Determinant becomes unpredictable, uncomputable, and undecidable

by Bruce Camber

Abstract. A simple mathematical model of the universe defines a range of domains, the dynamics of which are determinant and are also understood to inculcate the following: decidability [1], computability [2], and predictability [3]. Then comes a range of domains, the dynamics of which transition to indeterminate, yet become a very real transmogrification to Undecidability [4], Uncomputability [5], and Unpredictability [6]. By applying base-2 exponentiation to the Planck base units, the universe is parsed within 202 notations wherein which those domains can be further defined. There is a domain of perfection with no quantum fluctuations and a much larger domain of imperfection where quantum fluctuations become dominant.

Introduction. A simple mathematical model of the universe was unceremoniously developed and posted on the web in 2011 from within a New Orleans high school. That model has 202 base-2 notations which start at the first moment of time, Planck Time, and goes to the current age of the universe, the Now or today. Initially considered to be a good STEM tool, it is now projected to be much more.

We are now projecting that within the first 64-notations, just below thresholds of physical measurements, there is a dynamic range of perfectly-defined domains, and then, an even more dynamic range that transitions between determinacy and indeterminacy. Current analyses of predictable, computable and decidable do not recognize these domains. Although very early to these studies of logic, we will attempt to discern what difference it might make in the grand scheme of things.

Planck base units. We begin with the Planck base units of time, length, mass and charge. *If their face values are taken as a given*, we ask the question, "What would the universe look like if the very first moment begins with the instantiation of those four values?" Of course, these values are the result of equations with additional values used by Max Planck to render his four basic numbers.

Consider the four equations and their numbers for space (length), time, mass and charge (Illustration 1).

- Planck Length: $\ell_P = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616\,229(38) \times 10^{-35}$ m
- Planck Time: $t_P = \frac{l_P}{c} = \frac{\hbar}{m_P c^2} = \sqrt{\frac{\hbar G}{c^5}} = 5.391\,247(60) \times 10^{-44}$ s
- Planck Mass: $M_P = \sqrt{\frac{\hbar c}{8\pi G}} \approx 4.341 \times 10^{-9}$ kg $= 2.435 \times 10^{18}$ GeV/c^2
- Planck Charge: $q_P = \sqrt{4\pi\epsilon_0 \hbar c} = \frac{e}{\sqrt{\alpha}} \approx 1.875\,5459 \times 10^{-18}$ coulombs

Illustration 1. The four Planck base units, their formulas, and their discrete values (numbers)

In our high school geometry classes the question was raised, "If the Planck Length and Planck Time are the smallest possible units of length and time, does it follow that these are also the very first units of length and time? [7] Does it follow that these equations, with all their dimensionless constants, come together to become the very first moment of physicality?" We were unwittingly opening the "CDM of the universe" and wondered if Steven Weinberg would consider it a "*grand* reductionism." [8]

Our postulate is that these Planck's units are really-real physical entities, not zero-dimensional point particles, but an actual entity defined by the Planck base units. So our next question was, "What would that entity look like?"

Every equation is in part defined by the speed of light, pi (π) and the Planck Constant.

Because our students were studying basic geometric structures, they had a few answers. Yet, after some discussion, the students of pi, circles, and spheres prevailed. We then assumed not one sphere, but an impossibly-fast, steady stream of spheres emerge. We then wondered what the next dynamic could be.

Illustration 2: Kepler 1611 Sphere stacking

We decided to invoke Kepler (1611) and his sphere-stacking exercise of that year. So analogically, like Kepler, we now have this infinitesimal, raw stacking of spheres. We consider the first ten notations. Within Notation-10 there could be as many as 256 spheres. However, if we follow the advice of Freeman Dyson regarding scaling vertices and dimensional analysis, there could be as many as 67,108,864. (See Chart, column 10, lines 8 & 9). We decided that at some point we would learn a deeper logic and we would be able to decide.

The dynamics still beg the question, "What happens next?" Our students had a quick answer, "The spheres come alive."

First, there are the dynamics within cubic-close packing of equal spheres. The radii "discover" radii and triangulation begins (aka, triangulated coordination shells). [9] The discovery process continues and a tetrahedral layering begins enclosing octahedral cavities. There are structures within structures.

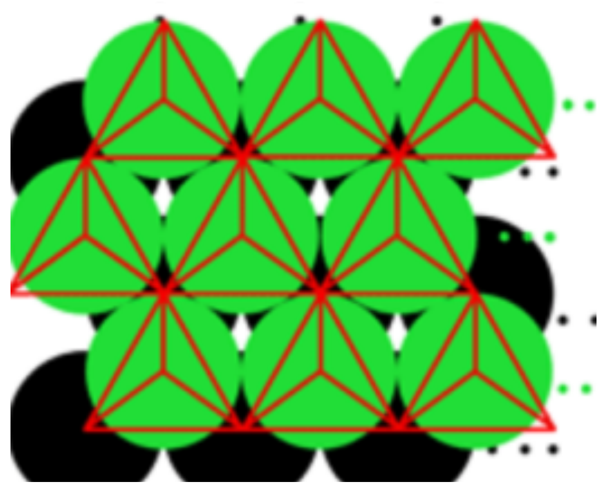


Illustration 3: Click on this link to go to a dynamic gif that demonstrates cubic close packing of equal spheres.

Fourier [10] rolls in with the initial transform. Then comes Lorentz [11] with linear transformations. The spheres are tied together and become Poincaré spheres [12].

There is so much to learn here *and we've only just begun.*
The key point is that everything fits perfectly.
Pure geometry meets physics 101.

Spherical perfections. Creating perfect continuity, perfect symmetry, and perfect harmony, this infinitesimal universe takes shape and the ubiquitous Plancksphere dominates. [13] There is nothing that is undecided, uncomputed, and unpredictable. It is all a quiet emergence within a simple perfection. Infinitesimal and way too small to measure, these are domains reached only by logic and mathematics. Actual physical measurements of a length begin around the 67th base-2 notation; and, a unit of time, the attosecond, is not measured until the 84th notation. That is an extraordinary amount of intellectual space to tie logic, numbers and geometries together. Of course, it will be a challenge, but it just may be relatively straightforward for some of the scholars who are already deeply involved.

It is a study of perfected states in space-and-time.

The expansion: geometric, arithmetic, and exponential. Scholars within Langlands programs and string theory have done a major amount of work to define this space and its automorphic forms [14]. Here is a discovery process whereby every equation within Langlands programs has a place within a highly-structured environment. Every radius of the spheres (a string) opens Witten's equations of state, with the Seiberg–*Witten* invariants.

This simple base-2 ordering system quickly becomes complex. Each of the nineteen subsequent prime-number notations — 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, and 61 — introduce even more complex mathematics. The remaining prime numbers — 67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 197 and 199 — also open potentials.

Base-2 is just one dynamic of this expansion. This universe appears to us to be opportunistic so may well use base-3, base-5, base-7, base-11 and base-13 to introduce yet even more complex functions.[15] Of course, most notations are included within base-2, base-3 and base-5.

Within this model all notations are active all the time. They build off of each other.

Pi. We discerned three facets of pi that come out of those never-ending, never-repeating numbers. First, comes the face of continuity. It is a perfect ordering system that creates new sets of numbers and flow. Also, within those circles and spheres is a deep and abiding symmetry that gives rise to tetrahedrons and octahedrons (See Illustration 2 above) which is also a perfection. Those symmetries begin to discover symmetries and there is a simple harmony. Kepler's music comes alive well before there is any range for human hearing!

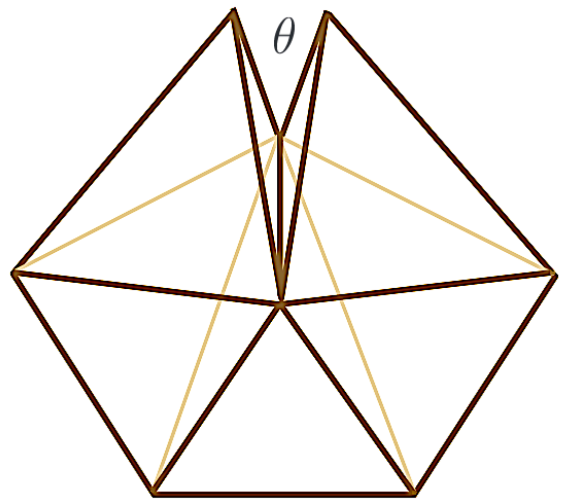
It is tangible perfection. And, it creates a homogeneous and isotropic universe.

Finite-infinite. This system is its own self-enclosed system with its own rules and axioms that are grounded in a problematic statement — t*he origins of this perfection are not finite*. Opening the finite-infinite relation is an age-old enterprise so please allow me to close that door rather quickly with this simple definition of the infinite: It is the qualitative expression of continuity, symmetry and harmony whereby continuity begets order, symmetry begets relations, and harmony begets dynamics. The finite is the quantitative expression. That's it. Nothing more. Anything else anybody wants to impute is their business; it is probably not relevant here.

Within a little over one second, the base-2 expansion is out to the 144th notation. Planck Length is 360,424.632 kilometers. Planck mass is a hefty 4.8537×10^{34} kilograms. Just to put that in context, the mean average distance between the earth and the moon is 384,402 km (238,856 mi). It is 356,500 km at the perigee and 406,700 km at the apogee. The sun's weight is around 1.989 × 10^{30} kg so at this notation, the density of the universe is like a neutron star. The universe as we know it begins to take shape between Notation-196 and 197; the universe is at 10,829,559,004,640,000 seconds or about 343.15 million years.

Just within these 202 notations are a few highlights of this base-2 model:

- ***One second, between Notation-143 and 144,*** ***[Planck Length is 299,792± km](#)***.
- A year is between Notation-168 and 169.
- The first 1000 years is between Notation-178 and 179.
- The first million years is between Notations-188 and 189.
- And, the first billion years is between Notations-198 and 199.



Pentastar 7.356+° gap

This model is primarily about the very early universe. Within the process, while it is being filled with Plancksperes and with the emergence of geometries from the Platonic Solids to the increasingly complex, a five-tetrahedral cluster forms.

Although Aristotle thought it was a perfect configuration [16], among many others, chemists in the 1950s recognized his mistake and calculated that gap. It is an important gap. Most pentagonal, icosahedral and dodecahedral structures have such a gap (or a stretched imperfect surface). In the 1960s the first concepts around aperiodic tilings were introduced. In 1976 Roger Penrose introduced his unique tilings and Alan Mackay followed up experimentally to show how a two-dimensional Fourier transform (with rather sharp Dirac *delta* peaks) manifests a fivefold symmetry. For more, see quasicrystals and notes. In 1982 Daniel Shechtman began his public-struggle to open the exploration of quasicrystals.

Pentagonal faces introduce new dynamics. We postulate that one of the possible dynamics is the beginning of quantum fluctuations and its aftermath, undecidability (subject), uncomputability (relation), and unpredictability (object).

As we search for answers to the question, "When and where do these fluctuations manifest?" We will beg for help. These are all new studies for us. Our simple history begins in 2011. Our critical history didn't really begin until 2016. Notwithstanding, we are speculative people and believe the fluctuations actually fluctuate, first between notations, and then between sets of notations, and within groups of notations.

We will continue asking scholars about this simple configuration as we learn more about the all the topics which it requires to make our universe work. Thank you.

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Endnotes, Footnotes, References, and Resources

[1] Decidability (Subject). A key to this theory and construct is the coherence of its logic. By definition, it includes "everything, everywhere, for all time." These foundations — Max Planck's four most-basic natural units and their dimensionless constants (c with special relativity, G with general relativity, ħ with quantum mechanics, ε0 (vacuum permittivity) with electromagnetism, and kB (Boltzmann constant) with the notion of temperature/energy) that define them — are the key to that key. So now, we struggle with first-order theory of Euclidean geometry of Euclidean geometry from Tarski (1949) to Hodges (Stanford Encyclopedia of Philosophy, 2018). We are also engaging the first-order theory of Abelian groups (W.M. Szmielew,1955), the first-order theory of hyperbolic geometries, (Schwabhäuser,1959). Another focus is Petra Wolf's work, From Decidability to Undecidability by Considering Regular Sets of Instances (June 2019). Within this radically relational model, the subject is always derived some the totality or relations that defines it uniquely.

[2] Computability (Relation). The question is asked, "Is it possible that computable functions, including Turing degrees, are not necessarily set within just Notation-202? In this model where space and time are derivative, computability theory logically begins within Notation-1 and builds logically to include Notation-202. The algorithms of computational logic, like dimensionless constants, do not necessarily reside within machines. Questions about the mind and consciousness are stretching us to start a theory of computation that logically starts within Notation-1 logically grows to Notation-202. This model is a profoundly relational model whereby everything is connected to *everything everywhere for all time*.

[3] Predictability (Object). Because the only notation that has a past and future is Notation-202, all others are complete yet fully dynamic, and fully symmetric; there is still change. Yet, the thrust for change is a dynamic that effects every notation. To begin to enter this intellectual space, some of the more recent work regarding predictability is being engaged:

- Predictability limit of partially observed systems, Abeliuk et al (Jan. 2020)
- Predictability, complexity and learning (William Bialek et al (July 2000)
- Decomposing predictability, Hofmann et al (Dec. 2019)

Transmogrification: There are many notations, starting with Notation-1 and going as high as Notation-67, whereby logic prevails and our mathematics is opportunistic. Here opportunistic means testing for more continuity, symmetry and harmony, always reaching for a higher perfection. The first ten notations have been generally associated with Plato's forms which are today associated with the automorphic forms of Langlands programs and string theories. Essentially this is the first-order of the planckspheres. Each of next notations are second-order for substances in the spirit of Aristotle's *Ousia*. And, the third order of planckspheres creates a diversity of structures. The emergent face of forms, substance and structure is qualities, the fourth face of the planckspheres. Perhaps as early as Notation-40 the first pentastar (five-tetrahedrons), icosahedral, or dodecahedral or icosahedral configuration becomes part active. Not until there is an ordering *as a system* would the gap and squishy geometry become indeterminant. We are projecting that transition from Notation-50 and Notation-67. That's strictly a guess.

[4] Undecidability (Subject). Within this idiosyncratic model of the universe, there is a deep respect for the scholarship that provides us with a list of undecidable problems (computability theory) and the list of statements independent of ZFC whereby the transmogrification induced by the pentastar gap provides a different look at that concept that quantum logic is undecidable (Fritz, 2016).

[5] Uncomputability (Relation). With more study the historic brain-mind discussion will be part of these discussions. The Mind, that all minds, are currently projected to emerge within Notations 50 to 60 while consciousness as we understand it today would always be within the current time within Notation 202. To grasp the boundaries our studies of uncomputability include the following:

- Uncomputability and complexity of quantum control, D.I. Bondar, A.N. Pechen, Jan 2020
- Uncomputability of Phase Diagrams, Johannes Bausch, (Oct 4, 2019)
- Uncomputability and free will, C. S. M. Nayakar, R. Srikanth (October 2012)

[6] Unpredictability (Object). In 1970 I became enamored with the work of John Bell at CERN labs in Geneva. He had a new way of looking at the EPR Paradox. In time I went to meet him stopping along the way to visit with David Bohm and Carl Friedrich von Weizsäcker. My goal was to better understand how the relations could be the primarily real within the subject-relation-object formula. It was only by making space and time derivative did the simple formulation of continuity-symmetry-harmony, a moment of perfection begin to open up. We wanted a container universe but did not discover the container until 2011. Now, all these articles are beginning to make some sense. Unpredictability is built into the very essence of geometries of the universe, yet the universe itself can be profoundly knowable. Freedom, creativity and high perfections are all built into the structure of unpredictability, yet it is not the fundamental structure. So, to help better understand this nascent model, we have lifted up a few related articles:

- On the unpredictability of individual quantum measurement outcomes
- Unpredictable Planning Under Partial Observability
- Bell nonlocality, signal locality and unpredictability

[7] The story behind this story. Although there are links throughout this website to the December 19, 2011 story of our high school geometry students and their teachers chasing tetrahedrons and octahedrons down into the Planck scale and then out to the age and size of the universe, here are other key links to tell a bit more of that story:

- Because of its systematic ordering, this project was initially considered a STEM tool.
- When we could find no place within our grid for Plato's Eidos and forms, Aristotle's Ousia, binary operations, pointfree geometries, Langlands programs and string theory (please see line 11 of our horizontal chart), we decided, "That'll all be within the first 67 notations." We knew then there would be an endless amount of work to do within this model.
- One of the earliest stories about this enterprise

[8] Grand Reductionism. We started as everything does — simple. We take very little steps and ask simple questions. We try to respect the scholarship that has gone on before us. When we become confused, we step back to something more simple. So, it was with deep respect that we engaged the CDM approach to the universe and Steven Weinberg and his book, *Facing Up*. Yet, we could not imagine a larger "grand reductionism" so, we did wonder!

We continue wrestling with his work and with these other scholars:

- Beyond the Dynamical Universe: Unifying Block Universe Physics and Time as Experienced, by Michael Silberstein, W. M. Stuckey, Timothy McDevitt, Oxford (2018) Also: https://www.relationalblockworld.com/
- In 1979 I first met Steven Weinberg at his office in Jefferson Laboratory at Harvard. He had not received his Nobel prize, but *The First Three Minutes* was out.

[9] Triangulations. Our initial studies of the work of F. C. Frank (H. H. Wills Physics Laboratory, University of Bristol, England) and J. S. Kasper (General Electric Research Laboratory, Schenectady, N.Y.) opened the concepts within cubic-close packing of equal spheres, the triangulated coordination shells, and the emergence of the tetrahedron from just four spheres. That all opened the way to engage *The Physics of Quasicrystals*, World Scientific, 1987 edited by P J Steinhardt and S Ostlund. We struggle to grasp the work of scholars within this area:

- Objections to set theory as a foundation for mathematics
- We found the work of Jonathan P. K. Doye and his group to be very helpful

[10] Fourier. Our first introduction to the Fourier transform was through Steven Strogatz on Pi day in 2015. His article for The New Yorker Magazine resonated at that time and it still does today. Now we are attempting to really dig into the Fourier work. Of course, we have a long way to go. Here are some of the scholars to who we are currently turning for help:

- *Danylo Radchenko*, *Maryna Viazovska*, *Fourier interpolation on the real line*
- Martin Stoller, Fourier interpolation from spheres (2020)
- The double **Fourier sphere** (DFS) method

[11] Lorentz Linear transformations are part of the dynamics within a notation. Yet, there is a homogeneity with all the contiguous plancksperes so geometries may readily extend within notations and across notations. It seems that the dynamics of all geometric models of the universe may hold insightful keys. With that mindset, we are open to all studies of space and time symmetry:

- Lorentz Transformation
- Rovelli: Reconcile Planck-scale discreteness and the Lorentz-Fitzgerald contraction
- Planck scale space time fluctuations on Lorentz invariance at extreme speeds

[12] Poincaré In 1980 I worked with Jean-Pierre Vigier and Olivier Costa de Beauregard at the Institut Henri Poincaré. Our focus was solely on the EPR paradox, Bell's theorem, and the experimental work of Alain Aspect at the SupOptique or "IOGS" in d'Orsay (just outside of Paris). Never did we look back at the work of Henri Poincaré. Today, a focus is on the Poincaré sphere and its underlying Lorentzian symmetry as a geometrical representation of Lorentz transformations. We continue working with these scholar's ideas:

- *The Poincare Conjecture: In Search of the Shape of the Universe*, Donal O'Shea (2007)
- *Sphere in Various Branches of Physics*, Tiberiu Tudor (February 2018)
- *Harmonic Analysis on Symmetric Spaces—Euclidean Space, the Sphere, and the Poincaré Upper Half-Plane*, Audrey Terras, Springer Science & Business Media, 1985, 2013

[13] The Infinitesimal Sphere. Also called the Planck sphere, it is a key, core concept and we will continue to research it until we find the best possible resources that go back as early as possible. To date, we start with John Wheeler's work with quantum foam could hold a key. Here are others:

- *Discrete Model of Electron*, April 2019, DOI: 10.13140/RG.2.2.28408.49920, Discrete Universe Project, Jose Garrigues-Baixauli, Universitat Politècnica de València, Spain PDF
- *Physical Significance of Planck Length*, Thanu Padmanabhan, Ann. Phys. 1985 165(1) 38-58
- Also, see Planck Particle: https://en.wikipedia.org/wiki/Planck_particle

[14] Automorphic forms. Who are the scholars to whom we can turn to learn about automorphic forms? Of course, there are the scholars within the Langlands programs and string theory. They have done sustained work since the 1970s and have done a major amount of work to define its automorphic forms:

- Automorphic forms (Wikipedia) "One of Poincaré's first discoveries in mathematics, dating to the 1880s, was automorphic forms."
- Langlands program (Wikipedia)
- *Is there an analytic theory of automorphic functions for complex algebraic curves?*, Edward Frenkel (ArXiv – December 2018)

[15] String theory. One of the world's leading scholars within string theory is Ed Witten. He is also a gentleman. Because the majority of his career has been in the shadow of big bang cosmology, his work has had an impossible starting point with which to contend. There is no easy migration to a theory that pushes time-space-and-light together at the Planck scale, and then with mass-and-charge at the next level (c^2). It will be fascinating to see if they will do better within a cold start that redefines the historic æther, and gives their discipline the radius of the plancksphere within Notation-1 and every plancksphere through Notation-67, and at least the first 67 notations of each subsequent notation.

- *The logarithmic equation of state for superconducting cosmic strings*, Betti Hartmann, Brandon Carter, November 2008 arXiv:0803.0266
- Seiberg–*Witten* invariants

Of course, base-2 is the first exponential expansion of this model such that no point within the universe, right from the first instant, is more than 202 notational steps away. Yet, I believe our opportunistic universe will also test base-3 which would aggregate a 67-step shortcut through to Notation-201. Base-5 would provide a 40-step shortcut through to Notation-200. Base-7 would provide a 28-steps to Notation-196, base-11 just 18 steps to Notation-198, and base-13 just fifteen steps through to Notation-195. These clusters of notations possibly can introduce even more complex functions.

- The largest square of a prime, 13^{13} is 169, obviously under 202; and, 17^{17} is over (289).

(continued)

[16] Pentastar gap. One of history's greatest thinkers made a most fundamental mistake that was repeated for about 1800 years. That is a tragedy of epic proportions. We are all taught to have such great respect for scholars, sometimes it holds us back. Aristotle (384–322 BCE), one of the greatest Greek philosophers and a polymath obviously had imperfect models of the tetrahedron, otherwise he would have seen and felt the Pentastar gap. Five tetrahedrons all sharing one common edge opens a gap. My first discussion about it was in 2016.

1800 years. The greats that followed him repeated his mistake and we failed to grasp a most-essential quality of simple geometry. One of our primary source article is "*Mysteries in Packing Regular Tetrahedra* (PDF)" by Jeffrey C. Lagarias and Chuanming Zong. They relied heavily on the Dutch article by D. J. Struik, *Het Probleem 'De impletione loci'*, Nieuw Archief voor Wiskunde, Series 2, 15 (1925–1928), no. 3, 121–137. Two chemists, F.C. Frank and J.S. Kasper with their article, *Complex Alloy Structures Regarded as Sphere Packings*, took it further and calculated that gap.

- D. Shechtman, I. Blech, D. Gratias, and J. W. Cahn, Phys. Rev. Lett. **53**, 1951 (1984). https://doi.org/10.1103/PhysRevLett.53.1951 , **Google Scholar** **Crossref**

We are undoubtedly among a very few who claim that this gap is the basis for quantum indeterminacy, imperfections, free will, unpredictability, undecidability and uncomputability, so yes, they is much more to come!

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