On The Road Not Taken

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Millennia ago, mankind arrived at a fork in the road. It became essential to answer a foundational question about the space in our universe. Are the most fundamental units of geometry, objects of zero dimension (dimensionless points) or would they be objects of an infinitesimal magnitude (extended points, i.e. monads)? As directed by Plato, physicists have followed the Zero Point road as an act of faith. Drawing on cues from the Pythagoreans, Aristotle, Proclus, Leibniz, Newton and Wheeler himself, we embark on a trip along Monad road. We report our suspicion that Mother Nature may have been using monads secretly as the 'it' (hardware), and their variable lifetimes as the 'bit' (the information and the software) of a digital universe, without obtaining Plato's consent.

1. Introduction

> "Two roads diverged in a yellow wood,
> And sorry I could not travel both
> And be one traveler, long I stood
> And looked down one as far as I could
> To where it bent in the undergrowth"
> – first verse of poem by Robert Frost, *The Road Not Taken*, 1916.

We all come to forks in the road in our personal, career and social lives where we must make a choice. Where choices made are not evidence-based, it is human to sometimes hanker after that alternative foregone, that road not taken. In this essay, we will indulge and crave after one such road, the Monad road in pursuit of an answer to the question, 'it from bit' or 'bit from it'? As with all cravings, contrived patterns may be described, it is left to the reader to decide if these are hallucinations.

The essay's outline goes thus. In section 2, we provide a glossary of certain terms we use, then in section 3, we recall what happened when mankind arrived at the fork in the road millennia ago, the dialectic that ensued and the decision on which road physicists were to subsequently follow. Using cues from the Pythagoreans, Aristotle, Proclus, Leibniz and Newton, we outline some attributes that monads can possess in section 4, adding one or two of our own. In section 5, we examine what monads are capable of by virtue of these attributes. In particular, whether they can be coaxed by Mother Nature to store and process information for a digital universe. To illustrate this, we attempt an amateur program for *digital motion* and compare this with the analog model. Closing arguments are reserved for section 6.

2. A glossary of terms

For the purpose of harmony between author and reader, we define some of the concepts used in this essay in such a way as not to conflict with currently successful theories but with enough flexibility to illuminate foundational issues that may arise in improving current theory.

Whether space has a discrete or continuous nature is a recurrent speculation. We therefore incorporate Euclid's definitions of the objects of geometry, the science and study of space. For Euclid's actual definitions, see [1],[2], book 1, definitions 1-7 and book 11, definitions 1 and 2.

It – a material thing; a substance; an extended object; anything that can act and can be acted upon by those things it can influence, in obedience to the action-reaction principle; something that can move.
Act – induce or influence a motion.
Acted upon – caused to move.
Information – a pattern that can be perceived by the senses or detected by instruments.
Storage of information – preservation of a pattern in a form that can be largely retrieved or reproduced.
Destruction or loss of information – interference with the pattern, such that it is no longer perceptible to the senses or a detector when hitherto this was the case.
Processing of information – information can be processed, if given a pattern, inputs are made such that a new pattern emerges called the output.
Have no part – not divisible into further geometric objects.
Point – a fundamental unit of geometry; that of which there is no part; a non-composite object of geometry; an object of zero dimension; that by which the road taken by current theory is paved.
Monad – a fundamental unit of geometry; that of which there is no part; a non-composite object having the dimension of the smallest possible infinitesimal magnitude, not extensible, compressible or divisible; an extended point; that by which 'the road not taken' is paved.
Line – a length but without breadth [i.e. a line has length but its breadth and thickness have no part]. The ends of a line are points [i.e. no matter how many segments a line is divided into, the extremities of those smaller lines will still be points].
Surface – a length with breadth but no depth [i.e. a surface has a line making up a length and another making up a breadth, but its thickness has no part]. The edges of a surface are lines [i.e. no matter how many parts a surface is divided into, the extremities of those smaller surfaces will still be lines. A surface is thus reducible to a collection of lines by continuous division. It should be questioned if when the original is divided lengthwise, whether the resulting lines of the smaller surfaces would not share in the breadth previously had by the whole surface].
Solid (i.e. a body) – a geometric object with length, breadth and depth [i.e. a body has a line making up a length, another making up a breadth, and a third making up its thickness]. The face of a body is a surface [i.e. no matter how many parts a body is divided into, the extremities of those smaller bodies will still be surfaces. It should be questioned if when the original is divided depth-wise, whether the resulting surfaces of the smaller bodies would not share in the thickness previously had by the whole body].
Motion – change of place.
Place – position relative to other objects of geometry.
Object – a zero-dimensional or an extended geometric entity.
Bit – a message representing one of two distinct choices; the basic unit of information; short for binary digit. According to Wheeler's definition, bits are detector-elicited answers to yes-or-no binary choices [3] and are usually denoted by the numerical digits 0 or 1.

3. Arguments at the fork in the road

Divisibility played a key role in apprehending the objects of geometry and arriving at a best definition of them. If all that has magnitude must be divisible, then only a zero magnitude cannot be divided and this will be the fundamental unit of geometry. One other argument attributed to Simplicius, goes as follows. If a body, having 3-dimensions is one dimension away from surfaces, then surfaces will have 2-dimensions. If a line is one dimension away from surfaces, then lines will have 1-dimension. By this logic then, the point would be one dimension away from a line and thus be of 0-dimension [4], p.157.

Right from the early era the definitions have been contentious. The Platonic view was that things in the physical world are imperfect replicas of things in a perfect realm and should be taken as such. On this basis, it meant nothing for a line to have no breadth, even though nobody had seen such a line in reality and even the lines used for illustration by Euclid in his book had breadth!

The Aristotelian view on the other hand appeared more inclined to getting descriptions as practical as possible to the reality we can actually behold. Like the Pythagoreans who were of the view that points were extended objects and called them monads to differentiate them from the dimensionless object of the Platonic school, Proclus and Aristotle also felt that points must really exist and had the attribute of position, but they were unclear at what magnitude the point could then be defined as the limit of divisibility.

Although commonly portrayed as the arrowhead of the view that points were of zero dimension, Plato himself is quoted as somewhat disclaiming this. In *Metaphysics*, book I, part 9, paragraph 14, Aristotle tells us, "…Plato even used to object to this class of things as being a geometrical fiction" [5]. Instead, Plato is said to prefer that points be referred to as the 'beginning of lines' or as 'indivisible lines'. This defense was however denied him as Aristotle counters that if that were so, then the same argument and logic that makes lines exist must then equally prove that points also exist.

For a fuller account of these arguments, other ancient definitions, criticism by commentators and modern views, see [4], pp.155-157 and [6], pp.76-80. Both also quote [5] and [7] frequently. In summary, the fact as to whether a point is an extended object or a zero dimensional idea has had to be postulated, i.e. the decision on which of the two roads to travel has had to be an act of faith and not from evidence. In our thinking, to accommodate the contending views, Euclid restricts himself to a least contentious, middle-of-the-road definition, but not as explicit in its detail, i.e. all are agreed that the fundamental unit of geometry would have no part. A point having no magnitude and of zero dimension would have no part. Likewise, an infinitesimal magnitude not further divisible into parts of itself would also satisfy Euclid's definition 'that of which there is no part'. This ambiguity may however have implications for the foundation of our physical theories, space being all pervasive.

Although some infinities, requiring renormalization are found in quantum field theories that have no shortest distance limit and a few paradoxes occur on the classical scale, the success of the physical theories built on the Zero Point road convinces many that points are mere indicators of location and not extended objects.

The current desire of a unification between classical and quantum theories, has however brought forth the proposition that a limit to division ad infinitum may exist at the Planck length ~ 10^{-35} metres. If indeed this is the case, then the definition of the point and other objects of geometry will eventually need to be revisited.

On the Monad road, we take the point as an extended 3-dimensional object of about the Planck dimension, in keeping with current theoretical speculations. The point in this case will be a physically real, discrete unit of space and not just a mathematical abstraction.

Extended points as fundamental objects of geometry and having a magnitude about the Planck size would confer composite things like lines, surfaces and bodies with dimension. A line will consist a variable number of points, thus having variable length but having the breadth and thickness of a point, i.e. it will have length, and be divisible in one way only (as Aristotle would say) but its breadth and thickness would 'have no part'. A collection of lines can confer a surface

with a magnitude, divisible in two ways since the resulting breadth would now be a line. Surfaces can confer a body with a magnitude divisible in three ways as the resulting thickness would now be a line. A line having the width and thickness of Planck dimension, cannot divide space infinitely and in this interpretation of Euclid's original definition, a monad will be the limit and 'have no part'.

4. Attributes of monads

To apprehend some of the attributes monads can possibly have, we will have to rely on what can be obtained from the Pythagoreans, who incorporated monads in their doctrines as the fundamental unit of geometry, Leibniz, who believed space was a "nothing", but ironically wrote a paper on Monadology [8] and Newton who followed Plato down Zero Point road, but yearned after a space which was not a "nothing" and had substantival properties. We will quote these greats directly and develop the cues in the light of current theory and observations. At the end, we will outline some characteristics of monads (extended points).

Although we cannot be certain if Leibniz was referring to the same object as the Pythagoreans, since in later paragraphs, e.g. paragraph 65, he talks of divisibility to infinity, he like the Pythagoreans, says that monads "…have no parts". In addition, "…they can't be extended, can't have a shape, and can't be split up". By not having a shape implies they cannot be said to have borders. Leibniz regarded them as "…the true atoms of Nature - the elements out of which everything is made". He also makes the assumption that the whole of space was not empty but was a plenum full of monads. This is what appears to equate his monads with that of the Pythagoreans. In paragraphs 4-6, he makes what we feel is a very fundamental assertion concerning monads, "… the only way for monads to begin or end - to come into existence or go out of existence is being created or annihilated all at once. Composite things in contrast with that, can begin or end (gradually) through the assembling or scattering of their parts". This idea is remarkably prescient of the current observation in quantum physics that particles can indeed spontaneously emerge and also disappear depending on their lifetimes.

Monads can differ from each other. To Leibniz they differ by differences in a quality he calls 'perception', 'changes in perception', etc. Unlike, his proposal, we suggest that extended points differ in a simpler way, only in the variation of their lifetimes, in just the same way virtual and real particles differ from each other.

If extended points can have a variable lifetime, how long do they exist? In keeping with current speculations, we assume a minimum lifetime of about the Planck time ~ 10^{-43}seconds, which we equate to an instant. The maximum lifetime for monads is however speculative.

As we shall propose and attempt to show, the variable lifetimes of monads would be the foundation for all events and information processing in a digital universe. Phenomena capable of inducing their emergence and annihilation can be exploited by Nature to write its software programs. In the final analysis, seemingly elaborate structures and events will be reducible to space (points of non-zero dimension) and time (lifetime of the points as characterized by their appearance and disappearance).

The property of each extended point having a lifetime starts declaring part of its potency by settling the recurring question whether space is discrete or continuous. Although no boundary or other geometric object can exist between two contiguous extended point magnitudes, making them continuous by definition, the unshared lifetimes of the points technically breaks that

continuity, revealing the discrete nature that space can also exhibit beneath the seemingly continuous geometry. So to speak, time serves as their boundary, not a geometric object.

This dual nature presents the scenario whereby the continuous property serves better in distance measurements but will result in paradoxes if events, such as motion are founded on that premise. On the other hand, while the discrete nature in terms of a limit to divisibility of space and the variable lifetime of points is more suitable for dynamical geometry, absurdities may result when static measurements are to be made based on that property. Among such known difficulties will be 'Pythagoras' trouble', also called the 'Weyl tile argument' for measurements in a discrete space [9] and Zeno's paradoxes [10] for motion in a continuous space.

Newton considered space as capable of acting to differentiate linear from circular motion as he tried to demonstrate with his Bucket and other experiments. However, he recognized that something can only be accepted as capable of acting, if and only if, it can also be affected by those things it can influence. This is the action-reaction principle. If there is to be any interaction between bodies in motion and the space in which they move, this principle must be operational. To elucidate this was an unfinished Newtonian assignment. Believing strongly that there was a killer argument somewhere but frustrated in not being able to immediately apprehend this to confront his opponents who viewed space as nothing but a relational concept [11], he says in his uncompleted paper, *De Gravitatione*, "…it is clear that they (philosophers) would cheerfully allow extension (space) to be substance, just as body is, if only extension could move and act as body can" [12], p.8.

Elsewhere in the same paper, he says "…space is capable of having some substantial reality. Indeed, if its parts could move…, and this mobility was an ingredient in the idea of vacuum, then there would be no question about it - parts of space would be corporeal substance". Although holding that space was distinct from body, this he opined was not in a difference in their rudimentary elements. "And my account throws a satisfactory light on the difference between body and extension (i.e. between a body and a region of space). The raw materials of each are the same in their properties and nature, and differ only in how God created them…"[12], p.18. By this he meant that the only difference is that while body was created by God, the other, space was eternal and not created.

Despite his substantivalist leaning, Newton ironically put his faith on the Zero Point road. Points of zero dimension cannot have any sort of motion, either change of place or change in nature. This would be an irrelevant contemplation for an abstract object.

The question can however become relevant when the point is a physically real entity of non-zero dimension. From Leibniz, Newton's archrival, we learn that extended points (monads) can emerge from and annihilate to nothing. Such change of nature implies motion because it is change of place, i.e. moving from nowhere to somewhere and from somewhere to nowhere. Only extended points can be contemplated to move in this manner. We take this as that which was sought by Newton to confront his opponents and fully categorize space as an existing entity, whose parts can "move and act as body can".

From these Pythagorean, Leibnizian and Newtonian suggestions, but with apologies for any selective quotations, we now list some monadic attributes as:

i. extended objects, not further extensible or compressible.
ii. they are fundamental and not a composite of other 'its'.
iii. they are the fundamental units of geometry, both body and space.

iv. they are indivisible. Therefore space is not divisible ad infinitum. This is one way to appreciate the size of monads. Here, we take this limit as the Planck length.
v. they have no shape.
vi. they have no boundary.
vii. between two monads, there is no other geometric object to 'separate' them, monads being the basic representation of space. From v, vi and vii there can be no question of here is a monad and here is another. This being the case, space can exhibit a continuous nature.
viii. monads have a lifetime and this is variable between monads. This being the case, space can exhibit a discrete nature.
ix. monads by emerging from nothing and annihilating to nothing are capable of change of place, i.e. motion.
x. monads can be induced to emerge and be annihilated in certain phenomena. (This is our own addition and we try to show its importance in the next section).

5. What can Nature do with monads in a digital universe?

By virtue of the attributes listed above, we now contemplate what Nature can do with extended points.
(a) Use as hardware. Long living monads having the property of non-compressibility and impenetrability offer Nature a raw material with attributes commonly associated with matter. This can be utilized for the structure and hardware of human and cosmic computers.

(b). Use as 'bits'. Wheeler was in the forefront of a grand scheme to reduce physics to geometry. This he called 'geometrodynamics' [13]. It was his dream to obtain mass from the massless, charge from the chargeless and field from the fieldless. To him, "what else is there out of which to build a particle except geometry itself?" [14]. If we follow Wheeler along this road, we infer that 'it' is from 'geometry'. A literal interpretation of the same Wheeler's 'it from bit' is then that 'geometry' and 'bit' must be strongly related, if not same.

The attributes of monads that can make them useable by Nature for the storing and processing of information include that:
- they can exist in two distinct binary states, designated as 0 and 1. Monads can change from extended objects and annihilate to nothing (0) and can emerge from nothing to be extended points (1).
- information can be stored in long living spatial patterns of such 0 and 1, which may not necessarily be static. For analogy, consider a configuration of lights, some blinking ON and OFF in a rhythmic pattern, some doing so randomly and some staying permanently ON. The ON states can be taken as extended points and OFF as the nothing state.
- they can be induced to change in nature as we will demonstrate with digital motion in the next sub-section. Therefore they can be programmable and useable for processing information.
- they can change nature spontaneously. This leaves room for indeterminism and random events in information processing. Such non-algorithmic ingredient may give rise to free will and originality of thought as Penrose conjectures in [15], p.558.

It has been argued by Barbour [16] that though the binary digits 0 and 1 are abstract, they must stand for something quintessentially concrete and we concur. Now, in a very fundamental discussion, what information will be "occupying the ontological basement" [17], the "very deep bottom" [3], that for which Wheeler, Paul Davies and others have given so much and which the binary digits 0 and 1 will stand for? Certainly, it cannot be the left/right, spin up/spin down or the dead/alive kind of information as with Schrödinger's cat. In our opinion the two-valued attribute denoted by 0 and 1 must really occupy the deepest part of the basement!

Still tagging along with Wheeler that 'bits' are the information-theoretic answers to questions asked, what other question would you want to ask a universe or parts of it to get an answer occupying the ontological basement, if not are you existing or not existing? To us, it is to this that you get the answer, yes (1) or no (0).

The universe as a whole and in its smallest parts can be assumed capable of occupying either of this same binary states, existing/non-existing. In emerging and expanding, the universe is not moving from one place to another existing place. No other place exists outside the universe to expand into nor is there any to be left behind after collapse, rather we are having discrete changes of state from nowhere/not existing (0) to somewhere/existing (1) for expansion and for collapse, somewhere (1) to nowhere (0), such that when we ask the universe, 'art thou existing?', it can give us the digital answer yes/no, depending on if a place is created from nothing or annihilated to nothing.

(c) Use for writing programs. Now that we arrive at the scenario where monads and their attributes may serve as the 'its' and 'bits' of our universe, let us prove whether this is workable by writing a program for *digital motion*.

If we write a program, that whenever force is applied to a material object by contact or by action-at-a-distance, some extended points should be annihilated to nothing, i.e. converted from binary state 1 to 0 in the direction of the force, simultaneously as an equal number of points emerge from nothing, i.e. convert from binary state 0 to 1 in the opposite direction, what will be seen, say on your computer screen?

before force

Fig.1. An object **O** located in its place equidistant between a location **A** and **B** on a line **AB** before force is applied.

after a force acting on **O** *in the direction of* **B**

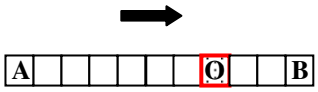

Fig.2. After force is applied, object **O** is translated to a position nearer **B** and further away from **A** on the line **AB**.

The following can be noted in Figs.1 and 2.
- after force is applied, object **O** moves nearer to **B** and away from **A**.
- the phenomenon is similar to what we assume for motion in continuous space. The fundamentals are however different. In digital motion, space is an active participant in the motion and the points along the route do not eternally exist. In the illustrated example, two extended 'points' have annihilated to nothing in the direction of **B**, and simultaneously two have appeared from nothing in the direction of **A**. (For illustrative purposes only, take each small square as representing a monad).
- object **O** actually remains in its own place despite motion occuring. As Zeno would say in his Arrow paradox, "What is in motion moves neither in the place it is nor in one in which it is not" [18].

- a vector quantity, displacement **AB** is conserved and simultaneous, equal and oppositely directed motion of monads are characteristic of the interaction.

The rate of disappearance and appearance of points determines how quickly bodies move along their lines. The rate of shortening of a line in the direction of motion we call *velocity*. Sometimes this rate can be programmed not to be constant, the rate of change in the rate of shortening we call *acceleration*. The manner in which the mass of colliding bodies subsequently influence the rate of disappearance of points in a given line can therefore be programmed by Nature, leaving Sir Isaac Newton to discover them in his laws of motion.

In contrast, analog motion in a continuous space model is confronted by paradoxes, such as Zeno's Dichotomy Argument as there is no limit to the number of places to be traversed between origin and destination in such a model, space being infinitely divisible. With the help of calculus and other tools, such as those of Cauchy and Cantor, the paradox can be negotiated and although the last fractional step taken is unknown, destinations are reachable. In one form or the other, certain intuitive assumptions must be sacrificed for the mathematical solutions. Dowden has shortlisted these [10]. To mention one: it must become accepted as a possibility that a segment can be of same measure as its line.

Analog motion in an absolute space which is substantival does not fare better. As Newton pondered, "…when a part of space moves, it is translated from one place to another. But a place is a part of space, so this implies that the moving part of space is translated out of itself; unless we postulate that there are two spaces that everywhere coincide, a moving one and one that is at rest, so that the movement of a part of the moving one involves a translation of that item from the corresponding part of the resting one to a different part of the resting space…That is crazy (translator's inclusion)", [12], p.11. How a body as a geometric object having the property of place is translated out of its geometric property is an enduring difficulty for a space that is not a "nothing" (see also Aristotle's discussion in [8], books IV-VI). In digital motion, a body does not move out of its own place as has been demonstrated, yet it reaches its destination. This advantage over the analog model of motion convinces us that 'digital physics' [19] is a field awaiting further exploration.

As a last example, let us imagine an influence or signal travelling wave-like through space with input 1010 as its signature, representing "existing monad detected (1)-annihilation of monad occurs (0)-existing monad detected (1)-annihilation of monad occurs (0)" interacting with another input 1001 representing "existing monad detected (1)-annihilation of monad occurs (0)-annihilation of monad occurs (0)-existing monad detected (1)" or imagine both signals being fed into a device to give an output signal different from the inputs. This can form a basis by which monadic behavior can be manipulated. Annihilation of a monad takes an instant and the resulting infinitesimal delay and cumulative instants before the next existing monad is read by a detector can code for that annihilation. If monads can be so manipulated by Nature, given its size, the universe could be a computer capable of storing and manipulating 10^{180} bits of information.

6. Closing arguments

Your honor, we seem to have been led along the wrong road, but we will not be seeking punitive damages or costs from anyone. All we will be asking the court is that Zero Point road be renamed Extended Point Highway. Most theoretical physics investments built along Zero Point road can therefore remain where they are and need not lose their total value. This is because unlike Zero Point road which permits only a continuous nature for space, Extended Point Highway can accommodate investments in both continuous and discrete natures of space, as we have submitted

in our evidence. Indeed, many of the existing investments on Zero Point road may appreciate in market value when put on a stronger, non-zero foundation.

Finally, your honor, as learned senior counsel on the opposing side did not utter any objection during Aristotle's testimony, that counsel himself and his clients announced publicly to everyone's hearing that the point is not a geometric fiction, we hereby rest our case.

Judge: (turning to opposing counsel) Does counsel still insist that the point is not a geometric fiction?
Plato: Yes I do, your honor.
Courtroom audience: (murmurs, gasps).
Judge: Do you wish to contradict any of the exhibits of Aristotle, Leibniz, Newton and Wheeler tendered in court?
Plato: No, your honor. I also have the exhibits in my library.
Judge: Well then, if the point is now an 'it', what do you say about 'bit'?
Plato: Zero dimensional points cannot undergo any change of nature so they cannot serve as 'bits'.
Judge: What of extended points?
Plato: Extended points may or may not be able to undergo change of nature, which will be change of place.
Judge: What do you say about this, 'it' from 'bit' or 'bit' from 'it'?
Plato: Your honor, all is geometry. From the dialectic of counsel for Atomistic Enterprises Inc., monads are 'it' and their change between two alternate states is the 'bit'. Thus, 'it' is from 'bit' and 'bit' is also from 'it'.
Judge: Very well then. The court shall rise.

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