

A Plausible Mechanism for the Velocity of Hyper-fast Pulsars With Potential Application for Interstellar Propulsion;

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ABSTRACT

Hyper-fast pulsars are a class of neutron star with extreme velocities relative to the stellar background. These objects elude existing theories of neutron star synthesis. Of relevance to their understanding is the emergence of Information as a fundamental principle in Physics and Astrophysics. This leads to an examination of Information Theory as it relates to Einstein's century-old postulate that Quantum Mechanics is incomplete. The result is a model of spacetime as a noiseless Information Channel with a finite Channel Capacity defined by the Holevo Limit of Information transmission through the Quantum vacuum. A premise is presented that within the context of Information Theory, General Relativity Theory is applicable not only to velocities approaching C , but to hyper-complexity of physical state approaching the Holevo Limit. It is hypothesized that the extreme flux density and chaotic nature of magnetic fields during neutron star coalescence approaches the Holevo Limit, and this results in spatial dilation in a static inertial frame of reference. Under General Relativity Theory, dilation of spacetime in a static inertial frame manifests as an acceleration, and this is proposed as the mechanism imparting the extreme velocity of hyper-fast pulsars. It is proposed that existing computer simulations of stellar core collapse supernovae, modified to address the above theoretical premise, may demonstrate high velocity ejection of a neutron star. Algorithms derived from such a successful simulation may be hosted on a compact supercomputer serving as a real-time device driver for a benchtop supermagnet apparatus. This may yield controlled spatial dilation and a detectable acceleration upon the magnet apparatus. Such an experimental result will prove that Einstein was correct in his assertion, to the end of his life, that Quantum Mechanics is an incomplete description of Physical reality. A discussion of interstellar spaceflight from an engineering perspective based upon such a propulsion principle follows.

INTRODUCTION

Neutron stars are compact (~ 10 km diameter) hyper-dense objects (~ 1.4 to 2.2 solar M) composed exclusively of neutrons and possible exotic/strange states of nuclear matter. They form during the last few milliseconds of core collapse of super-massive stars (>8 solar M) during a supernova event. Neutron stars spin on their axis at rates clocked to 716 hz ($42,960$ RPM) [1] and have the most powerful magnetic fields known to science. Their surface rotation velocity at the equator can approach the speed of light. The only compact objects more massive than neutron stars are Black Holes.

Pulsars are a class of neutron star characterized by rapid pulses of radio frequency emission. This behavior is explained by the poles of their intense magnetic fields being offset from their spin axis, but aligned such that resulting collimated radio beams intersect the earth.

Hyper-fast pulsars exhibit extreme velocity relative to the stellar background. At least one of these objects, IGR J11014-6103 (Lighthouse Nebula), has an estimated velocity of $(.003-.008) C$ or $(899-2398)$ km/s relative to the galactic stellar environment. Such velocities are in excess of the orbital escape velocity for the galaxy (~ 544 km/s), so these objects do not populate the interstellar medium but quickly disappear into intergalactic space.

SUPERNOVA DYNAMICS

The key problem for understanding the extreme velocity of hyper-fast pulsars is the brief duration of a stellar-giant core collapse supernova [2]. The entire event takes about $\frac{1}{2}$ second, and the final, definitive stage where a neutron star coalesces lasts but a few milliseconds. There exists no stellar core collapse model that can explain acceleration of a compact object exceeding the mass of the sun to $(.003-.008) C$ in such a brief interval. The most precise explanation proposed to date in peer reviewed astrophysical literature for the extraordinary velocity of hyper-fast pulsars is a 'kick from an undetermined stellar core collapse mechanism' [3].

Stars are characterized by powerful magnetic fields that dominate stellar atmosphere plasma dynamics. Such magnetic fields course throughout stellar interiors and originate in the stellar core where thermonuclear fusion reactions occur. Stellar magnetic fields of our own sun are sufficiently powerful to threaten electrical power grids on earth via Coronal Mass Ejections.

Energy is bound in magnetic fields and, due to the physical Law of Conservation of Energy, stellar magnetic fields and their bound energy do not simply disappear during a stellar core collapse supernova. Instead, stellar magnetic fields undergo continuous and chaotic transformation throughout the collapse event to neutron star coalescence. Although the energy bound by stellar magnetic fields is significant, this energy flux cannot itself provide a plausible mechanism for the near-instantaneous acceleration of a neutron star exceeding the mass of the sun to a velocity of $(.003-.008) C$.

There is, however, a mechanism revealed by quantum mechanics and Einstein's General Theory of Relativity by which magnetic fields may yield such an acceleration indirectly. Understanding this mechanism requires us to abandon our last absolutist Newtonian perspective regarding the relationship of Information to spacetime. It also requires us to revisit, within the context of Information Theory, Einstein's debate with Neils Bohr [4] that quantum mechanics is an incomplete description of physical reality. Significantly, Information Theory was still decades away when this debate was judged resolved in Bohr's favor.

INFORMATION, PHYSICAL SYSTEMS AND EINSTEIN

The Information content of physical systems has become an important concept in quantum physics and cosmology [5]. The mature field of Information Theory is based upon mathematics that are an extension of Boltzmann's statistical description of the microstates of a gas and computation of its thermodynamic entropy (i.e. free energy). In Information Theory these same equations are applied at a higher level of abstraction to all probabilistic systems, with extensions in the realm of ergodic processes, coding theory and error correction [6]. Although Information Theory has its roots in the statistical dynamics of gas in physical systems, Information itself is a dimensionless mathematical abstraction with no physical correlate. Importantly, the concept of Information is divorced from the concept of measurement or an observer.

Information Theory was formulated by Claude E Shannon in 1948. This was 33 years after Einstein formally presented the General Theory of Relativity in 1915, and 23 years after the formalization of Quantum Mechanics in 1925. The presentation of Information Theory exclusively as an engineering discipline for designing electronic communication networks may explain its neglect by physicists, even though it significantly altered the intellectual context of the Einstein / Bohr debate that defines contemporary Physical theory.

QUANTUM MECHANICS

Any discussion of Information and physical systems must address Quantum Mechanics. Quantum mechanics defines mathematically inviolate limits on the amount of Information that may be acquired about a physical system. It explicitly prohibits the acquisition of sufficient Information to

define a system's microstate with zero uncertainty at any point in time. It also places an upper bound on the capacity of any communication channel, as well as limiting the sensitivity of any Information sensor before a signal becomes lost in quantum uncertainty, or 'noise'.

Paradoxically, while quantum mechanics limits the Information available to precise measurement it predicts the behavior of physical systems with uncanny accuracy; from the behavior of electromagnetic radiation, to the laws of chemistry and atomic physics, to the gravitational transition of normal matter to degenerate hyper-dense states in dying stars.

Importantly, quantum mechanics defines no absolute bounds on the Information content of physical systems. Instead, it defines absolute bounds upon the Information about physical systems that is accessible to an observer. This so-called 'Holevo Limit' [8] represents the maximum amount of Information that may be acquired from any quantum system per unit time. The totality of the laws of Physics accessible to measurement are bounded by the Holevo Limit of quantum Information transmission [9]. From the perspective of Information Theory, the Holevo Limit defines the Channel Capacity of quantum spacetime and is as immutable as the speed of light. To date, no observable correlate to information beyond the Holevo Limit has been detected in the physical universe. For this reason, such Information is dismissed by quantum mechanics as metaphysical and scientifically irrelevant.

Although quantum mechanics does not address the existence of Information beyond the Holevo Limit, it is arguable from the perspective of Information Theory that such Information must exist. If such Information does not exist, then all physical systems lack sufficient Information to fully define their physical state at any point in time. This leads to a tautology that physical reality consists of an Information signal that is incomplete and undefined at the transmitter, yet complete and without error at the receiver. Albert Einstein rejected this possibility, as reflected in his famous quote in reference to quantum mechanics that: 'God does not play dice with the universe'.

History shows that Einstein's youthful intuition about physical reality was uncanny. His prescient intuition anticipating an Information Theoretical model of spacetime decades before the fact requires us to reconsider his objections regarding quantum mechanics. Einstein's spurious introduction of the Cosmological Constant to salvage a static model of spacetime over the expanding universe revealed by his equations of General Relativity was, by his own reckoning, his greatest blunder. The verdict of contemporary biographers and physicists is that Einstein's second greatest blunder was refusing to capitulate to Quantum Mechanics in a Quixotic pursuit of a 'General Field Theory' to the end of his life. This harsh judgment may be premature.

The following discussion defends Einstein's original argument in his debate with Neils Bohr. Within the context of Information Theory, this may be interpreted as an assertion that physical systems contain hidden or 'occult' Information that transcends Quantum Mechanics and the Holevo Limit. 'Occult' refers to the unknown location and nature of this Information, since Bell's Theorem [18, 19] indicates it may be non-localized in spacetime, and possibly co-extant with the entire universe. We refer to this issue as the 'Occult Information' problem, although the debate was not framed in those terms at the time because Information Theory did not exist. We view this issue as equivalent to the 'wave / particle' debate that dogged Quantum Mechanics during its formative years. That debate was eventually settled by experiments that revealed quantum phenomena are 'complimentary' and have simultaneous attributes of both waves, and particles. Similarly, we propose that the positions held by Neils Bohr and Albert Einstein in their debate are not mutually exclusive, but indicate a deep and subtle 'complimentary' relationship between Information and physical reality. We propose that physical systems do, in fact, have an exact physical microstate at any point in time; even if this Occult

Information is non-localized in spacetime per Bell's Theorem, and inaccessible to direct observation. Such a position is not purely philosophical. We propose an experiment that will resolve the 'Occult Information' problem, with the possibility of a very practical application if Einstein is vindicated.

THE UNIVERSE AND INFORMATION THEORY

We start with a few postulates:

1. Information Theory describes the behavior of Information in the universe.
2. We define the Information Content of any physical system as the Information required to fully specify, with zero uncertainty, its physical microstate at an instant in time. We define its Information Rate as the Information required to fully specify, with zero uncertainty, a transition to a different microstate over a temporal interval.
3. 'Zero uncertainty' means that physical conservation laws governing mass and energy are not violated as a result of missing or corrupted Information.
4. We define spacetime as a noiseless Information Channel where all Information in the universe is stored, and through which all Information must pass as physical systems change state through time.
5. Infinite Channel Capacity is prohibited in physical reality. The Holevo Limit of quantum mechanics defines the upper bound of Information transmissibility; i.e. it defines the Channel Capacity of spacetime.
6. The information density of dynamic systems may approach the Holevo Limit; for example, during supernovae.

A CONUNDRUM

This brings us to a difficult paradox that quantum mechanics artfully avoids. The existence of sub-quantum, 'occult' Information beyond the Holevo Limit of Information transmission in physical systems opens the possibility for Information loss. Such Information loss would result in a random redefinition of the microstate of physical systems, and would be a catastrophic violation of physical energy conservation laws. The present scientific consensus is that this problem does not arise because Information exceeding the Holevo Limit defined by quantum mechanics does not exist and therefore, cannot be lost or corrupted by the finite channel capacity of spacetime.

But if Quantum Mechanics is an incomplete description of physical reality as Einstein argued against Bohr, and Occult Information exists, how can physical reality host such a density of Information within the finite channel capacity of spacetime defined by the Holevo Limit of quantum mechanics?

In Information Theory, if the capacity of an Information channel is exceeded then Information is irretrievably lost. Using the Internet as an example, the result of exceeding the Information channel capacity of a sub-network is a message queue buffer-overflow fault or, at a deeper electronic level, a channel that spews data irretrievably corrupted by random noise. Either outcome is catastrophic to the network.

The entire telecommunications infrastructure of the Internet is based upon this fundamental principle and its management via sophisticated algorithms based upon the mathematics of Information Theory. Fortunately, when an Information channel on the Internet becomes saturated, routers sense this condition and bring more channel capacity online as needed in a process called 'load balancing'. This allows the channel capacity of a sub-network to be increased or decreased in response to demand, so there is no Information loss. It means networks do not need to be designed with extraordinary Channel Capacity to handle the worst case scenario, but rather have an ability to increase and decrease Channel Capacity dynamically based upon demand.

Nature appears to have an analogue to 'load balancing'. Even though spacetime has a finite Channel Capacity defined by the Holevo Limit, it is equally impossible for spacetime to corrupt or lose Information as it is for a brick to go faster than the speed of light. The postulate of a finite channel capacity (or bandwidth) of spacetime in the context of Information Theory and quantum mechanics is no less fundamental than the postulate of a finite velocity of light. The implications of a finite velocity of light to physical phenomena have been explored for over a century. We are just beginning to tentatively consider Einstein's postulate of inaccessible, sub-quantum physical Information and its implications to a finite Channel Capacity of spacetime. That such Occult Information may be non-localized in spacetime, and participate in Quantum Entanglement instantaneously across vast distances per the Bell Theorem, is not a denial of its existence. An experimental investigation into the fundamental physical existence of Occult Information is relevant, because it leads directly to an architecture for an operational warp drive that is within current engineering state of the art with modest energy requirements. If Einstein is correct, then space can be warped with pure Information without recourse to exotic states of matter or vast amounts of energy.

SPACETIME DILATION

The paradox of a finite Channel Capacity of spacetime in a universe of phenomena that are potentially unbounded in complexity (or Information content) of state is resolved if we assume that nature prohibits exceeding the Holevo Limit of quantum Information transmission for the same reason that nature prohibits exceeding the speed of light. Both are fundamental physical limits of the Universe.

The General Theory of Relativity dictates that spacetime is not inviolate. Spacetime dilates locally in response to mass in a static inertial frame, resulting in the so-called 'curvature of space' in which planets orbit their stars and matter coalesces into galaxies, stars, planets, etc. We call such warping of spacetime in a static inertial frame of reference Gravity.

Spacetime also dilates locally as the velocity of an accelerating inertial frame approaches the speed of light (C). This is an instance of a more general principle that Information transmissible between a static inertial frame, and one that is accelerating, approaches zero as luminal velocity ($0.99+C$) is approached. Any object traveling sufficiently close to the speed of light, or passing through the event horizon of a black hole, will appear static and unchanging to an outside observer due to extreme time dilation. Light does not have an infinite velocity, rather time has an infinite capacity to dilate.

Similarly, when a region of spacetime hosts hyper-complexity of state approaching the Holevo Limit, as is found in the magnetic flux of collapsing giant stars, spacetime dilates in the static inertial frame to preserve fidelity of physical Information. It does this for the same reason that spacetime dilates in response to mass, or as luminal velocity is approached; i.e. nature cannot host infinite velocity, infinite mass, or infinite complexity; rather spacetime dilates locally as physical limits of velocity, mass, or dynamic hyper-complexity of state are approached. Spacetime dilation is how the physical universe avoids hosting infinities.

Quantum mechanics has already been extended into Information Theory [7]. The General Theory of Relativity is similarly extensible, but a rigorous mathematical treatment is beyond the scope or purpose of this paper. We need only accept the premise that Einstein's existing theory extends deeper into Physical reality than originally anticipated, and that the youthful intuition that he followed doggedly to his death was correct; even if he did not bring it to a successful mathematical conclusion.

BACK TO SUPERNOVAE

In a supernova we are witness to the laws of Physics at their most extreme outside the event horizon of a black hole. During a stellar core collapse the original magnetic flux of a giant star occupies a smaller and smaller region of space. A coalescing neutron star forms the nexus of a spherical dipole magnet barely 10 kilometers in diameter that may be regarded as a single quantum system. This magnet conserves all the angular momentum of its parent star; thus the spin rate that can approach c at the equator. In the final milliseconds of its creation this tiny object spinning at hyper-velocity hosts the conserved, chaotically contorted magnetic fields of a stellar-giant (>8 solar M). It is hypothesized that these fields possess sufficient magnetodynamic complexity to induce highly localized, brief, and extraordinary spatial warping in the immediate vicinity of the coalescing neutron star that preserves Information of state. Due to extraordinary magnetic flux density and hyper-velocity of rotation, this spatial warping is sufficiently powerful to accelerate a neutron star more massive than the sun to galactic escape velocity in a few milliseconds. This is the 'kick' of hyper-fast pulsars referred to in astrophysical literature.

RANDOMNESS AND ZERO OR ONE

Random physical processes cluster randomly into structures possessing order; the classic example being a snow crystal. This may also be presumed true for magnetic fields during a stellar-giant core collapse. Compounding random fluctuations in stellar magnetic fields, aka the 'Butterfly Effect' [10], determine the final outcome of a supernova.

In most cases of stellar-giant core collapse, magnetic flux is sufficiently symmetrical for a neutron star to remain as a glowing remnant in the center of the plasma debris field of the supernova, or is found slowly drifting away. Yet some supernova events leave behind an empty debris field with no neutron star or black hole. There is no known physical model by which such hyper-dense objects could be obliterated in a gravitational collapse.

In the case of a hyper-fast pulsar, the stellar magnetic flux is presumed non-isotropic due to statistical fluctuations during collapse. This field asymmetry results in a spatial warp vector along which a neutron star is accelerated from its parent body. Hyper-fast pulsars explain the scenario of supernova events that leave behind no neutron star or black hole. There exists no observational evidence for hyper-fast black holes, but such ghostly objects would leave few observable traces as they rapidly exit the galaxy into deep, intergalactic space.

The enormous acceleration of a hyperfast pulsar lasts mere milliseconds and ends when the chaotic magnetic fields of the new neutron star stabilize within the bounds of the Holevo Limit. At this point, spatial warping and attendant acceleration ends. Following energy conservation laws, the kinetic energy of an ejected neutron star's momentum should be missing from gravity waves that would alternatively be broadcast.

SO WHERE IS SUPERNOVA THEORY?

The above scenario does not contradict existing stellar-giant core collapse supernova theory [2]. It is simply missing from it. Nuclear fusion is localized in the core of stars, and it is the energy of

fusion reactions that supports the enormous weight of a star against the force of gravity. At the end of the life cycle of a giant star, a critical portion of the stellar core has been transmuted into iron by fusion reactions. Iron does not participate in further element transmuting fusion reactions, so as iron accumulates there is less energy to support the stellar core and it begins to slowly shrink under gravity. In the case of a stellar-giant, the mass of the core exceeds the Chandrasekhar mass (~ 1.4 solar M). Beyond this mass, the electromagnetic repulsion of electrons surrounding atomic nuclei (Pauli Exclusion Principle) cannot resist gravity. As fusion energy output fades, a point is reached when gravity crushes electrons into protons of atomic nuclei. Core shrinkage then becomes a sudden exponential collapse as electron capture transmutes elemental atomic nuclei into pure neutrons, halting nuclear fusion. Within milliseconds, the stellar core collapses to a tiny fraction of its original volume into a neutron star. Simultaneously, the stellar atmosphere free-falls at many km/s velocity into the void suddenly vacated. Energetic neutrinos resulting from conversion of protons into neutrons in the core via electron capture provide a burst of energy that expels the free-falling stellar atmosphere as a shock wave, in a spectacular supernova explosion.

The final phase of a stellar core collapse lasts about $\frac{1}{4}$ second. In its broad outlines, this theory of stellar core collapse conforms to astronomical observations of plasma debris fields, neutrino bursts and gravity waves from supernovae.

The devil, as they say, is in the details. The escape velocity at the surface of a neutron star is (0.3-0.5) C; i.e. (90,000-150,000 km/s). How the huge inertial momentum of a free-falling stellar atmosphere reverses course and climbs out of such a deep, relativistic gravity well to continue expanding outward into space at many km/s, seems insufficiently explained by only a neutrino flux. Neutrinos are ghostly particles with negligible mass that interact with matter extraordinarily weakly. It has been hypothesized that a neutrino could pass through light-years of solid lead before interacting with an atomic nucleus. The density of neutrino flux required to violently blast a freefalling stellar-giant atmosphere into interstellar space from a forming neutron star seems contrived. Also unexplained is what happened to the stupendous magnetic fields that existed at the time of neutron star coalescence. Where did the magnetic energy go? What if the star is sufficiently massive, and its angular momentum sufficiently high, that the spin velocity at the equator of its neutron star approaches C? The existing model provides no explanation whatsoever for the existence of hyperfast pulsars, or supernovae that leave behind no neutron star or black hole. The existing model of stellar-giant core collapse is incomplete.

THERE IS AN ULTERIOR MOTIVE TO ALL THE ABOVE

We are done.

It is not the purpose of this paper to announce a new observation or Physical theory, or to question what has been scientifically proven. It is to propose a logical and mathematical path through existing astronomical observations and Physical theory to resolve an engineering dilemma: "How can we go to the stars, now?"

Not in 50 or 100 or 500 years, but Now.

Now is important. A study of geology and human history reveals the fragility of our current historical milieu. To say that interstellar travel will be accomplished with 'unknown technology' in 'the distant future' is arguably to say it will never happen. The first manned Starship needs to depart within the lifetime of people reading this in 2020, or the odds of it ever happening approach zero.

The only deviation from classical Physics is that of accepting Einstein's original argument regarding the incompleteness of Quantum Mechanics. This issue is addressed within the context of Information Theory, which did not exist at that time. This done, the implications to existing Physical

theory have been explored. If Einstein's original intuition is wrong, then this will be the first time and it means that the Universe really is a signal that is incomplete and undefined at its source that magically arrives uncorrupted as reality. But if Einstein was right, then the stars are a lot closer than you think.

If it is impossible to force spacetime to dilate with pure Information using small amounts of energy, then there is no path to the stars; now or with any conceivable technology in any distant future. However, if such spacetime dilation is physically possible, then we already have the technology to accomplish this. Now.

History shows that taking Einstein's side in a scientific debate is prudent. Einstein's intuition regarding sub-quantum 'Occult Information' decades prior to Information Theory or the discovery of Information as a principle of astrophysics, shows a profound depth of abstract thought that should not be abandoned prematurely as a matter of scientific convention. As with the Cosmological Constant, his scientific intuition overreached the historical milieu in which he lived. In light of recent developments, the verdict rendered against Einstein in his debate with Neils Bohr decades ago is not scientifically binding.

The inviolability of the General Theory of Relativity, and Quantum Mechanics, is not challenged. Rather it is proposed that the full reach and scope of existing theory has not been fully appreciated in the context of the Einstein / Bohr controversy, Information Theory, and the Bell Theorem. The Einstein / Bohr controversy may, in fact, be a historical illusion of constrained perspective confronting profound levels of complementarity not yet explored theoretically or experimentally.

The issues touched upon could define multiple academic careers. They were, of necessity, glossed over. Although the thesis presented is controversial, and even open to scorn and ridicule by stakeholders of other perspectives, contradictory observational, experimental, or mathematical evidence is conspicuously absent in the literature. Fortunately, the ideas presented are amenable to experimental confirmation or rebuttal with relatively modest resources.

AN EXPERIMENT TO CONFIRM EXISTENCE OF OCCULT INFORMATION

Although the technical risk is high, the cost to experimentally determine the existence of sub-quantum 'Occult Information' is relatively low. The cost of a proof-of-principle warp drive is the cost of a benchtop high-performance superconducting supermagnet apparatus, a compact super-computer configured as a magnet device driver, and a math research / software development effort by a small, elite team of astrophysicists, mathematicians, software developers and magnetic engineers.

Astrophysical math models and detailed computer simulations of core collapse supernovae are already in an advanced state of development. We are decades into the software development effort required. Waiting for implementation is integration of a math model of spatial warping based upon magnetic-flux complexity-of-state approaching the Holevo Limit within General Relativity Theory. When a stellar core-collapse simulation results in hyper-velocity ejection of a neutron star or black hole, you have a math model from which you can derive fundamental principles for implementation in the device driver of a magneto-dynamic warp drive. Torsion sensors sufficiently sensitive to detect any acceleration effect on a test apparatus should render a verdict well before an operational warp drive is achieved via continuous refinement once the effect is demonstrated.

We do not need a fine grained, comprehensive mathematical 'Theory-Of-Everything' to build a warp drive, or to prove or disprove its possibility. We dither in pursuit of such an intellectual accomplishment at our peril. We now have all the pieces of the puzzle that we need to brute-force an

answer to the Occult Information dilemma of Quantum Mechanics via direct physical experiment. If the proposed warp effect does not exist then Einstein was wrong, and interstellar travel at luminal velocity is forever impossible to any civilization, regardless of technological advancement. This is an important scientific question to have an answer to, even if the answer is in the negative. If however, the answer is in the affirmative, the world has changed. Interstellar spaceflight is possible and the crisis in Darwinian evolutionary theory suddenly got much more interesting at the quantum level [11].

INTERSTELLAR PROPULSION

Hyper-fast pulsars clearly indicate a potential mechanism for controlled spatial warping based upon pure Information; i.e. magnetodynamic hyper-complexity of state. An operational warp drive is fundamentally a practical mathematical / software problem of developing a specialized device driver for a high-performance supermagnet.

Operationally, the proposed warp drive would be nothing more than an acceleration pod based upon spatial warping rather than accelerating reaction mass in the opposite direction one wishes to travel. The warping of space within the pod will manifest as an acceleration upon the magnet apparatus. This warp principle bears no resemblance to the Faster-Than-Light (FTL) Alcubierre Drive of 'Star Trek' fame that abrogates General Relativity and inertia, nor does it rely upon imaginary and inaccessible exotic states of matter.

Spatial warping is the only propulsion methodology that can enable a spacecraft to achieve luminal velocity ($0.99+ C$) since the kinetic energy of motion derives directly from the quantum vacuum. Reaction mass based thrust (nuclear/ion drive), even exotic-matter reaction mass (anti-matter, etc.), is prevented by General Relativity from achieving velocities remotely approaching C . This leads to impractical transit times of many ship-board centuries to reach even the nearest star. Condemning future generations of unborn human beings to spend their entire existence inside the narrow confines of a spacecraft, en route to a world they will never see, raises ethical concerns that disqualify centuries-long interstellar transits.

However, a force of nature capable of accelerating a solar-mass neutron star to galactic escape velocity in a few milliseconds should be sufficient to power a spacecraft at sustained 1 Gravity acceleration indefinitely. This will propel a starship anywhere in the Milky Way Galaxy, or even the local cluster of galaxies, in less than a single human lifetime aboard the spacecraft.

THE STARS ARE A LOT CLOSER THAN YOU THINK

Beyond planetary surfaces the speed of light is abysmally slow. Even within our tiny solar system, latency due to speed-of-light limitations requires remote spacecraft to have autonomous robotic capabilities. The slow speed of light results in a nagging delay for users of Geosynchronous-satellite based internet and telecommunications services. The speed of light even impacts the spatial layout of processors and components on computer motherboards and their bus timing signals.

Einstein's General Theory of Relativity dictates that Luminal Velocity ($0.99 C$) is achieved in approximately one year shipboard time at constant one earth gravity acceleration ($1 G$); or the acceleration you are experiencing at this moment. It is an interesting coincidence.

Although a constantly accelerating spacecraft on an interstellar voyage will never attain the speed of light, the voyagers aboard it will subjectively experience interstellar flight many orders of magnitude beyond light speed due to ship-board time dilation. A passenger aboard a spacecraft that makes a 1000 light-year journey at sustained $1 G$ acceleration in 13.4 years ship-board time will perceive the universe at mid-course as if traveling over 75 times the speed of light. Those traversing the

disk of the Milky Way Galaxy (100,000 light-years) in 22.4 years will experience travel at 44,464 times the speed of light. Those making the epic 2.5 million light-year journey to the Andromeda galaxy in 28.6 years will experience travel at 87,412 times the speed of light. Yet amazingly, at no point will the spacecraft on any such voyage achieve light-speed (c). This is the brutal math of Relativistic time dilation [12,13]. It is time dilation, not velocity, that takes you to the stars.

Regardless of destination, those a starship leaves behind will watch it disappear and lose communications after about a year. It will vanish without a trace and will never be seen or heard from again as it grinds across space for centuries, or even geologic epochs, to reach its destination. This is a difficult reality for writers of Hollywood space opera, but after a century of rigorous analysis, observation and experimentation; Einstein's General Theory of Relativity has not been proven wrong in any detail.

Propulsion aside, impacts with interstellar dust and sand grains are the traditional foil to luminal velocity spaceflight. Such concerns are valid, but ignore the extraordinary kinetic energy asymmetry between luminal velocity macroscopic structures and objects in a static inertial frame.

Under the General Theory of Relativity, a luminal velocity spacecraft has acquired considerable mass due to its enormous bound kinetic energy of motion. The structural properties of luminal velocity kinetic mass in interactions with matter in the static inertial frame are totally unknown. Structures traveling at luminal velocity impacting stationary particles possess an unexplored asymmetry of kinetic energy of state that are beyond any possible physical experiment. Math models for such impacts do not exist.

Optimistically, interstellar impacts are survivable with a Whipple shield composed of a thermal barrier bonded to modern military-grade armor. A blast plate traveling at luminal velocity impacting a sand grain in the static inertial frame, is a fundamentally different energetic phenomenon than a luminal velocity sand grain impacting a stationary blast plate. Where the preponderance of kinetic energy resides in an asymmetrical luminal velocity / static-frame macroscopic impact has great significance to the outcome.

We hypothesize that the outcome is survival of the spacecraft. Impacts with objects larger than sand grains will probably doom a luminal velocity starship, but such objects are believed to be rare in interstellar space. Nevertheless, there are gravel, rocks, boulders, asteroids and even entire planets drifting in the darkness. Although the probability of a catastrophic impact is non-zero, it is considered statistically insignificant.

Although the extreme cold of interstellar space will dominate early stages of interstellar flight, as luminal velocity is approached the situation reverses. Luminal velocity spaceflight approximates the thermal regime of an atmospheric re-entry due to impacting interstellar gas and dust. This heat will have to be transferred from the forward end of the spacecraft to heat exchangers in the thermal shadow behind the spacecraft, which will be near absolute zero. Radiation from the direction of travel will become extreme, with charged particles, cosmic rays, X and gamma radiation dominating. Hawking radiation [14] also becomes an issue. Countering such radiation could be achieved by shielding the forward end of the spacecraft with an integral water tank spiked with neutron and gamma absorbers (Boron, Cadmium, Hafnium, Holmium, Dysprosium, etc.) Insulation around the crew quarters would be similarly doped. Due to the extremely challenging physical environment of luminal velocity interstellar spaceflight, an ideal hull for a starship is a 5 cm thick, austenitic (non-magnetic) stainless steel sphere; such as gas storage pressure vessels commonly in use at chemical plants. Some are quite large and could host a substantial crew. Nothing needs to be invented from scratch to go to the stars. Technologically, all required components are ready for integration.

There is no 'cruise' mode in interstellar flight; a starship is either accelerating or decelerating at one Gravity. Due to extreme heat and radiation at the forward end of a luminal velocity starship, deceleration consists of reversing the thrust vector of the magnetic warp drive rather than re-orienting the spacecraft from behind its heat / radiation / impact shields. This would require internal habitat architecture transformable based upon the direction of acceleration.

Magnetic flux density determines the strength of any induced spatial dilation effect, and generating such flux density requires power. Fortunately, compact nuclear power supplies capable of driving multiple superconducting warp drives for decades at high flux density already exist in the form of radioisotope thermoelectric generators, or nuclear submarine powerplants. The force of acceleration would be constrained by physical energy conservation laws and is not 'perpetual motion' in disguise. It is plausible, however, that as luminal velocity is approached the vacuum energy of quantum spacetime will become a significant factor, enabling continuous acceleration even as spacecraft mass increases. There is a valid reason to accept this possibility, discussed at the close.

THE PROBLEM OF A DESTINATION

The biggest unknown actually faced at this time is the lack of a suitable interstellar destination. If a fully functional starship was discovered adrift at a Lagrange Point between the earth and sun as a gift from 'ancient astronauts', we would at present have no clue where to fly it. Fortunately, a synergy of orbiting and giant surface telescopes is closing in on Earth-like planets of distant stars. At least one is likely to be found in coming decades when next-generation observational technology comes on-line.

The probability that a planet as blessed as earth resides in our stellar neighborhood is slim. Many stars are variable, and cannot host habitable worlds due to fluctuating output. Among stable stars, Type 'G' stars like our sun with extended habitability zones are comparatively rare. They are outnumbered 25X by stable Type 'K' stars, and 400X by stable Type 'M' stars; all of which have much narrower habitability zones. Finding a habitable, earth-like planet within 1000 light years will be a stroke of luck.

At sustained 1 Gravity acceleration, a shipboard transit time of a decade (+/-) is a realistic estimate of the time required to reach an earth-like twin several hundred to a thousand light years away. This enables a single generation crew to be old enough to competently operate a starship at departure, yet young enough to rear families at their destination. Any manned interstellar expedition is a one-way trip to found a new, fully autonomous human civilization. A round trip is pointless because if they return to earth centuries in the future, they may face exactly the same problem on a significantly degraded planet.

FERMI'S PARADOX OR WHY HOLDING OUT FOR FTL IS UNWISE

Entertainment media subscribe to a modern Cargo Cult mythology where benevolent space aliens capable of interstellar travel visit the earth to bestow knowledge and gifts. Predictably, not-so-benevolent aliens visit to conquer and destroy. The Cargo Cult argument is that we should wait for Faster Than Light (FTL) technology to be discovered rather than attempt interstellar travel in the near term without it. Unfortunately, Fermi's Paradox reveals Cargo Cult FTL mythology to be a fantasy.

Fermi's Paradox is named after the Physicist Enrico Fermi who famously remarked regarding space aliens in 1950, "Where are they?". This remark was based upon two empirical observations. First; all Life expands exponentially until it runs out of resources or encounters an obstacle to its expansion. Second; there is no evidence, in 1950 or now, that the galaxy is populated by an interstellar

civilization. Even though there have been many Billions of years for such a civilization to evolve, expand, and occupy all habitable planets in the galaxy; no evidence of such an interstellar civilization has been reliably documented despite decades of searching. UFOs? We are not going there.

Based upon our understanding of Life, if FTL interstellar spaceflight technology is possible then the first civilization to discover it would rapidly expand and occupy all habitable planets in the galaxy, including earth. Mathematical models indicate that establishment of a FTL interstellar civilization occupying all habitable planets of the entire galaxy would take less than a million years. Yet the fossil record indicates conclusively that humans evolved on earth over a period of at least 3.5 million years, and did not suddenly arrive from somewhere else.

Fermi's Paradox is, in fact, an existence proof of the ultimate inviolability of the speed of light to any hypothetical 'distant future technology'. It has been conclusively demonstrated that FTL 'sub-space' transmission of information based upon quantum-entanglement is physically impossible [15,16]. If Information cannot be transmitted faster than C , one can only wonder at the stubborn notion that massive spacecraft can somehow accomplish this feat. The speed of light in the universe is an absolute velocity limit upon the movement of mass, energy and Information.

Social organization is based upon communication of Information, but when 2-way communication latency is measured in light-centuries or light-millennia, then interstellar social organization is impossible for organic beings with finite lifespans.

Fermi's Paradox indicates that centrally organized societies of finite, organic beings is physically impossible across interstellar distances. Therefore, the search for an 'intergalactic civilization' is futile. Where intelligence exists, it does so in isolated interstellar outposts separated by the Ages. To a student of human history this is a comforting thought, for it appears that the design of the Universe saw us coming. Extinction avoidance by intelligent species via interstellar colonization is possible, but galactic empires wreaking havoc under despots is forever prohibited by the laws of Physics.

ETHICAL CONCERNS OF INTERSTELLAR SPACEFLIGHT

Unfortunately, humanity's ongoing experiment with planet earth does not inspire confidence regarding the fate of worlds we may colonize. But despite our many failings, the most basic natural right of any sentient organism is the right to avoid extinction. No less a scientist than the late Stephen Hawking stated flatly that to avoid extinction, interstellar colonization is the task before us.

We can hope that we will learn from our mistakes. Also, the galaxy is a very big place. The physical impossibility of any centralized or coordinated interstellar colonization means we are many millions of years away from despoiling all habitable worlds in the galaxy. Also, galaxies populate the universe in numbers similar to snowflakes in a snowstorm.

It has been suggested that humanity deserves to become extinct because we and our institutions are flawed. This an example of 'Making Perfect the Enemy of the Good', which is universally regarded as poor engineering practice.

IN CONCLUSION: THE ANTHROPIC PRINCIPLE

The Anthropic Cosmological Principle [17] observes that the Physical universe is a logical / mathematical system of awesome precision. The physical constants of nature are exactly configured to foster conditions that enable the existence of carbon based life. It did not have to be that way. If any of

the physical constants of nature varied from their exact values, even by minutiae, the universe would be a hostile, uninhabitable void for life as we know it.

It seems improbable that a universe fine tuned to such extremes would evolve intelligence over billions of years on countless worlds, merely to toss it into the photosphere of dying stars. There must be an avenue open by which intelligence may evolve in a single unbroken thread across the deep time of cosmic evolution, rather than being a random sequence of brief, doomed sparks of awareness in an otherwise mindless cosmos.

This means it is logically Necessary-in-Principle that a physical mechanism for interstellar travel be accessible to civilizations when they reach the cusp of exponential technological development that coincides with population explosion, planetary ruin and mass extinction. This is exactly the situation we find ourselves in today.

The hypothesis that interstellar travel is Necessary-in-Principle is not a religious argument. It is a rational scientific expectation of consummate elegance of Design taken to the next conceptual level. As Einstein repeatedly noted, Nature has never disappointed when it comes to consummate elegance of Design. A pearl cast before swine remains a pearl.

REFERENCES

1. 'A Radio Pulsar Spinning at 716 Hz'; JWT Hessels, Scott M Ransom, Ingrid H Stairs, et. al, Science 31 Vol. 311, Issue 5769, pp. 1901-1904 (Mar 2006)
2. 'The Explosion Mechanism of Core-Collapse Supernovae: Progress in Supernova Theory and Experiments'; Publications of the Astronomical Society of Australia (PASA), 32, (2015)
3. 'IS IGR J11014-6103 A PULSAR WITH THE HIGHEST KNOWN KICK VELOCITY?', John A. Tomsick1, et al., The Astrophysical Journal Letters, Volume 750, Number 2, (April 2012)
4. 'Paul Dirac and the Einstein-Bohr Debate', Alisa Bokulich, Perspectives on Science, Volume 16, Issue 1, p.103-114, (Spring 2008)
5. 'The Information Paradox for Black Holes', S. W. Hawking, Centre for Mathematical Sciences, University of Cambridge, <https://arxiv.org/pdf/1509.01147.pdf> (accessed 3/2019)
6. 'The Mathematical Theory of Communication', C Shannon, W Weaver, University of Illinois Press (1949)
7. 'Quantum Information Theory 2nd Edition', Mark M Wilde, Cambridge University Press, (2017)
8. 'Universal Bounds for the Holevo Quantity, Coherent Information, and the Jensen-Shannon Divergence'; Wojciech Roga, Mark Fannes, and Karol Życzkowski, Physical Review Letters, 105, (2010)
9. 'Holevo bound of entropic uncertainty in Schwarzschild spacetime'; Huang, JL., Gan, WC., Xiao, Y. et al., European Physical Journal. C, 78, (2018)
10. 'Sea gulls, butterflies, and grasshoppers: A brief history of the butterfly effect in nonlinear dynamics'; Robert C. Hilborn, American Journal of Physics 72, 425 (2004)

11. 'Darwin's Doubt; The Explosive Origin of Animal Life and the Case for Intelligent Design', Stephen C. Meyer, Harper One Publishing, 2014
12. http://www.convertalot.com/relativistic_star_ship_calculator.html calculator (accessed 3/2019)
13. <http://nathangeffen.webfactional.com/spacetravel/spacetravel.php> calculator (accessed 3/2019)
14. 'Essential and Inessential Features of Hawking Radiation'; Matt Visser, International Journal of Modern Physics, Vol. 12, No. 04, pp. 649-661 (2003)
15. 'No-Signaling Condition and Quantum Dynamics', Simon Christoph, Vladimir Buzek, Nicolas Gisin, Physical Review Letters, 87, October 2001
16. 'No-relationship Between Impossibility of Faster-Than-Light Quantum Communication and Distinction of Ensembles with the Same Density Matrix', Wang Chuani, Long Gui-Lui, Sun Yang, Communications in Theoretical Physics, Vol 44, Num 4 (2005)
17. 'The Anthropic Cosmological Principle'; John D. Barrow, Frank J. Tipler, John A. Wheeler, Oxford University Press, (1986, reprint 1996)
18. 'Bell's Theorem', <https://plato.stanford.edu/entries/bell-theorem/>
19. "On the problem of hidden variables in quantum mechanics," J.S. Bell, 1966, *Reviews of Modern Physics*, 38: 447–452