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Landscapes, Circles and Antikythera: The Birth of the Mechanical Universe

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Abstract

The joint Greek/UK/US Antikythera Mechanism Research Project is currently producing a definitive set of experimental optical and X-ray imaging data of the Mechanism. The interpretation will require a good knowledge of the context in which it was made. Following from the "sacred landscapes" of northern Europe it is difficult to escape the symbolism of the "circle" in prehistoric cosmologies, and the pre-eminence of the circle in Greek astronomical thought is obvious. Is the "circular" ikon of the main wheel in the Antikythera Mechanism simply another gear wheel, or might ideas of cosmology have influenced its design? How important would devices like the Antikythera Mechanism have been in providing a physical model of the Universe, pushing mathematical abstraction into reality? The relevance of the Mechanism in understanding the development of ideas and philosophy, particularly determinism, is emphasised.

Keywords: *ancient cosmology, circle symbolism, greek astronomy, determinism*

Introduction

A major re-investigation of the Antikythera Mechanism is under way. The seminal work by de Solla Price (1974; briefly summarised in Edmunds and Morgan 2000), and subsequent stimulating research by Michael Wright (e.g. 2002-2006) and others, underline the extraordinary sophistication of the device. But many questions remain unresolved, not least the original purpose of the Mechanism. We (*The Antikythera Mechanism Research Project* – see acknowledgements) are hopeful that our new work will resolve many of the problems. It involves both surface imaging of all known fragments using a special technique pioneered by Maltzbender and his colleagues (www.hpl.hp.com/research/ptm/antikythera_mechanism/index.html), at Hewlett-Packard and complete X-ray tomography using state-of-the-art equipment by X-Tek Ltd (www.xtekxray.com/antikythera.html). Very successful data gathering was carried out in September and October 2005 at the National Archaeological Museum in Athens, and we expect the release of initial results in the Autumn of 2006 (Freeth et al).

In this short paper, however, I will not focus on

the structure of the Antikythera Mechanism (henceforth "the Mechanism") itself but on the two topics of (i) the context in which it must have been made and (ii) the powerful imagery (intentional or unintentional) that it involves. Such considerations may ultimately be important in understanding its purpose, and certainly underline its - perhaps so far rather unrecognised - importance in the history of ideas. Much of this may be seen as unfounded speculation, but it will have served its purpose if it provokes necessary debate.

The Mechanical Universe

A wide-spread perception is that *"Of all the changes that swept over Europe in the seventeenth and eighteenth centuries, the most widely influential was... the "scientific revolution"...and the view that the world functions like a machine"* (Hooker 1996). The existence of the Mechanism immediately challenges this view, since it is could represent a mechanical model or representation of the Universe from eighteen or nineteen centuries earlier. The beautiful woodcut shown in Fig. 1 well illustrates the idea of discovering the underlying mechanical "workings" of the Universe, and the image of one of the main Mechanism gears (Fig. 2) inevitably suggests parallels.

But we need to probe more deeply into the meaning – contemporary and historic – of "mechanism" and "mechanical". For a current definition of mechanism we can turn to a dictionary (http://en.wiktionary.org/) giving:

- A machine
- A group of parts performing a specific function in a machine
- A group of objects that interact together
- A mental, physical or chemical process
- (Philosophy) A theory that all natural phenomena can be explained by physical cause

Of these, the second and third are certainly true of the Mechanism. But is the fifth applicable? Could the Mechanism be regarded as a "clockwork" and "deterministic" model or representation of the Universe? Certainly the suggestion of a modern "orrery" or "tellurium" interpretation of the Mechanism's function is not new. I will comment on imagery later, but a quotation from de Munnynck (1911) is revealing:

"There is no constant meaning in the history of philosophy for the word mechanism. Originally, the term meant that cosmological theory which ascribes the motion and changes of the world to some external force".

This implies the important question of whether it is the Mechanism or the Universe that is the metaphor! In other words, a valid interpretation is that the Mechanism is a representation of the behaviour of the Universe, rather than the Universe being

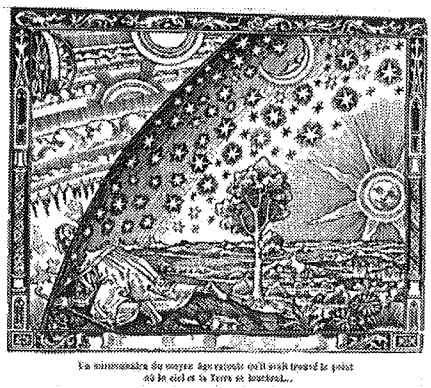

***Fig. 1:** An unsigned woodcut which first appeared in Flammarion's L'Atmosphere; Paris 1888.*

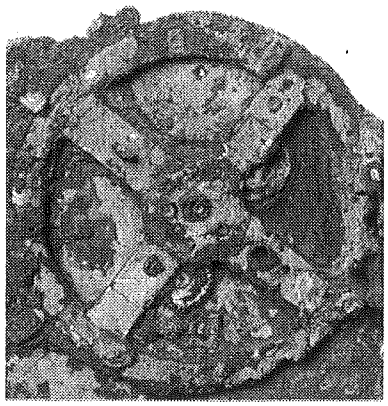

***Fig. 2:** The main fragment of the Antikythera Mechanism, with its prominent "Sun" wheel (Image copyright of the Antikythera Mechanism Research Project).*

imagined as actually functioning like the mechanism. Modern mechanistic thought is surely more like the latter – even if we have abandoned a "clockwork" model and do not yet understand all the physical details, we nevertheless do to some extent regard the Universe as a machine. The Greeks probably had a dichotomy of views, since Ptolomy (Almagest, XIII 2) actually warns against too literal acceptance of "mechanical" models:

"...it is not appropriate to compare human [constructions] with divine, nor to form one's beliefs about such great things on the basis of very dissimilar analogies.....We see that in the models constructed on earth the fitting together of these [elements] to represent the different motions is laborious, and difficult to achieve in such a way that the motions do not hinder each other, while in the heavens no obstruction whatever is caused by such combinations. Rather, we should not judge 'simplicity' in heavenly things from what appears simple on earth, especially when the same thing is not equally simple for all even here" (Toomer 1998).

There is criticism here of both impiety and mechanical limitations. He may be particularly referring to problems of the practically interlacing of crystal spheres, but the criticism surely holds for two-dimensional as well as three- dimensional models. Indeed, we note in passing that there is still some confusion over the meaning of *"sphaera"* – the subject of the lost book of Archimedes. It is well known that the strongest classical reference to an Antikythera-like Mechanism comes from Cicero's *De Natura Deorum*, again referring to *"sphaera"* – which presumably is used in a generic way to refer to two- as well as three-dimensional models. Ptolomy may have been writing some 250 years after the construction of the Mechanism, but the fact that he is writing this at all implies that there had been at least some belief in a "mechanistic" – i.e. working like a mechanism – Universe. His concern perhaps demonstrates that such mechanisms had been important in the early development of human ideas of a mechanical Universe, and that they were not simply regarded as amusing but philosophically irrelevant "toys".

Imagery

The principal gear (Price's B1) of the Mechanism (Fig. 2) is unique in its structure. None of the other surviving gears has its spoked structure – all the others are solid discs.

We do not know whether this form of construction was deliberate. It could have been a strengthening innovation to carry additional gear mechanisms on the spokes (there seem to have been some kind of fittings on the spokes), but another gear carrying additional mechanism (Price's E3/4 and of comparable size) is solid. The spoked wheel is sometimes described as the "Sun Wheel" because it is directly involved in the drive for the indication of the Sun's position in the Zodiac on the front dials of the Mechanism. We note the use of a symbolic "sun wheel" ⊕ of similar shape in various cultures (with the quarter divisions possibly representing the four seasons) – for example Odin's cross in Norse mythology. The Sun cross *"is... one of the oldest and most universal religious symbols, and a traditional neopagan sun symbol"* (Wikipedia 2006a).

Visually, the spoked structure immediately suggests a chariot wheel – the four-spoked pattern being common on Greek (and perhaps Mycenaean) vase decoration, intaglios and marble reliefs. A small votive offering to Aphrodite, now in the National Archaeological Museum in Athens, has a similar structure. Was the imagery of the Mechanism's wheel intentional, or just the sensible way to make a strong gear? The chariot-wheel sign is used as a symbol in Canaanite Hazor, 2nd Millenium BC. There are of course resonances with the idea of the "sun chariot" – for example, as *Sol in Quadriga, the Soli Invicto* portrayed in a four-horse chariot on the coins of Probus (A.D. 276-282). The history of the evolution of both the "solar" signs ⊕ (or ⊗) and ⊙ may well be worth further investigation. The sign ⊕ later became more associated with terrestrial phenomena, and the ⊙ is still widely used in modern

astrophysics. The ⊙ may have evolved from (or, rather, perhaps have passed through) forms of the greek letter Θ (theta) where the bar degenerates to a dot, in which form it is also found on the Mechanism – but probably as a number, rather than as a solar symbol. It is tempting to push the invention and significance of both signs much further back to the geometry of the circular henges, and stone circles, of northern Europe. Here, in landscape, the circular geometry must represent some ideas of the wider or ritual Universe – even if originating from much humbler roots in circular dwellings. Bradley (1998, p108) argues *"that... constant emphasis on the circle reflects a shared perception of the world – a prehistoric cosmology"*. Again one could allude to the circular form of the Sun and Moon, and even the annular solar appearance at some eclipses.

The symbolism of ⊕ was apparently powerful, since it was used both astrologically as the "lot of fortune" (and later indeed "The *Wheel* of Fortune"), and as the obvious basis for the Christian celtic, gnostic and Chrismon crosses.

It is difficult to escape the idea that the design of the Antikythera Mechanism "Sun" wheel must have owed something, even if only subconsciously in mind of the maker or as a expression of conventions at the time, to a traditional cosmological meaning of circles. Indeed, returning to our discussion of "mechanism" the use of (inevitably!) circular wheels in constructing the Mechanism may have had its own significance – perhaps acknowledged in the term *"spherae"*.

Implications

Where does this leave us in our study of the Mechanism? In terms of direct analysis of its function, it probably has little effect. We know that the Mechanism could be used for astronomical and calendrical calculations. So far we have found no evidence for astrological, rather than astronomical, use. We can confirm, however, the use of the word "stationary" in the inscription – a term very suggestive of planetary behaviour. This is interesting because de Solar Price (1959) mentions it in his early Scientific American article, but omits any reference to it in his 1974 book. Whether he had simply forgotten, or was waiting for further evidence of planetary function in the Mechanism is unclear. We are not yet able to confirm that the term in fact refers to planetary behaviour. Drawing parallels with some interpretations of the much earlier northern European monuments (e.g. Ruggles 1999) might suggest looking for evidence of lunar standstill prediction within the mechanism. But so far as I am aware there is no known literary reference to Greek interest in the lunar standstills – perhaps simply because at the lower Mediterranean latitudes the phenomenon appeared much less spectacular as the moon never skimmed the horizon.

There is still a great need for more investigation of Greek mechanical devices in general. A copy of Archimedes' "de Spherae" might yet turn up in excavation of a lost library, or in palimpsest. I even wonder if some of Apollonius' work on circles (e.g. his three circles problem) might be based on attempts to refine meshing of gears. One possibility should not be overlooked, although a rather faint hope. The Antikythera Mechanism *cannot* have been unique. It must have come from a tradition of "spherae" making – there must have been other versions. Cicero's description (around 45 BC and describing a "recently made" mechanism) was probably written after the Antikythera wreck had occurred, and probably does not refer to the Antikythera Mechanism itself – although he *might* perhaps have seen it while studying in Rhodes 79-77 BC. Since the best bronzes seem to survive only from shipwrecks, the best strategy must be to look for another mechanism lost in transit among uninvestigated Mediterranean wrecks.

Although the imagery is not very helpful in studies of *function*, it may yet shed light on purpose. The "sun wheel" structure may or may not have been deliberate, and our reconstructions should at least indicate whether it was ever meant to be visible during use of the Mechanism. The ikonic imagery of the turning gear wheels, with all

the pre-historic metaphor of circles behind them, is hard to escape. Indeed, even today in understanding the Universe we appeal to images of spheres and circle – e.g. in the representation of "bubble" Universes (Bousso and Polchinski 2005, 48) in a recent Scientific American article. But gears are special – they are completely deterministic and regular in their combined action. Determinism is *"the philosophical proposition that every event, including human cognition and action, is causally determined by an unbroken chain of prior occurrences. No mysterious miracles or wholly random events occur"* (Wikipedia 2006b). The implications of a geared mechanism describing the behaviour of the Universe (or vice versa) cannot have been lost on the Greeks – and this surely must influence our understanding of the evolution of Greek philosophy. It is surely critical in the comparison of the Stoic view of the Universe as governed by divine intervention versus the (Enlightenment) Epicurean view of soulless regular repetition. I do not think I need to emphasise further the importance of our understanding of the Greek (and ultimately, therefore our own) association of the idea of "Mechanical" with "Universe", and the central role that the very existence of the Antikythera Mechanism must play in that debate. Is a machine a mirror of the Universe or the Universe a mirror of a machine? – a fine circular problem!

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