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A critical reflection on the Antikythera Mechanism from an idealist perspective and its implications on technological development as a means of understanding our Cosmos

Una reflexión crítica sobre el Mecanismo de Antikythera desde una perspectiva idealista y sus implicaciones en el desarrollo tecnológico como medio para entender nuestro Cosmos

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Abstract

Technology can be an insight into how humanities' needs have changed along the centuries and how science has been applied in order to solve these conundrums, to make the world our own and understand it to learn about what surrounds, what is true, and what is unchangeable. The Antikythera Mechanism's complexity and recent discoveries allow the academy to know its functions and how exact it was, as a new model has been proposed that shows that it was a device to unravel one of the biggest mysteries of antiquity: The Cosmos and the Stars. Along with the help of the perspective of Collingwood's sense II and sense III, this paper aims to define and analyse the epistemological and methodological significance of the Antikythera Mechanism, by looking into what is says about the old world and how it contrasts with the new.

Keywords: Antikythera Mechanism, Epistemology, Methodology, Idealism, Collingwood, Minimum Space, Minimum Time, Parmenides Proposition, Metaphysics, Astronomy, Theodore of Smyrna, Thinking and Being.

Resumen

La tecnología muestra una mirada perspicaz hacia cómo las necesidades de la humanidad han cambiado a lo largo de los siglos, y cómo la ciencia ha sido aplicada para resolver estos acertijos, para hacer el mundo nuestro y entenderlo para aprender lo que rodea, lo que es cierto y lo que es inmutable. La complejidad del mecanismo de Antikythera y

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recientes descubrimientos permiten a la academia saber sus funciones y qué tan exacto era, ya que un nuevo modelo ha sido propuesto que muestra que era un dispositivo para descifrar uno de los más grandes misterios de la antigüedad: El cosmos y las estrellas. Con la ayuda de la perspectiva del sentido II y el sentido III de Collingwood, este artículo busca definir y analizar el significado epistemológico y metodológico del mecanismo de Antikythera, al estudiar lo que dice del viejo mundo y cómo contrasta con el nuevo.

Palabras clave: Mecanismo Antikythera, Epistemología, Metodología, Idealismo, Collingwood, Espacio mínimo, Tiempo mínimo, Proposition de Parménides, Metafísica, Astronomía, Teodoro de Esmirna, Pensamiento y Ser.

This paper will explore the historical device and the mathematical and anthropological research done upon it, particular the work done by the University College London team headed by Tony Freeth; having presented a mostly narrative background, we will attempt to analyse it critically from Robin Collingwood's propositions on natural science whilst touching on some related concepts in philosophy of nature as found in the thought of Theodore of Smyrna.

The Antikythera Mechanism –so named scientists found off the coast of the Greek Island of Antikythera– has proven a mystery to scientist for the past twenty years. And not only because there is no signature, dating, or possible provenance, but because it was incomplete and what wasrecovered was a mechanical marvel too formidable to unravel.

Ascribed to figures such as Posidonius or even the great Archimedes –which gives a wild datingrange of over five hundred years– it wasn't until very recently that a team from University College London[2] pieced together the mathematical principles with a rather finalised (the ambiguity here is necessary, as theANTIKYTHERA MECHANISM, was broken up into 82 pieces forming 3 distinct bodies) digitalrendering of the working of the mechanism.

A commentary on their findings is most necessary before we attempt to view this from Robin Collingwood's idea of causation and minimum time and space as applied to the ANTIKYTHERA MECHANISM.

Firstly, we must clarify what is meant when, in popular scientific parlance, the ANTIKYTHERA MECHANISM is described as a "computer". Inasmuch as it is a machine that uses a definite set of rules to carry out calculations that will yield a model of a state-of-affairs, it is such a device.

But we must be careful to differentiate between what we call a computer in the XXI century and analog computing devices. The ANTIKYTHERA

[2] https://doi.org/10.1038/s41598-021-84310-w

MECHANISM belongs to this latter category and as such, the model of the state-of-affairs it will yield is constrained by minimum space and minimum time, actually bridging humanity's ability to use minimum space to describe cosmic spatial and temporal notions.

The aforementioned UCL team describes the mathematical principle behind the ANTIKYTHERA MECHANISM as that delineated by Plato in Parmenides 154 b-155b.

This model, described by Fowler as the Parmenides' Proposition,[3] details the ratios between temporal coordinates which translate into spatial ones in the ANTIKYTHERA MECHANISM. According to Plato, two temporal coordinates will have the same distance between them whether αριθμοι are added or subtracted to them. This ratio considers the numbers as relative to a scale. But when αριθμοι are added or subtracted to the relative ratios between them, the marginal error decreases as the relative amounts also are fractioned. This is expressed as p:q < (p + r):(q+s) < r :s. As Fowler accurately mentions, these ratios are homogenous within confined space, giving us constant relative values that can then be applied to points in space and time, namely, orbital positions.

The orbital positions of the planets in the ANTIKYTHERA MECHANISM are calculated as being relative one to another according to the constraints of minimum space and time as dictated by gear ratios. These follow a very important principle: that of Οικονομία, that is, as many orbital paths ascan be determined by the same homogenous ratio that follows Parmenides' Proposition.[4]

This discussion will be developed further, but for the time being, it is imperative that we explainthe theoretical basis for a minimum space and minimum time, and for that, we will refer to two works by Robin George Collingwood, ie, An Essay on Metaphysics and The Idea of Nature.

In An Essay on Metaphysics,[5] Collingwood ventures forth the concept of Causation and makes anargument that this is used in three different "Senses". We will be most concerned with senses II and III, as they are the ones that pertain most closely to the study of the cosmos and the applicationof mathematical principles to astronomical observation. To be succinct, sense II is that ofrelativistic causation, that is, when an event in nature can derive its cause from the observation carried out from the point of view of humans. Now, one

[3] Fowler, D., *The mathematics of Plato's Academy* (2nd ed.), Oxford: ClarendonPress, Oxford University Press, 1999, p. 41.
[4] Fowler, D., *The mathematics of Plato's Academy,* p. 42.
[5] Collingwood, R., *An essay on metaphysics* (2nd ed.), Lanham, Md: Univ. Pr. of America, 1984, p. 314.

might argue that this is not the case for orbital paths of planets as they were there millions of years before humans and they will inexorablycontinue their paths around the Sun and Milky Way whether we are there to measure and observethem or not. However, the measurement of orbital paths that correspond to mathematical propositions does tell us one thing about mathematical science, ie: principles are as much derivedfrom Nature as explanatory of nature.

Which leads to Sense III as Collingwood applies it to theoretical sciences, of which astronomy was until not too long ago one of the most prominent. It is not so anymore as it is squarely set within the realm of applied sciences, but we will address this topic at length further on.

Sense III for Collingwood is that contrary to the contingency of the observer-observation synergyrequired in Sense III, these are necessary events both in existence and operation. He states: "there are no CONDITIONES SINE QUIBUS NON".[6] Let us rephrase this as a positive statement: the conditions must always be there for its existence and operation.

But which conditions are these if the necessary inference is that they cannot not be? These conditions are such that causation and effect are not only chronologically but also ontologically simultaneous. As applied to the orbits of the planets in the Greek and also our modern Cosmos, the orbits and planets are both chronologically and ontologically simultaneous, necessary one forthe other in what Collingwood calls a one-to-one tight relationship.

The ANTIKYTHERA MECHANISM, as a computational device for such orbital paths, is then a product of Sense III in which Collingwood describes causation. However, such a simplification does not allow us to deal with the principle of Οικονομία. As the authors of the paper explain, this is tied in with the idea of factorisability, that is, finding the common Prime Numbers that will allow the smallest number of related gears within the mechanism to explain more than one orbital path. These two interrelated concepts interestingly are part of Collingwood's Sense II, inasmuch as there was a volitional and conditional aspect in generating the physical body of the Mechanism. How so? The calendar count used for this was the ever-so-popular in the Ancient World Metonic Calendar, developed fully in its Lunar synodical observation by Meton of Athens, but widespread amongst the Hebrews and Babylonians, from whence the count for the Antikythera Mechanism was devised. The volitional aspect, as well as the existence of CONDITIONES SINE QUIBUS NON –mainly, the association of Prime Numbers and the very idea of a compact astronomical

[6] Collingwood, R., *An essay on metaphysics*, p. 317.

device over against a large-scale observatory– show us the explanatory view of mathematics, over against the derivational view as seen in Sense III.

This seems elegant, albeit being incomplete, as something else was required to be able to apply the Metonic Calendar, the factorisation using Parmenides' Proposition to the orbital paths of the known planets, and the calculation of exacting periods for multiple celestial bodies using a limitedphysical space. And it is exactly that, what Collingwood describes as Minimum Space and Minimum Time.[7]

For Collingwood, the advent of contemporary physics, as he draws a distinct line from Newton toWhitehead, has brought back a most important idea that he seems to draw from Pythagoreanism, mainly, that the quantitative and qualitative notions of physical reality are tied in together at the most elementary level, mainly: at the subatomic level in both rhythm and matter, or time and space.As he states, the mathematics behind modern physics is a complicated matter, especially pertainingto mechanics, but we are concerned, as he is, with the metaphysics behind it. We cannot help but see here Aristotelian principles at work. In Physics II (154b-d), Aristotle already established the relationship SINE QUA NON of time and space when he describes motion. Motion can only comefrom matter into a given space which takes time.

However, it is our suspicion that Collingwood, whilst not mentioning this notion by name, is closerto Theodore of Smyrna's supposition of a dynamic cosmos, which the latter describes in his Epitome. Theodore of Smyrna was a Byzantine commentator of Aristotle's and one of his originalinsights is that Τοπος, that is, a physical place; Διάστιμα, that is space-time and the idea of distancebetween two objects or bodies; and Περιεχον, that is, the space that matter occupies are distinct ontologically. Interestingly, this insight allows Theodore to separate place and motion, that is motion requires space, but space does not produce in Sense III of the definition of causation, any motion.

If we look at the combined elements that make up the Antikythera Mechanism, we see that these three elements are at play: in having a Metonic Cycle ruling the basic calculations alongside Parmenides' Proposition, we have the Διάστιμα that in turn, creates the conditions for the Περιεχον to be described in Prime Numbers which in turn gives us the gearing required to establish the Τοπος of each orbital planetary path. Finally, following Theodore of Smyrna along these lines, heproposes the idea of Πόρρο και δευτέρως έννουμένου. This is most important as it is through a secondary place, devoid of vacuum –which Collingwood says is one of the advantages of modernphysics, whilst

[7] Collingwood, R., *The idea of nature* (1st ed.), London: Oxford University Press, 1945, pp.142-143.

making it clear that only in our modern Copenhagen Interpretation and thank to theGeneral Theory of Relativity can we understand this vacuum properly– that the dynamic cosmoscan come into play. Place and Location are thus necessary, and we come full circle with our thirdSense of Causation in the dynamics of astronomical observation.

Collingwood, of course, was for the most part laying out a historical argument from the metaphysics of science. We merely complement it with some elements from Theodore, but it is the application of such principles to the study of the Antikythera Mechanism that are our focus.

The Antikythera Mechanism was built, as we have shown, with the presuppositions of the physicalscience available at the time, which includes the aforementioned metaphysical implications of time, space, motion, and place. Perhaps we should explain this point further. Not only did Aristotleand his commentators explain these topics at length for they were ultimately trying to understandwhat Collingwood sees as one of the pivotal points in astronomy, that is: the relation between forceand motion. This cannot be understated, as it is a central aspect of both Newton's and Kepler's models for planetary motion but one that, given the context from Theodore, we can see was also paramount for Greek Cosmology.

The main idea, that of Δύναμις, is a most complex one as it entails both energy and activity. It is always forceful. So, for Theodore's and Collingwood's dynamic cosmos, movement and so space-time will be dynamic, that is, there is a positive activity, a drive that is intrinsic, a priori, and necessary to the cosmos. So, inasmuch as the cosmos exists and we can perform derivative mathematics from it, it is so because of this dynamism which, as Collingwood explains, is not onlya physical quality but a metaphysical reality that underlies the material properties of space and thatultimately allows for an understanding of the cosmos. So, we can establish with certainty that thisontological realm grants epistemic quality to the cosmos which allows for mathematical principlesto be derived and explained. The Antikythera Mechanism is a reflection of this inasmuch as it is adynamic, not a passive machine, that calculates and measures dynamic relations of orbital planes and cycles.

We must clarify once more, lest the reader think that Collingwood was indeed influenced by Byzantine philosophy in his historical appreciation of Greek Cosmology, that this is a personal insight from this author and one that should be taken with a moderate view as Byzantine sources are scarce and much is interpretational. However, we saw it fit as a connection between the Greekand modern understanding of cosmology that is valuable and unique as it allows for a more thorough understanding of the metaphysical underpinnings of this venture.

Having established a theoretical foundation for this discussion, let us centre our attention in the cosmology presented in the Antikythera Mechanism.

The Mechanism is comprised of a central dome representing the Earth. The discussion on Heliocentrism vs Geocentrism is an interesting one, but it will not concern us so long as the metaphysical principles established from Collingwood and Theodore remain true for either and allsystems.

Adjacent and tied into the Geodome is a sphere to mark out the lunar phases and its Zodiac position. The gears that are interlinked with the Metonic Cycle according to the mathematical principles described above are, in order: Mercury, Venus true Sun, Mars, Jupiter, and Saturn. Uranus and Neptune would not be a part of the cosmic array until 1781 by Herschel and 1846 by Galle respectively. It must be noted that this would not have affected the relative positioning ofthe planets nor have an actual effect on gearing calculations for a reason. As discussed above, oneof the main concerns with the theory behind orbital location was that of gravity as a force. We nowknow[8] [9] that Jupiter's gravitational influence on the inner planets is just as important as the Suns,so, as long as Jupiter accounts as a bridge in its ratio between Mars and Saturn, all of the planetarylocations and secondary locations can be more or less accurately pinpointed as the primefactorisation will make Jupiter's calculation of its synodic and Metonic cycle the most accurate. The outermost disc marks the date, as well as the oppositions that will mark Lunar and SolarEclipses. The mechanisation process that was required to build the mechanism is truly remarkable,as the authors of the article mention, as it allowed for complex calculations and several scientific theories to be proven and systematised. But, whilst the scientific value of it is great, we must lookat the philosophical value of analysing this mechanism.

What can we learn about the epistemic need to understand Nature, how are we able to do so; what are our metaphysical presuppositions when approaching the study of nature, and where does this lead in our contemporary society?

The metaphysical presuppositions have been discussed at length; however we can say more aboutthe epistemic requirements and motivations.

And we point to both Collingwood and Harvard Professor Irad Kimhi to give us a satisfying explanation of this. In Thinking and Being, Professor Kimhi points to the "syncategorematic" capacity for thought, that is, the Parmenidean conundrum of the thought and the thinker being intrinsically

[8] Ceres, Retrieved 31 May 2021, from https://solarsystem.nasa.gov/planets/dwarf- planets/ceres/overview/
[9] Ceres.

linked as the category of thought can only be a category for the thinker.[10] And we would do well to recall Sense II that Collingwood proposes. The actual computation and usage of a machine to determine relative positions cosmologically are entirely volitive and so it's an "anthropocentric idea that man looks at nature from his own point of view". Now, Collingwood asserts that this anthropocentrism might have to do with some utilitarian means to an end as man attempts to manipulate nature in order to benefit from it. This brings up a radical question or rather,series of questions. They're radical inasmuch as it can only be answered by speculation, one that must bridge almost two millennia of scientific and philosophical vacuum: what was the purpose of the Antikythera Mechanism? Well, to study the cosmos. Yes, to what purpose? What was in store for the designer of the Antikythera Mechanism? Why go to such lengths to put together sucha complex machine that involved studying all the ancient cosmological theories and charts and piecing together mathematical principles from logical views of the natural world?

Perhaps Collingwood wasn't wrong in ascribing not only an anthropocentric view in the study of nature –ultimately, man can only ever view nature from his perspective and mental state– but also in its utilitarian sense. To be able to understand the movement of the cosmos would grant thewielder a power that was quite terrible. Indeed, that of being able to establish not only astrologicaldata that was important for the religious and social life of a society, but also to have clearly demarcated seasons that would in turn profit the reaping and sowing of harvests.

Now, into the realm of supposition that we find ourselves in, we do not tread lightly but actually find it quite plausible. Both harvesting and religious festivals tied into the seasonal changes are thebloodline of civilisation. The cosmos thus becomes an icon or iconographic representation of ourown volitions. And not because as humans we are able to control planetary motion in any way, shape or form. Rather, that in understanding the structure of the cosmos that surrounds us, we canmake use of that cosmos to our advantage, to pursue the ultimate Aristotelian goal in life: happiness. Now, it is not our intention to leap into an ethical conclusion, nor do we think it is the scope of this piece. Rather, we wish to show how an understanding of the physical and metaphysical principles of the cosmos is both an epistemic and moral activity for man. Ultimately,knowing when to reap and sow will provide sustenance for the anthropocentric gods and for ourselves, so there is always a utilitarian bend on things. Seeing the cosmos as an icon, or as Theodore of Smyrna says: ὡσπερ άν έι τις τροχόν έν τροχόν έννοήσειε, that is,

[10] Kimhi, I., *Thinking and being* (1st ed.), Cambridge, Massachusetts: Harvard University Press, 2018, p. 14.

as a wheel within a wheel, takes us to the ultimate question on the nature of reality. Is it simple or complex? Of whatnature are the elements of the cosmos? Saint Maximos tells us that the universe has a multiplicityof parts and places that share in a single substance. In trying to understand this is that we see causality as a priori to the cosmos, allowing for us to intervene and derive principles from it.

And this leads us to analysing the implications on technological developments in our time. The last few years have been filled with technological wonder, especially in the art of observing the cosmos. We no longer need the Antikythera Mechanism to help us estimate planetary positions: we have Hubble, Cassini, Huygens, Voyagers 1 and 2, New Horizons; we have SETI and the International Space Station; and now we even have eyes and ears on Mars with Perseverance andZhurong.

Firstly, we must poise the question about the Third Sense of causation in nature. Is the Greek Cosmos, our Solar System –now augmented with Uranus, Neptune, Pluto, and most recently the recognition of Ceres as a dwarf planet[11]– still operating dynamically under no conditions without which it wouldn't? To put it more bluntly, does our Solar System function without us? As philosophers trying to unravel not only the substance of the natural world but also the minds that wish to comprehend it, we must not be coy in seeing a transition of Astronomy from being a purely theoretical science to an applied one in Collingwood's sense. Ever more we are not only seeking to understand the planetary bodies that surround us but are claiming them by human will for humangain under a human lens. Perseverance and Zhurong are, in opposing Space Programmes,attempting to grasp the terraforming capability of Martian soil and atmosphere; the Israeli Beresheet lander was there to test Lunar minerals that might work towards cleaner energy on Earth; the Parker Solar Probe was designed to study radio-magnetic interference in the Sun and coronal discharges that might adversely affect human telecommunications. We have here a most interesting transition from seeing the cosmos as an icon of an ontological reality to an icon of our own needs. In that sense, we have become the primary looker towards the secondary place that Theodore was so concerned was a purely metaphysical exercise. In doing so, we are learning to manipulate the cosmos as we manipulate other minds in order to reap some benefit other than the intellectual pursuit.

In conclusion, when putting the Antikythera Mechanism under an idealist lens, we see a most nobleavocation in seeking to understand the immensity that surrounds us. But Collingwood's idea of Nature is not a fixed science,

[11] Ceres.

but rather, a historical reality that shifts according to human needs. And humans need to comprehend the cosmos in such a way that it may become an asset, and no longer a vast expanse of mathematical wonder.

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