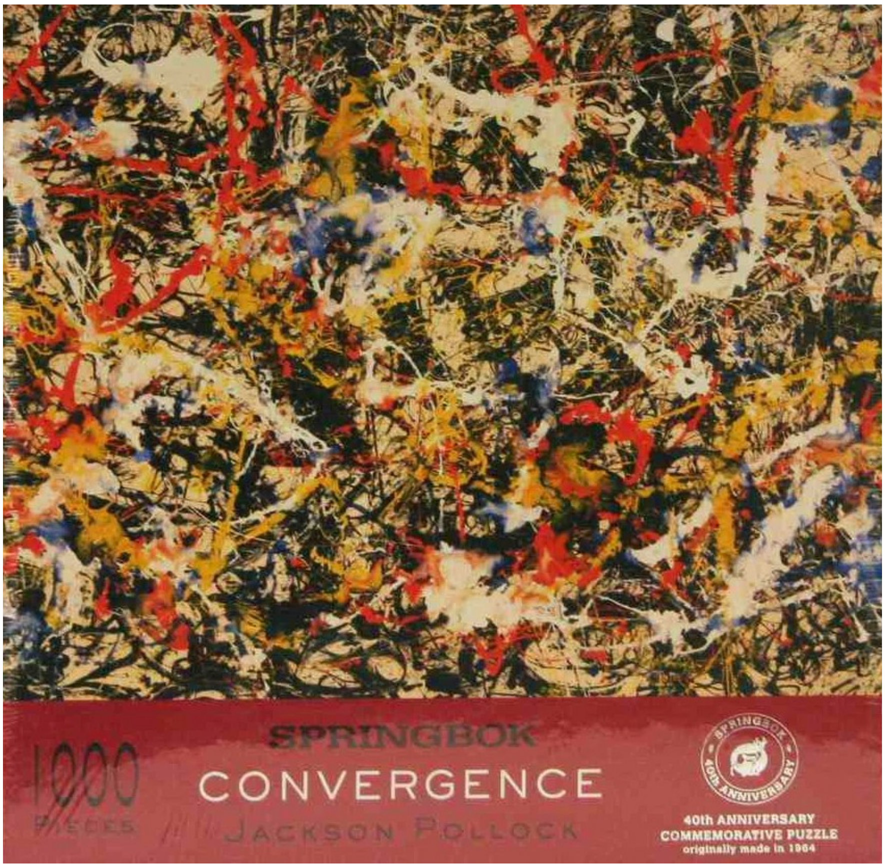
Chauncey's Dreams

by Rowan Grigg

When a family settles down after Christmas lunch to solve a 1000 piece jigsaw puzzle of an abstract work like Jackson Pollock's *Convergence*, we first establish the boundaries, then each of us begins the assembly of individual pieces into fragments. Occasionally, when leaning back to scan the entire field, someone will glimpse a connection between two fragments and reach across everyone else to merge them, to the delight (or occasionally the annoyance) of those who previously had ownership of the problem.



Steven Weinberg wrote a short paper[i] in 1967 proposing the unification of electromagnetism and the weak nuclear force, advancing the Standard Model of particle physics in just such a leap. With the recent detection, in high probability, of the Higgs boson, the progenitors of the Standard Model are rightfully congratulated on their achievement.

I do not profess to be a mathematician or a physicist, but I do enjoy the stories told by those working in these fields, and looking, without the prejudice of deep understanding, for patterns in what they have to report. Great though *Convergence* may be, it was not Pollock's only masterpiece, indeed I would argue that *Blue Poles* advances the art by superimposing structure on the abstract. Every age establishes a paradigm informed by the dominant technology of their era – Isaac Newton's *clockwork* universe has become today's *computational* universe.

Weinberg, commenting in 2002 on one such computational model of the universe, suggested that those who study the workings of computers, day in, day out, would perhaps be inclined to start thinking that the universe was itself a computer – "So might a carpenter, looking at the moon, suppose that it is made of wood."[ii] But of course many a foundational thinker (including Weinberg himself) is just so inclined – for example in 2008, Max Tegmark, a mathematical physicist, argued that the universe is literally 'made out of mathematics.'[iii]

In 1936, Alan Turing demonstrated that all decidable mathematics (encompassing the mathematics with which we model the universe) could be computed.[iv] Computation, or more formally the lambda calculus[v] as developed in parallel to Turing by Alonzo Church, has since been considered more foundational than mathematics. At the deep basis of reality, we should be looking for the most primitive computation, rather than the most primitive equation, to emblazon our T-shirts. Despite his unfortunate demeanour, we should not throw out the baby with the bathwater – Stephen Wolfram must be credited with having elucidated this entity, a 2-state 3-symbol Turing machine, (and with having enticed Alex Smith to prove its universality).[vi]

Through various schemes, some speculative, some rigorously confirmed, we have

(…) → Computation → Mathematics → Physics → Consciousness → Artificial Computation → Artificial Mathematics → Artificial Physics → Artificial Consciousness → (…)

and this garden path (were it to be established in fact) could lead us on for ever and ever.

In 1990, John A. Wheeler saw a clear opportunity to break this cycle, mounting an argument that the world consists entirely in information enacting the laws of physics – delivering 'it' from 'bit' – and that our consciousness creates the very reality from which it has emerged, in a self-referential loop.[vii] That last bit still has people scratching their heads. Indeed many schemes (not least Tegmark's Ultimate Ensemble) have employed the (ancient) notion of self-reference to avoid being foisted on an infinite tower of turtles. The latest victim of this (equally ancient) malaise of infinite regression is of course the 'multiverse', a spectre beckoning from beyond the Big Bang.[viii]

Exquisitely beautiful as many mathematical models of reality may be, we suspect they are idealized approximations to a reality that is fundamentally discontinuous. The E_8 Lie group[ix] employed by Garrett Lisi is a gorgeous creature, but the macroscopic fermions and bosons it is modelling present composite behaviour that emanates from machinations many (twenty) orders of magnitude downstairs at the Planck scale.

Solid modelling is the basis of artificial reality, and three spatial dimensions are of elegant sufficiency to allow us to emerge out of flatland. The ideal modelling method is *spatial occupancy enumeration*, where each cell (voxel) of a regular spatial grid is individually calculated in relation to its twenty-six neighbouring (cubic) voxels. However, this method is rarely used in practical modelling, because it is computationally verbose, requiring a large number of calculations in each cycle for every point within the simulated space.

Jürgen Schmidhuber has suggested that a simple Turing machine, executing a compressed algorithm, could compute the histories of all possible universes, subject to all possible computable laws.[x] Julian Barbour has argued that time is not a fundamental concept, but emerges from the process of change.[xi] Thus it does not matter how many steps are required to complete this 'ultimate' computation – execution in its entirety could manifest as just one 'instant' of time as we know it, and could be executed all over again within each subsequent instant.

The observable universe would contain about 8×10^{184} voxels[xii] if it were a simulation at the Planck scale, and spatial occupancy enumeration would become a practical method of rendering this universe if a computational core were assigned to each individual voxel (the number of voxels is, after all, *only* a number). Each core would only need to reference its immediate milieu, and Wolfram's 2,3 machine, a reduced instruction set computer, would be an ideal candidate for the job.

As a systems engineer, I work with virtual computers day in, day out, and not surprisingly I sometimes get to thinking that the universe might itself be a virtual machine. In the practical world of systems engineering, we of course understand that there is ultimately some real hardware behind all this virtualization, indeed that our virtual machines are merely hypervisors hovering precariously above the foundational hardware. But occasionally we will mount a virtual machine upon a host that is itself already virtualized. In doing so we get

Real → Virtual → Virtual

Such machines, embedded within other machines like Russian dolls, don't run very efficiently, because the real bit holding everything up is subject to the laws of physics, and gets rather hot. Yet despite all the hyperbole about Turing inventing the 'computer', Alan never intended his gadget to be made into a physical reality – he invented it as an abstraction for generating mathematics (albeit not all mathematics, as Gödel so elegantly demonstrated). As an abstraction, Turing's machine is not subject to the laws of physics, indeed it isn't physical at all. Thus a pair of *universal* Turing machines could be arranged such that they simulate one another, neither of them *existing*, in a very fundamental sense, until simulated by the other. We thus introduce self-reference to the most primitive element of reality, and get

Virtual ↔ Virtual

where previously there was *nothing*.

Gottlieb Leibnitz predicted the existence of this fundamental entity, calling it a 'monad' (Newton developed his 'fluxion' in parallel to Leibnitz).[xiii] John von Neumann proposed how such machines, which he called 'automata', might replicate.[xiv] And as already discussed, these monads might then enumerate each of the voxels of an artificial *reality*, giving us

Virtual ↔ Virtual → Real

The expansion of this virtual space, as each monad replicates, would be centred at *each* voxel, giving uniformity. The monad replication can become exponential, giving a space whose expansion accelerates. In 1969, Konrad Zuse described how these automata would engender a space that 'calculates'.[xv] The limiting speed (of light) is intrinsic to this architecture. The phenomenon we know as 'light' cannot be passed from one voxel to the next, across this virtual space, any 'faster' than the capacity of a monad to enumerate a voxel allows. The change in state of each voxel is a fundamental unit that manifests as 'time'.

In generating this virtual space, the monads engender lineal dimension where previously there was only abstraction. The vast bulk of mathematics is only possible after this linearity has arisen, starting with number theory from the one dimensional number line, to planar and spatial geometry and so on into higher dimensional geometry.

If the monad is an abstraction, having no intrinsic dimension, then it is perhaps fair to suppose that all the numerous (but countable) monads generating this virtual reality 'exist' at a single dimensionless point. Albert Einstein described such a point as a singularity, a 'place' where all spatial dimensions cease to exist. However, it is just as valid to think of this point as a *superposition* of the monads, a place where one massively parallel computer, burgeoning in capacity, engenders reality.

When researching and developing 'quantum computing', we should bear in mind that we may be accessing precisely this superposition of the universe. If the entire machinery of reality exists in one place, concurrent action at a distance no longer seems 'spooky'.

Jackson Pollock *Number 11* 1952 National Gallery of Australia, Canberra reproduced with permission

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[xii] Based on a universe radius of 4.4 x 10^{26} metres

[xiii] Leibnitz, G. (1695). "New System of the Nature of Substances and their Communication" Tuttle, Morehouse & Taylor, pp. 71-92

[xiv] von Neumann, J.; Burks, A. W. (1966). "Theory of Self-Reproducing Automata"

[xv] Zuse, K. (1969). "Rechnender Raum" translation "Calculating Space"