons of black holes, then CPT itself is supported. If it does not survive these regions of our universe, then CPT and its 20th-century quantum theories are seriously wounded, opening the door for a better physics – or at least a serious modification of quantum theories.

Most tantalizing is how emerging 21st-century physics can provide the framework of a more viable theory of everything. It would be built on more elegant, non-random ideas of quanta (which I call yin/yang particles, and their particle strings and loops) – *and* a 21st-century understanding of multiversal push/shadow gravity. Once we know how the very smallest elements in nature relate, we can dialectically assemble/disassemble systemically dynamic structures in all larger dimensions of the cosmos.

Parity Inversion Mirror Image Planes

We have just read that parity transformation (the P in CPT) requires parity inversion mirror-image planes anywhere and everywhere. Space for curved planes inside black hole event horizons is part of dimensional "anywhere and everywhere." In other words, the "P" element of CPT synchronizes with the "C"

⁶ <http://astronomy-links.net/Holograms.html>

⁷ <http://astronomy-links.net/timearrow.html>

⁸ <http://astronomy-links.net/Antimatter.pdf>

and the “T”. What would this package look like just inside the event horizon?

The best analogy of such a mirror image of everyday reality is Plato’s “allegory of the cave” in his book, *The Republic*.⁹ Plato asks us to imagine a group of people trapped with keepers from birth in a dark cave. Their only visual idea of the real world is given to them by reflections on the cave wall produced by fires lit by keepers behind them. The shadows they see appear real, because that’s all they visually know. Then one of the prisoners escapes up and out through a hole, only to be astonished at the difference between “cave reality” and reality itself.

This hero goes back down into the cave, and leads some of them out through the hole, where they acutely learn the shocking truth about our real world. Here is where the word, education, etymologically originates. It literally means “to lead out of.”

20th-century physics has its own version of Plato’s cave. It is called the “holographic universe,” and was necessitated by the need to follow the claim of CPT symmetry. Its most famous proponent was the illustrious Stephen Hawking. Our next section examines what Hawking and his physics associates have had to say – leading to what their increasingly bizarre black-hole holographic ideas mean for CPT and quantum theory itself.

The Holographic Universe

Hawking and his associates’ strong devotion to the idea of holographic projections onto the inside of black-hole event horizons – and even onto the expanding universe’s boundary itself – is like the proverbial tail wagging its dog. Hawking and his physics associates twist their tautological mathematics to justify something very strange and counter-intuitive. It all has to do with defending CPT symmetry everywhere in the universe,

⁹ <https://web.stanford.edu/class/ihum40/cave.pdf>

even within black holes. Their fear is that quantum theory itself will fail everywhere if CPT fails anywhere.

In 2016 Hawking and his co-authors presented their most advanced ideas for how information is preserved even after matter/energy plunges inside an event horizon. This model is important for how energy later emerges back out of black hole event horizons through the misnamed Hawking radiation.

It has long been known among physicists that Hawking went to the Soviet Union in 1973 to meet with two of their most senior nuclear physicists. They explained to him how radiant energy can escape from event horizons through quantum black hole evaporation.¹⁰ In 1974 Hawking brazenly attached *only* his name to *their* discovery. Therefore, the correct name for so-called "Hawking radiation" should be something like "Zeldovich-Starobinsky radiation." Nevertheless, to smooth this discussion we will continue to associate Hawking's name with this quantum mechanical phenomenon.

Here we have a 1973 solution to the dismal idea of black holes consuming the extended universe. However, the purely radiant evaporation solution itself negates CPT – as random radiation escaping black holes no longer has the negentropic information of what earlier entered that black hole. Therefore, the escaping mechanism is no longer purely quantum mechanical, which requires yet another model. Addressing this information paradox without overturning CPT was the impossible goal of the Hawking group's 2016 paper.¹¹

A further dimension to this problem involves the diabolical Second Law of Thermodynamics, which predicts the inevitable and eventual end of negentropic order, being replaced by entropic disorder. So it seems like the Second Law wins out either by black holes sucking up and hiding everything else in the universe;

¹⁰ https://en.wikipedia.org/wiki/Yakov_Borisovich_Zel%27dovich

¹¹ <https://arxiv.org/pdf/1601.00921.pdf>

or by random radiant energy emerging with increased entropy. Here is where the holographic fantasy comes in to rescue the day.

Even though Hawking and associates had tried to deny event horizons themselves in 2014, thus avoiding the sticky problem of information being stuck behind these horizons in the first place, Hawking made a better stab at his favorite idea in 2016. In 2014 he had said: "A different resolution of the paradox is proposed, namely that gravitational collapse produces apparent horizons but no event horizons behind which information is lost."¹²

Here links a cute *YouTube* video presenting ideas about the relationship between CPT and black holes.¹³ The main idea of this video is that a BH works like a gigantic hard drive, and every bit of information from everything ever captured is preserved in a hologram just inside the event horizon.

Only delusional math could support this CPT fantasy. All parameters of even a modest rock passing through the event horizon would necessitate petabytes of information carefully stored in 2D – possibly waiting for some Hawking radiation trillions of Earth years later to come along and release this tiny object's data, and thereby the rock.

Another absurd idea of this video is that we in the here and now may just be Platonic holographic projections onto the curved boundary of our expanding universe. We think we are 3D within the fourth dimension of time, but really we are just part of a 2D hologram. In 2014 there was a brilliant experiment at Fermilab that sought to establish the holographic principle.¹⁴ Its heroic failure is a cautionary tale for the BHIP.

¹² <https://arxiv.org/pdf/1401.5761.pdf>

¹³ https://www.youtube.com/watch?time_continue=612&v=yWO-cvGETRQ

¹⁴ <https://www.cnet.com/news/is-the-universe-a-2d-hologram-fermilab-intends-to-find-out>

Hawking and his associates seem to have been aware of the audacity of trying to defend CPT symmetry at black holes (which are still part of the quantum universe). That challenge led to his 2016 idea of soft supertranslation “hair” within the sub-Planck dimension providing enough virtual surface area to encode everything in holographic form.¹⁵

However, adding tiny hairs to a literal or virtual surface only modestly increases the total surface of an otherwise smooth curve, far less than what would be needed to encode everything of energy and matter that enters. If the number of so-called hairs were to be increased to *near infinity*, the space available for them on any *fixed-radius* event horizon would still be defined by its finite Schwarzschild¹⁶ dimension. As hair numbers increase toward infinity, the size of each hair must equally decrease toward zero. The smaller each such hair, the less surface it has to encode data. Result is a *zero sum gain* in storage capacity, with no theoretical progress.

This 2016 Hawking associates essay was a valiant fail. He went to his tomb having made *no progress* against the challenge of electromagnetic firestorms swirling inside supermassive BH event horizons. Such storms would shred apart even what he mistook for arriving fundamental particles, but which are in fact composite particles. However, the great news is this: The true fundamental building elements that will be needed for a new negentropic local universe are thus created.

If randomizing maelstroms are a true phenomenon, then CPT symmetry fails in critical areas of the universe. Interestingly, reductive randomizing is one key to escaping the “physics Platonic cave.” A major paradigm shift is thus needed to rescue what is valuable in quantum theories. What follows herein will give scientists a fresh path toward better 21st-century physics.

¹⁵ <https://arxiv.org/pdf/1601.00921.pdf>

¹⁶ <http://astronomy.swin.edu.au/cms/astro/cosmos/S/Schwarzschild+Radius>

Beyond CPT Theory

We have established the absurdity of holographic universes, with the failure of CPT theory inside black-hole dimensions. We have furthermore observed how experimental physics is just one limited tool to make sense of it all, and how mathematical physics can be absurd and tautological. Even a mixture of the two, as for example the famous Drake Equation,¹⁷ is probability-limited, however valuable for possibility speculation.

[I have through a series of papers, some footnoted here, presented key elements of the new physics. This series goes back several years. More recent copyrights reveal better theory. It is not my purpose in this brief thesis to reference all that was written before. Therefore, please visit numbered footnotes herein, and visit other essays in the "Clark's Web Pages" section of *astronomy-links.net* as you wish.]

Here are some key elements that constitute my emerging theory:

(1) My theory is more classical than not. I hold that there appear to be two fundamental vector forces at work, both already expressed by inverse-square formulas of Newton and Coulomb.

(2) The gravitational inverse-square "force" at any point of space-and-time is the *net* product of the push of fundamental particles, *and* the shadowing effect of relatively near masses. This apparent net force predominates outside event horizons, up to great multiversal distances. To some degree it is possible to describe this net effect with the purely correlative math of GR.

(3) The Coulombic electromagnetic "force" also follows the inverse square law. It operates inside event horizons, and everywhere near yin/yang fundamental particles. It also is a

¹⁷ https://en.wikipedia.org/wiki/Drake_equation

player in such areas as electromagnetic force fields around the Earth. Fundamental unit beads express two types of EM, primary and secondary. Only secondary EM is polar (+ and -), as with force fields.¹⁸

Given a distance of some 10^{-39} m between the centers of any two juxtaposed yin/yang spheres in a beaded string, with both spheres attracted to each other by primary EM, their direct cohesive Coulombic force would be *immense*¹⁹ – perfect for allowing very long bead strings producing detectably long EM photons, and for building other so-called primary particles.

(4) I adhere to a flat 4D concept of our visible universe, and of the surrounding multiverse. This fixed matrix negates much of Einstein's curved general relativity, and all of string geometry. The new multiverse theory is thereby closer to Euclid, to Newton, and to classical particulate quantum theory.

(5) The century-old Heisenberg model of quantum activity is superseded by a neoclassical model of the simultaneity of cause and effect, whether immediately apparent or not. Things that appear random may or may not be. We don't need an "observer" to establish absolute/relative location or vector. However, we do need an overall 3D matrix, which the multiverse supplies for vectors/time.

(6) Light in vacuums does not establish a cosmic speed limit. The fixed speed of "c" is just the acceleration of single-pop, separating yin/yang particles, individually and in strings.²⁰

Theoretically, there is no limit to how fast a mythical space ship could accelerate in sum relative to its initial launching site.²¹ All

¹⁸ <http://astronomy-links.net/String.Types.pdf>

¹⁹ <http://www.endmemo.com/physics/coulomb.php>

²⁰ <http://astronomy-links.net/LightSpeed.pdf>

²¹ <http://astronomy-links.net/Time.travel.pdf>

the craft needs are many pulses of propulsion along the journey – and an equal amount decelerating as the target is approached. That zero sum puts both launching site and destination target in different parts of the same 3D overall frame. In such a journey each rocket pulse starts from a new resting reference point, so never do we exceed the acceleration of local photons at any new point of changing local time.

(7) Push/shadow gravity strongly supports the idea of a 4D bubble multiverse. “Gravity particles” are *not* tiny billiard balls, as was incorrectly conceived by Fatio and LeSage. Rather, such “particles” are flexible energy/matter units. The multiversal force field is composed of balancing flows of fundamental units from all directions. Such units freely cross “universal boundaries” within the bubble soup. Also, gravity is a net pushing force, not a weird attracting tractor beam between adjacent string-theory branes.

(8) Primary interstellar quanta could mostly be unattached yin/yang spheres. These matter/energy “particles” (individually, and in particle strings and loops) exist as a “quantum soup” everywhere. There is no such thing as empty space, thanks to diffusion. The wonderful LIGO experiments have recorded waves associated with distant phenomena. However, these waves are DeBroglie-Bohm bow waves in the deep-space quantum sea, not GR membrane wiggle waves.²²

(9) Some quanta in the interstellar soup may be linked as Loop Quantum Gravity would have it, which could allow some spooky action at a distance.

(10) Although GR has seemingly been “confirmed” by several local observations, it has also been found woefully lacking by

²² <http://astronomy-links.net/LIGO.and.GR.pdf>

other measures;^{23,24} or equally well explained by push-shadow effects using shared correlative math.²⁵

(11) The puzzling predominance of matter over antimatter in our visible universe is best explained by a 4D multiverse, or at least by a highly residual former universe; and this model has Higgs bosons.²⁶

(12) "Dark matter" is only dark to the frequencies measured by our current instruments. It too is mostly composed of the truly fundamental matter/energy particles. For that reason it gravitationally interacts with baryonic matter. Yin/Yang particles often combine in strings sufficiently long to have vibrational frequencies low enough to yield detectable photons – whereas shorter strings are not yet detectable in a truly "dark" matter.

(13) "Dark energy" is physics fiction associated with not understanding the push/shadow gravitational relationship between adjacent universes in the multiversal bubble bath. Factor in this interactive relationship among nearby universal interfaces, and Einstein's "lambda" simply becomes another expression of push/shadow gravity on a very grand scale.

Inside and Near Black Holes

We will end this essay with some thoughts about what may be going on inside and just outside black hole event horizons. What follows is envisioning, not direct vision, except in visible regions outside the event horizons. We seek to inspire a modern model.

The latest big-science data regarding black holes all relates to what we can see outside and near supermassive event horizons.

²³ <http://astronomy-links.net/DipoleRepellerExplained.pdf>

²⁴ <http://astronomy-links.net/GGvsGR.html>

²⁵ <http://astronomy-links.net/correlation.and.causation.pdf>

²⁶ <http://astronomy-links.net/Antimatter.pdf>

The hidden cores inside are compressed massive objects involving millions of solar masses that have profound gravitational effects on their proximal environment. The greater the core mass, the larger the Schwarzschild radius. Our best telescopes can record spectrum Doppler shifts far beyond event horizons involving individual Milky Way stars; and in regions of galactic planes of more distant galaxies. In general, both GR vortex and push/shadow models can correlate with spectrum observations, but only push/shadow models causally correlate.

Close to supermassive black holes is a bright region called the photosphere, sometimes called the photon sphere. Here is where large numbers of stars and assorted electromagnetic energy visibly swirl around just outside the event horizon. In the near future when we first "image" black holes we will only be imaging the "dark disc" inside the visible photosphere.

We can also image some jets of energy rising above magnetic N/S lines from the black hole's photosphere. If you have a large amateur telescope, and rare optimal viewing conditions, you may see the visual signature of such a jet from the giant elliptical galaxy, M87, in the Virgo Cluster. It is theorized that such jets from supermassive black holes can shut down star formation in their host galaxy.

Anywhere inside a BH event horizon is where gravity and/or attractive electromagnetic effects from the core become stronger than the ability of individual photons to escape the central mass. For all that, in the event that a firestorm maelstrom is not just inside the event horizon, *deeper inward* toward the supermassive core the radically increasing destructive forces will disassemble everything down to yin/yang spheres anyway. Remember too that just as some photons near the horizon shoot away from the core, just as many shoot inward toward the core.

Space near but outside the spherical event horizon captures or distorts the vector path of multiversal matter/energy units that would otherwise linearly pass beyond the BH area. Many of these

passing yin/yang units are distorted as gravitational lenses. However, the only apparent lenses we can detect are from much longer electromagnetic yin/yang beaded strands: photons in visible frequencies.

With the advent of improved instruments later in this 21st century we may directly detect so-called gravitational lenses with dark-matter EM frequencies. Extremely short beaded strands are not the same as theorized "dark photons."²⁷ Real dark matter electromagnetic frequencies would be higher than gamma rays, due to shorter strands of spinning yin/yang particles. They would not have additional mass per unit length.

In comparison, the soon-to-launch James Webb Space Telescope will be optimized for long infrared frequencies, which are in the opposite direction from dark matter frequencies. The detection game is all about matching instruments with lengths of vibrating/rotating, yin/yang particle strings.

Individual yin/yang spheres *do not radiate* detectable polar electromagnetic frequencies, though they would still have tiny gravitational and Coulombic effects at any distance, and strong cohesive effects when juxtaposed to each other.

Let us consider energy radiating out from an event horizon: Staying just inside the event horizon, there are two possibilities. First, the event horizon is almost a perfect sphere, because the central mass is spherical, and everything is flowing smoothly. A much more likely scenario would be this second model:

Even if the central mass is perfectly spherical, matter and energy units inside the horizon will smack into each other, creating differential currents at high speed, and breaking down participants to their fundamental identities. These products are produced by the kinetic maelstrom inside the black hole, and likely even more intense maelstroms closer to the core mass.

²⁷ <https://phys.org/news/2018-04-fine-structure-constant-dark-photon-theories.html>

This second model is how an imperfectly spherical event horizon can envelop even a perfectly spherical central mass, rotating or not. Whenever kinetic energy zipping around just inside a black hole encounters a fluctuating dip inward, adjacent photons have a better opportunity to escape their virtual barrier.

Such escapes could be described as quantum events, or also described as classical photon-acceleration events. Either way, the descriptive energy that entered has previously been destroyed by the maelstrom, and there can be no conserving holographic memory plane with nothing left to conserve.

Due to the law of conservation of energy and matter, even when things are disassembled, there is no total matter/energy lost. Entropy is disorder, but not loss of total matter/energy. If and when the multiverse resolves into a sea of entropy trillions of years hence, it will still have its full quota of matter and energy. Perennial push/shadow gravity is all we need to create new forms of negentropy within a sea of random entropy.

Early models of the Second Law of Thermodynamics did not understand the idea of eternal thermal oblivion. We now see entropy as just another aspect or phase of possibly endless cyclical cause and effect. Recycling universes could be as basic as dead trees providing elements needed by new organisms to continue the dance of existence.

Recycling in the multiverse largely occurs when new local universes burst forth in the 3D multiverse. Most supermassive black hole cores behave themselves. However, when enough incoming matter/energy creates a critical mass, the core's individual yin/yang particles start crushing from the combination of gravitational accumulation and Coulombic forces, both forces operating on the inverse square.

A crushed fundamental particle does not fully disappear. It transforms into energy over matter, meaning there is always

some matter associated with the energy, as with photons. Later on, as the radiant energy starts to cool, balanced yin/yang particle strings reappear. They first begin to electromagnetically assemble as beaded strings, and thereafter into protons and hydrogen molecules. This progression starts a very beautiful symphony of increasingly complicated interactions.

There are always the makings of an infinite multiverse. Some of us questioning apes will occasionally choose to confront the unknown unknowns of how negentropy got here in the first place. Even if we say God did it, how did God get his/her/its negentropy in the first place? How will order end, if ever? Perhaps it's the mystery of all things we cannot understand (*myoho*) operating through the simultaneous law of cause and effect (*rengé*), as the *Lotus Sutra* would say. That's fine, but I really want to know what's for supper.

Individual human lives are extremely brief on the geological scale. The geological scale itself is brief on a cosmological scale. The same level of brevity exists for humanity itself. Future wisdom in general has the potential to prosper for many billions of years, free from the doomsday scenario of universal entropy.

Perhaps today's human society is being looked at with sadness by undetectable ancient life forms – while we careen toward our ecological and nuclear self-destruction.²⁸

I still have hope for a better near future for us all. We need more wisdom, and soon, to help myopic humanity triumph over seemingly random facts, and over our killer-ape genes.

²⁸ <http://astronomy-links.net/Boiling.Frogs.pdf>