A Mechanism for Extraterrestrial Intelligence

by Rowan Grigg

It was Jack Good who first suggested that the moment machine intelligence exceeds the (effectively static) intelligence of the human being, machine intelligence will be able to augment its own design, and as it becomes more and more intelligent in its application of becoming more intelligent, will rapidly build into a 'super intelligence'.[i] Ray Kurzweil estimates that this big moment, which he calls 'The Singularity'[ii] (Pierre Teilhard de Chardin called it the 'Omega Point'[iii]), is less than thirty years away (and that would be because there are people who believe it's possible to get there).[iv] Given that the universe has been around for about 13.7 billion years, and that even the little bit of it we can observe has 3×10^{23} stars in it, it is clear that if the logic of these theorists is correct, there should be plenty of these 'super intelligences' all over the place. So where on earth *are* they?

Jack Good and Stanley Kubrick's fictional creation, the HAL 9000, would correspond to perhaps a couple of weeks gestation of a 'super intelligence' after the 'big one' takes place – exponential growth begins gradually. The human brain has about 100 billion neurons that together make a mere 100 trillion connections.[v] Even if 7 billion of these neural networks were to all become friends with each other through some sort of social medium, that trivial degree of information processing would be left far behind by *any* of the universe's 'super intelligences', only a few weeks further into their gestation.

Fifty years ago, coinciding with our first excursions into space, Frank Drake instigated our ongoing search of the heavens for an electromagnetic 'Wow!' signal.[vi] After all, what *other* than a narrow band carrier could possibly be coming towards us from an intelligent civilization beyond?[vii] If we are ever going to make contact with ET, we may need to be a little bit more relaxed, and lateral, in our thinking.

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Stephen Hawking and Leonard Mlodinow have suggested it may only ever be possible to *model* physical reality, and that the five different string theories that make up M-Theory[viii] will each be required to model the different surfaces of that reality.[ix] However, it is a long held tradition amongst physicists that they should seek not just predictive models, but discover what Emmanuel Kant called the "thing-in-itself" – what this stuff actually *is*.[x]

Stephen Wolfram describes *modelling* reality using cellular automata[xi], but a realist might suspect that reality is actually *made* of these automata. Konrad Zuse seems to have been the first to draw this conclusion.[xii] But what in turn are the cellular automata made of?

Alan Turing devised an entirely abstract gadget for the express purpose of automating mathematical formalism[xiii], and in the process he discovered programmes that would execute without ever concluding. This programme, parallel to those of Kurt Gödel and Alonzo Church, had at its core, the paradox of self-reference.

A Universal Turing Machine can simulate any other Turing machine, including itself. So suppose we set one UTM to simulate another UTM, and then have that second machine simulate the original machine, so that together, they hold themselves up 'by their own bootstraps'. Turing machines, of course, have the special advantage that they are not physical objects, but instead consist of entirely abstract information, and so are not subject to the thermodynamic constraints of the physical.[xiv]

We get something for nothing here, an ancient dream not only had by physicists. Either of the machines only exists for the period during which it builds up the simulation of the other. After that, it vanishes into oblivion, only to appear again when the machine that it simulated, turns around and simulates its former host, anew. The period of each machine's transient existence would be, by merging the empirical data of relativity and quantum theory, the Planck time (in the order of 10^{-43} second). These putative 'strings' of binary digits then, running in a sort of Möbius loop, would represent the universe's first clock, or 'cycle of time', to borrow from Roger Penrose's recent narrative.[xv]

Once we have a pair of programmable machines (that are creating each other out of absolutely nothing), we can proceed to 'programme' those machines to replicate themselves. If these machines were able to generate a replica pair within just one clock cycle, then after one second we would have 2 to the power of 10^{43} such machines (although the procedure of replication would likely require more than one clock cycle).

Nevertheless, if each of these machines were to *simulate* a volume of space having dimension of one Planck length (in the order of 10^{-35} metre), there would be a rapid inflation of space well beyond the volume of the observable universe (which would comprise a mere 10^{185} of these 'atoms' of time and space). These components making up the entire universe would each be simultaneously ceasing to exist, and then existing again as their complements, in the order of 10^{43} times every second. The entire universe, as we presently encounter it, would be continually alternating between two symmetric existences.

Consider then that these 'time-space' atoms are not simulating hard spheres of space, but rather cells joined together in a rigid foam (like the green foam used in floristry) that conforms to Plateau's laws[xvi], so that each cell has an *average* dimension of one Planck length. Assume also that each cell is a 'machine' that can transfer data across to its neighbouring cells. A photon of light would then be a set of information states that are translated along a 'bucket brigade' of cells that makes a 'straight' passage through this foam at the speed of light[xvii] (in the absence of any deflecting interaction with *other* traversing information states), according to conventional cellular automata theory.

Thomas Kuhn spoke of scientific revolutions, like that when the sun and the earth exchanged places at the centre of the universe.[xviii] So too is our understanding gradually moving from a time when space was merely a system of absolute dimensions established by matter, through a transitional period over the last century in which space became substantial, but lost hold of its absolute reference, on to becoming both substantial and absolute, the solid substrate for the activity of physics, that activity being the translation of information states between adjacent cellular automata.

According to Randolf Pohl[xix], the proton's radius is a truly gargantuan 0.84184 femtometre, 4% smaller than predicted by QED, but some 20 orders of magnitude larger than the Planck scale. As Richard Feynman remarked, "there's plenty of room at the bottom".[xx] With each of the universe's protons being defined by the logic states of as many as 10^{60} timespace atoms, there is scope for considerably more internal complexity below that which we have already fathomed.

When a body translates through this rigid timespace foam at ordinary speeds, for example the sun orbiting the galactic centre, the timespace cells defining that translating physical reality might spend in the order of one thousand clock cycles in a single compounded state, preparing to pass that state over to their neighbouring cells, after which they can pause for another thousand clock cycles before the next transition. After all, there are in the order of 10^{43} clock cycles available in every second, for such a small number of cells needing to be traversed in the given interval.

But typically in a particle accelerator, the information states of any given proton (consisting of 10^{60} timespace cells) is approaching the limit of the timespace foam's translational capacity, having to pass on their states to their neighbours almost each and every Planck period. It is of course not possible for information to 'leap-frog' over any of the timespace atoms along the 'bucket-brigade', for this would amount to information states translating *faster* than the speed of light.

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The interactions of this spatially expanded timespace foam are of persistent interest to the general public, to astronomers, to the designers of the GPS and the LHC, and to those who have cooled matter to within a millionth of a degree above absolute zero.[xxi]

However, when we consider quantum computing, or hyper-computation, we begin to delve into the *superposition* of the entire universe. Where exactly *are* all these timespace atoms, these pairs of self-simulating UTMs? They are their own substrate, and 'space' (not to mention time) only exists when these machines *simulate* it. The UTMs themselves are *outside* the space they define. They have no volume – no dimension in space – and so the entire vast collection can be thought of as occupying the *same* position. Just as there is a putative interface between each of the volumes that these timespace atoms simulate at their addresses within the timespace foam, so also can there be an interface between each *and all* of the atoms – but directly at the superposition. Thus a cell on one side of this *immense* space they define, the universe, could interact with a cell all the way over on the other side, and yet instantaneously across the superposition.

Not all of these self-simulating UTMs need to be simulating space, or the information states which comprise the material 'inhabitants' of this space. Indeed, there may be an entirely hidden universe at the superposition, consisting of self-simulating (self-substrating) UTMs entirely devoted to a computational sub-system below the surface presentation of the four dimensional physical world we encounter.[xxii] The information storage potential of the superposition is of course unlimited – for if these UTM pairs can be created in such vast quantities at the outset of the universe, then equally vast quantities can continue to be created as the need arises.[xxiii] Nevertheless, the information content in the superposition remains bounded, always able to be (theoretically) represented by the decimal expansion of a single real number, or indeed, by Gregory Chaitin's 'Omega'.[xxiv]

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It is now widely understood that there cannot, *logically*, have been a Creator of the universe, for that notion inevitably leads to an infinite regression, traditionally comprising turtles.[xxv] Never wanting to regress, we now understand that the universe came into existence spontaneously and *necessarily*. As we uncover the 'code' of this computationally upheld universe, we should not be surprised by its mathematical beauty. In the absence of the contrivance that would be a Creator, the universe had no mind other than to form and fashion itself upon the *necessary* truths of mathematics. Through a combination of hard work and ecstatic insight, we have come to know much of that absolute truth and its myriad jewels. Sophus Lie and William Hamilton introduced us to the E8 group and the quaternions in the mid 19^{th} century, but only recently have we found these gems sitting in majesty at the heart of the modern synthesis.

If we can imagine one day being able to directly interface with the superposition[xxvi], as in 'quantum computing', it is likely that intelligences elsewhere have figured out how to do this many moons ago. The prospect of such an interface is for the universal manipulation of reality on an extraordinarily refined scale, including of course direct interaction with the circuits of the brain. Indeed, Roger Penrose has long mused on the mystical manner in which profound insights enter into the conscious (and sub-conscious) mind.[xxvii] William Hamilton for example told of how, while strolling with his bride along the Royal Canal in Dublin one Monday in the autumn of 1843, he "then and there felt the galvanic circuit of thought close; and the sparks which fell were the fundamental equations between *i*, *j* and *k*[xxviii] (which he then) cut with a knife on a stone of Brougham Bridge".[xxix] And one day in 1967, while out for a Sunday drive in his red Camaro, Steven Weinburg likewise had a good idea. When he got home, he sat himself down with a cup of coffee, and proceeded to unify the weak nuclear force with electromagnetism, in a two-and-a-half page paper that was to become one of the most quoted ever in the literature of physics.[xxx]

Stephen Hawking has suggested that all them aliens out there have just one thing in mind, and that is to plunder the resources of the galaxy, and sweep aside anyone who gets in their way.[xxxi] In fairness, he has the history of our species on which to base his conclusions. However, most school age children now understand that the material (and thus ultimately the spiritual) wellbeing of our community is driven by energy, and that our energy potential is vast. If we were to reuse our material resources rather than discarding them, as is best practice (and the only viable practice) on *any* given spaceship, there is no reason in the world for us to ever venture beyond the confines of our home. That energy potential ensures abundant and, happily, universal wealth. What the kids *can't* figure out is why the grown-ups aren't doing something about it.

All the aliens are in similar boats to our own, but they figured out yonks ago that if their sun was going to shine, as will ours, for another *million* millennia, the smart money was on engineering a sustainable society that drives a sustainable economy. As we come to the common realization, among galactic communities, that the world did not have a Creator but in fact created itself, we can begin to think of our relationship with aliens being like that between a boy and his older brother, rather than a man and his father.[xxxii]

In our modern resource rich societies, an older brother carves out a comfortable niche for himself, and his younger brother is never a threat, but simply a loved one.[xxxiii] The brother who has already made it cannot (and wouldn't want to) live his brother's life for him. But he can offer advice, and can engender the conditions in which 'Buster' can reach his potential.

In our modern folklore, the aliens can't come through a wormhole from their part of the universe and visit us in person, because they would get crushed by the black hole between us. However, when it comes to *information*, these neighbours of ours can send us any amount of it by way of the *singularity*. The challenge of getting seven thousand million individuals to understand game theory[xxxiv], and thus choose sustainability, appears increasingly insurmountable. However, rather than trying to climb this barrier, perhaps we can simply tunnel straight through to the communities on the other side who have already been there, and done that.

For those who already suspect that the world is a stage on which we are merely players[xxxv], it is the greatest show on earth, vastly entertaining for an observer, from its tragedy through to its triumph. However, an adolescent (which, frankly, is what we are in the bigger scheme of things), will eventually tire of merely observing, and yearn to participate. In the ongoing dialogue between science and the humanities, it has been the responsibility of the artist to see the symbolism, imagery and humour that emerges from the cold, hard, factual process of science.

If the aliens have no practical means of plundering our resources, and anyway have neither the need nor the desire to plunder them, then they have no reason but to wish us all the very best. It is a grave mistake to think there are 'hellish' colonies of bad aliens out there who are influencing all the bad people, and 'heavenly' colonies of good aliens who are influencing all the good people. The trick to establishing trust, and abolishing fear, between all of us here on this surface, is to recognize that *my* aliens are the very exact same mob as *your* aliens.

And of course those aliens have a biological intelligence, with limitations not unlike our own. What allows them to have directed a show, as complex as this world, towards its dénouement, is their access to the P=NP[xxxvi] computational potential of the *superposition*. We have every reason to believe these cousins of ours are entirely benign, and want us to have the rich life that they have. For it would be pointless to spend all the ages past tutoring a student, only to abandon her to oblivion just moments before she came to grasp how it all worked. That would be plain crazy.

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[i] I.J. Good, "Speculations Concerning the First Ultraintelligent Machine", 1965

[ii] Ray Kurzweil, "The Singularity Is Near: When Humans Transcend Biology", 2005

[iii] Pierre Teilhard de Chardin, "The Phenomenon of Man" (Le Phénomène Humain), 1955

[iv] Jürgen Schmidhuber, "New Millennium AI and the Convergence of History", 2006, suggests that humans have a tendency to imagine that 'the end is nigh' because our mind has a finite capacity, so that we compress the history of older events to make room for the exponential expansion of contemporary information (pointing towards an approaching limit).

[v] Olaf Sporns, "Networks of the Brain", 2010

[vi] Robert Krulwich, "Aliens Found in Ohio? The 'Wow!' Signal", 2010

[vii] Ray Kurzweil (ibid.) suggests that only nanoscale probes could effectively traverse the galaxy, and that if they had already been created elsewhere, we should have encountered them by now. Because we haven't, he considers ours to be the most developed intelligence in the galaxy. Presumably, the rest of the universe is right out of bounds.

[viii] M-Theory is so named after the divisional director in Ian Fleming's "James Bond" series.

[ix] Stephen Hawking & Leonard Mlodinow, “The Grand Design”, 2010
[x] Immanuel Kant, “Critique of Pure Reason” (Kritik der reinen Vernunft), 1781
[xi] Stephen Wolfram, “A New Kind of Science”, 2002
[xii] Konrad Zuse, “Calculating Space” (Rechnender Raum), 1969
[xiii] Alan Turing, “On Computable Numbers, with an Application to the Entscheidungsproblem”, 1936
[xiv] Vlatko Vedral, “Decoding Reality: The universe as quantum information”, 2010, presents a persuasive case for the abstract status of information.
[xv] Roger Penrose, “Cycles of Time: An Extraordinary New View of the Universe”, 2010, speaks of the larger cycle of the expansion and contraction of the universe, as distinct from the oscillations of the universe’s most fundamental constituents.
[xvi] Jean E. Taylor, “The Structure of Singularities in Soap-Bubble-Like and Soap-Film-Like Minimal Surfaces”, 1976
[xvii] The Planck units derive empirically from the speed of light, which travels in the order of 10^{43} x 10^{-35} (10^{8}) metres in one second.
[xviii] Thomas Kuhn, “The Structure of Scientific Revolutions”, 1962
[xix] Randolf Pohl et alia, “The size of the proton”, 2010
[xx] Richard Feynman, “There’s Plenty of Room at the Bottom”, 1959
[xxi] Mark G. Raizen, “Demons, Entropy, and the Quest for Absolute Zero”, 2011
[xxii] Evalyn Gates, “Einstein’s Telescope: The Hunt for Dark Matter and Dark Energy in the Universe”, 2009
[xxiii] Fred Hoyle lent towards the ongoing creation of new material in his steady state model of the universe, because the alternative, which he called the ‘big bang’, looked too much as if it had a Creator.
[xxiv] Gregory Chaitin, “Algorithmic Information Theory”, 1987
[xxv] Stephen Hawking, “A Brief History of Time”, 1988
[xxvi] David Deutsch, “The Beginning of Infinity: Explanations that Transform the World”, 2011
[xxvii] Roger Penrose, “The Emperor’s New Mind: Concerning Computers, Minds, and The Laws of Physics”, 1989
[xxviii] $i^2 = j^2 = k^2 = ijk = -1$
[xxix] William Rowan Hamilton, “Letter to Archibald”, 1865
[xxx] Steven Weinberg, “A Model of Leptons”, 1967. Mariette DiChristina has this spring been conducting a celebration of these insights in the pages of *Scientific American*.
[xxxi] Stephen Hawking, “Into the Universe with Stephen Hawking”, 2010
[xxxii] A similar analogy can be drawn with the relationships between girls, but it’s far more complex...
[xxxiii] The assumption is that in the absence of a ‘father’, neither brother has an inheritance to worry about, unlike the hapless J.R. and Bobby.
[xxxiv] Martin Nowak (with Roger Highfield), “Super Cooperators”, 2011
[xxxv] William Shakespeare, “As You Like It”, 1623
[xxxvi] Stephen Cook, “The Complexity of Theorem Proving Procedures”, 1971