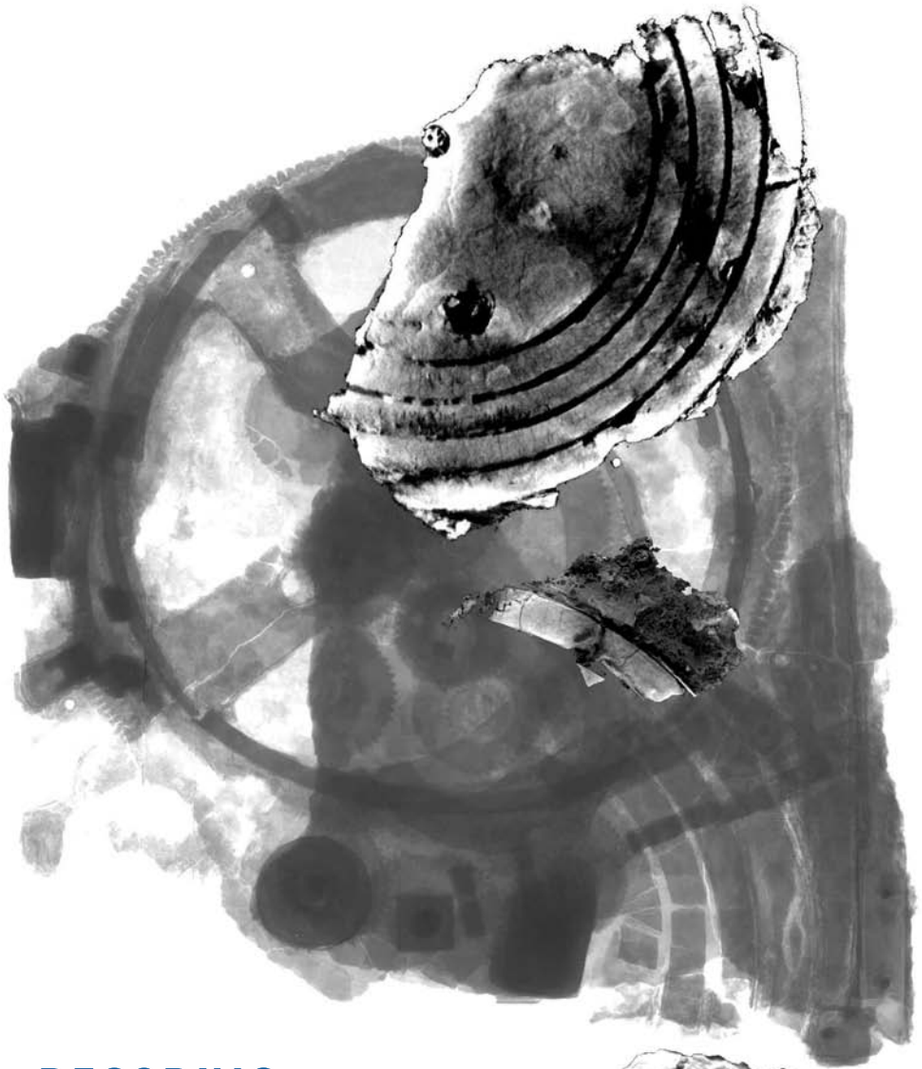
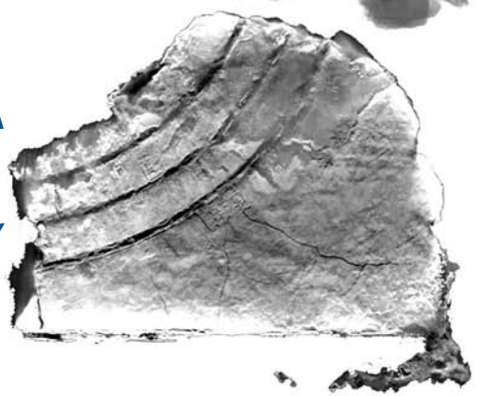
CULTURAL FOUNDATION
OF THE NATIONAL BANK OF GREECE

NATIONAL BANK
OF GREECE



DECODING THE ANTIKYTHERA MECHANISM

SCIENCE AND TECHNOLOGY IN ANCIENT GREECE



INTERNATIONAL CONFERENCE
30th NOVEMBER AND 1st DECEMBER 2006
ATHENS

DECODING THE ANTIKYTHERA MECHANISM

In 1901 a group of sponge divers from the island of Syme discovered off the island of Antikythera a huge shipwreck with many statues, including the beautiful "Antikythera Youth" and other treasures. Amongst the numerous objects they recovered a curious as much as mysterious clock-like mechanism, damaged, mutilated, calcified and corroded, as it has been in the sea for longer than 20 centuries. The first studies showed that this precious item was a complex astronomical instrument, the oldest instrument with scales, initially named the "Antikythera Astrolabe", but much more complex than any other known astrolabe. It was later renamed as the "Antikythera Mechanism".

Several studies have been performed during the 20th century by J. N. Svoronos, G. Stamires, V. Stais, R. T. Gunther, R. Rhediades, A. Rhem, K. Rados, J. Theophanides (who studied carefully and constructed the first working clockwork-like model of an advanced astrolabe), K. Maltezos and Ch. Karouzos. A breakthrough came with the use of radiography (X-rays and Thallium 170 radiation) by Derek de Solla Price and Ch. Karakalos, and later by M. T. Wright, A. Bromley and H. Mangou, who used tomography and furthered our understanding of the Mechanism.

As new very advanced techniques become available new ideas emerged that led to the formation of the international team of the *Antikythera Mechanism Research Project* (University of Cardiff, University of Athens, University of Thessaloniki) who got a substantial research grant from the Leverhulme Trust, and in collaboration with the X-Tek Systems (who developed powerful microfocus X-ray computed tomography) and Hewlett-Packard (using reflectance imaging to enhance surface details on the Antikythera Mechanism), The National Archeological Museum and under the auspices of the Ministry of Culture (Dr. P. Tatoulis), undertook a new research starting September 2005.

The first new results are very exciting as they enable us to have new detailed three-dimensional reconstruction of the internal structure of the Antikythera Mechanism, using a total of one terabyte of computed tomography data and the surface polyno-

mial mapping images. Every single gear in the corroded mechanism is revealed, studied, mapped, with all the details possible, accurate teeth count estimations, axle positions, gear interrelations. New inscriptions, completely unknown until now and sealed for 21 centuries inside this ancient computer by corrosion and the calcification, have been read again, the "user manual" has been decoded (in collaboration with the Center for History and Palaeography, Cultural Foundation of the National Bank of Greece) giving us intriguing new information about the use of this astronomical device.

The forms of the letters in the inscriptions has indicated a re-estimation of when they were written (courtesy Dr H. Kritzas), suggesting a date in the second half of the second century B.C., which could lead to the greatest astronomer of all times, Hipparchos. Numerous astronomical terms are in this newly formed group of inscriptions, which is very interesting in terms of astronomy, technology, geography and even linguistics, for example the name of Spain (ΙΣΠΑΝΙΑ, ISPANIA) appears in this text for the first time.

Initial analysis reveals interesting features and deep flaws in all previews models. We support Wright's advocacy that they show the 19-year Metonic cycle and a Callippic subsidiary dial, the idea that the back dials were in the form of spirals. We show new evidence that establishes the purpose of these spirals. We prove that the subsidiary dial is a Triple Saros, or Exeligmos Dial. We identify the "glyphs" (astronomical symbols in the dials) as eclipse predictions. This research leads to a unified new picture of the Back Dials, with periods of 19, 76, 18+ and 54+ years.

The Lower Back Dials are a Saros/Exeligmos system which strongly suggests that it was implemented by a fixed-axis train including a gear with 223 teeth. X-Tek's CT supports the new idea that the epicyclic system at the back of the Mechanism exploits the pin-and slot mechanism discovered by M. T. Wright in an extraordinary mechanical realization of Hipparchos' Lunar Theory.

Our research shows that the Mechanism was even more sophisticated than previously thought, with a remarkable ingenuity of design.

THE ANTIKYTHERA MECHANISM PROJECT

www.antikythera-mechanism.gr

ACADEMIC RESEARCH TEAM

People from the following institutions have, at various stages and in various roles, contributed to the new investigation of the device known as the "Antikythera Mechanism":

UNIVERSITY OF CARDIFF, UK
Mike Edmunds (Academic Lead), Tony Freeth

NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS, GREECE
Xenophon Moussas, Yanis Bitsakis

ARISTOTLE UNIVERSITY OF THESSALONIKI, GREECE
John Seiradakis

CENTRE FOR HISTORY AND PALAEOGRAPHY, CULTURAL FOUNDATION OF THE NATIONAL BANK OF GREECE
Agamemnon Tselikas

NATIONAL ARCHAEOLOGICAL MUSEUM, ATHENS, GREECE
Helen Mangou, Mary Zafeiropoulou, Gerasimos Makris and team of conservators

Data Gathering and Technical Support

HEWLETT-PACKARD LABS, PALO ALTO, CALIFORNIA, USA
Tom Malzbender, Dan Gelb, Bill Ambrisco

X-TEK SYSTEMS, TRING, HERTS, UK
Roger Hadland, David Bate, Andrew Ramsey, Martin Allen, Allan Crawley, Peter Hockley, Stuart Wright, Geraint Dermody, Andrew Ray

VOLUME GRAPHICS GMBH, HEIDELBERG, GERMANY
Christof Reinhart

PHOTOGRAPHY
Costas Xenikakis

KEELE UNIVERSITY, UK
Jim Austin, Peter Haycock

IMAGES FIRST LTD
Stephen Macmillan

ACKNOWLEDGEMENTS

Science is a collaborative venture. Without the support and generosity of funding institutions and agencies and the dedication of several individuals, its pace, effectiveness and success are greatly limited.

This work was supported by the Leverhulme Trust. Without its generous support, the Project would still be in its infancy. The Walter Hudson Bequest, the University of Athens Research Committee and the Cultural Foundation of the National Bank of Greece and in particular its Director, Dionysis Kapsalis, all played a pivotal role in the success of the Project.

The support of the Ministry of Culture, Greece (in particular, Petros Tatoulis, former Deputy Minister) was invaluable. We also acknowledge essential support from the National Archaeological Museum in Athens (Nikolaos Kaltsas, Director, Rosa Proskinitopoulou, Deputy Director and Head of Bronze Section).

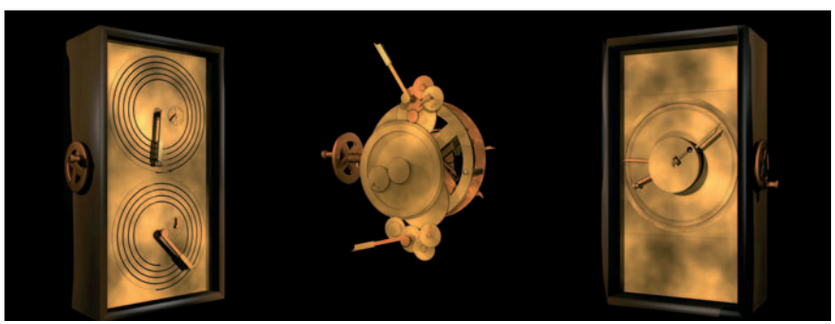
We acknowledge the generous support of the staff of the National Archaeological Museum and of X-Tek Systems.

The Athens International Conference was supported by the National Bank of Greece.

The French Embassy and the French Institute in Athens contributed to the organisation of Session 3 of the Conference.

Special thanks to the Athens Traffic Police for their assistance in conveying X-Tek Systems' eight-tonne X-ray machine to and from the National Archaeological Museum.

Finally, we acknowledge help and advice from Alex Abravanel, Stella and Eftichios Alfieris, Janet Ambers, Hazel Forsyth, Ian Freestone, Dimitris Gogos, Robert Halleux, Velson Horie, Alexander Jones, Mark Jones, Panaghiotis Kipouros, Haralambos Kritzas, Ioanna Mantzavinou, Josef Lossl, Dionysios Mouzakis, Efthymios Nicolaidis, Maria Papathanassiou, George Simantonis, Ioanna Soufleri, Christos Stathakopoulos, Ioannis Theophanides, Lefteris Tsavliris, Harry Tzalas, Alexandros Valassopoulos, Ruth Westgate, Tim Whiteside and Angelos Xenos.



3D models of the back dials, the back gears and the front dial, based on the new model of the Mechanism

INTERNATIONAL CONFERENCE

DECODING THE ANTIKYTHERA MECHANISM SCIENCE AND TECHNOLOGY IN ANCIENT GREECE

PROGRAM

THURSDAY 30 NOVEMBER 2006

Welcoming Session

09:00 - 09:15 Welcome – Opening

09:15 - 09:30 The Antikythera Mechanism Research Project: a collaborative project

Session 1: The Antikythera Mechanism Research Project

Chairman: HARRY TZALAS

09:30 - 10:00 MIKE EDMUNDS The Antikythera Mechanism in context

10:00 - 10:15 HELEN MANGOU A short research history of the Antikythera Mechanism since its discovery in 1902 up to the Antikythera Mechanism Research Project in 2005

10:15 - 10:30 MARY ZAFEIROPOULOU The statues of the Antikythera shipwreck as a "context" for the Mechanism

10:30 - 10:45 JOHN SEIRADAKIS The pioneering use of new technology in archaeological research

10:45 - 11:05 TOM MALZBENDER Reflectance imaging : Enhancing surface detail on the Antikythera Mechanism

11:05 - 11:25 ANDREW RAMSEY 3D X-ray Imaging – The latest techniques reveal the earliest technology

11:25 - 11:45 COFFEE BREAK

Session 2: The results

Chairman: JOHN SEIRADAKIS

11:45 - 12:15 YANIS BITSAKIS, AGAMEMNON TSELIKAS The new inscriptions: 1. Assembling the operation manual, 2. Reading fragment G

12:15 - 12:40 TONY FREETH Journey to the centre of the Mechanism: 1. The back dials and eclipse prediction

12:40 - 12:50 MIKE EDMUNDS Counting teeth and scales

12:50 - 13:15 TONY FREETH Journey to the centre of the Mechanism: 2. The gears and the lunar mechanism

13:15 - 14:00 DISCUSSION

14:00 - 17:00 LUNCH BREAK

Session 3: Context and consequences

Chairman: EFTHYMIOS NICOLAIDIS

17:00 - 17:15 XENOPHON MOUSSAS The moon phase mechanism and the hypocycloidal gears

17:15 - 17:30 IOANNIS LIRITZIS, ALEXANDRA COUCOUZELI Ancient Greek heliocentric views hidden from prevailing religious beliefs?

17:30 - 18:00 MICHAEL WRIGHT A review of the evidence: the case for reconstruction as a planetarium

18:00 - 18.30 DISCUSSION

18:30 - 18.50 COFFEE BREAK

Public Session (in Greek)

Chairman: IOANNA SOUFLERI

19:00 - 20:30 MIKE EDMUNDS Introduction

HELEN MANGOU Salutation

TOM MALZBENDER Salutation

ROGER HADLAND Salutation

MARY ZAFEIROPOULOU Objects from the Antikythera shipwreck as a "context" for the Mechanism

YANIS BITSAKIS The new inscriptions: Assembling the operation manual

AGAMEMNON TSELIKAS The new inscriptions: reading fragment G

TONY FREETH Journey to the centre of the Mechanism

XENOPHON MOUSSAS First conclusions from the study of the Mechanism

JOHN SEIRADAKIS The Antikythera Mechanism: A calendar of astronomical events

20:30 - 21:00 DISCUSSION

FRIDAY 1 DECEMBER 2006

Session 3 (continued): Context and consequences

Chairman: MARIA PAPATHANASSIOU

9:30 - 10:00 ALEXANDER JONES The Antikythera Mechanism as an artifact of Hellenistic astronomy

10:00 - 10:30 CLIVE RUGGLES Ancient science and archaic cosmology: towards a broader context for interpreting the Antikythera Mechanism

10:30 - 11:00 ROBERT HANNAH Parapegmata, Hellenistic calendars and the Antikythera Mechanism

11:00 - 11:30 JOHN STEELE The solar / lunar functions of the Antikythera Mechanism in the context of Mesopotamian and Greek astronomy

11:30 - 12:00 DISCUSSION

12:00 - 12:20 COFFEE BREAK

Chairman: AGAMEMNON TSELIKAS

12:20 - 12:40 MARIA PAPATHANASSIOU Reflections on the Antikythera Mechanism texts

12:40 - 12:50 HELEN KARABATZAKI Ancient textual evidence possibly concerning the Antikythera Mechanism

12:50 - 13:05 DISCUSSION

13:05 - 13:15 ALEXANDRA SMITH Complex devices in Antiquity: The brethren of the Antikythera Mechanism

13:15 - 13:45 EMMANUEL POULLE "L'héritage d'Anticythère": mécanisations astronomiques dans l'Europe latine au Moyen Âge

13:45 - 14:00 DISCUSSION

14:00 - 16:30 LUNCH BREAK

Session 4: The Mechanism: Data archive and future well-being

Chairman: MIKE EDMUNDS

16:30 - 17:30 Round table
MIKE EDMUNDS, JOHN SEIRADAKIS, XENOPHON MOUSSAS, HELEN MANGOU, TONY FREETH, YANIS BITSAKIS Collaboration. Data and Web archive: what is wanted? What is possible?

KOSTAS KARATZAS A possible web portal for archiving, presentation and usage of the Antikythera Mechanism. Project results

ALEXANDER ARGYROPOULOS
Virtual operation of the Antikythera mechanism in its actual environment

17:30 - 17:45 HELEN MANGOU The role of the National Archaeological Museum as a custodian for the Antikythera Mechanism

17:45 - 18:15 VELSON HORIE Conservation for use, now and in the future

18:15 - 18:30 DISCUSSION

18:30 - 19:00 COFFEE BREAK

Session 5: Future work

Chairman: XENOPHON MOUSSAS

19:00 - 20:20 Round table
What we have learned. What further investigations are needed. What we anticipate to learn in the future

Session 6: Summary

20:20 - 20:30 MIKE EDMUNDS Closing remarks

ABSTRACTS

ALEXANDROS ARGYROPOULOS

VIRTUAL OPERATION OF THE ANTIKYTHERA MECHANISM IN ITS ACTUAL ENVIRONMENT

In the beginning, a very brief description of the author's personal information sources about the Antikythera Mechanism is presented.

The main part of the presentation suggests the design and availability of a downloadable 3-D simulation model of the mechanism over the Internet using a specific colour code to depict its parts. This model will be combined with a computer program that will simulate the positions of the earth, the moon, the planets, the sun and the stars as they were back in 100 years B.C. and thus allow the researching mechanics and astronomers to virtually operate the mechanism in its actual environment at the date of its manufacture. The availability of the model on the Internet site will allow scientists from all over the world to contribute to this research.

This virtual "on site" operation will allow the researchers to fine tune the shape and teeth count of the gears and positions of various arbours and displays of the mechanism that are not complete, or not even existing in the original recovered fragments, in order to achieve the best possible accuracy in the actual reconstruction of the mechanism.

Next, the possibilities of mass production of replicas for educational, scientific and also commercial purposes are presented.

Last, the author explains why a new underwater exploration of the Antikythera wreck is very probable to reveal fragments of the mechanism still remaining under the sea.

YANIS BITSAKIS AND AGAMEMNON TSELIKAS

THE NEW INSCRIPTIONS:
1. ASSEMBLING THE OPERATION MANUAL, 2. READING FRAGMENT G

From the discovery of the Antikythera Mechanism, the inscriptions were of first importance for studying its origin and functions. For decades, they constituted the most important visible part, and lead to its early characterization as an astronomical device, although the texts were extremely fragmentary. With the Antikythera Mechanism Research Project,

inscriptions can now be read that have not been seen for more than two thousand years, and this is helping to build a comprehensive picture of the functions of the Mechanism.

The number of read characters has doubled from the previous research lead by Derek de Solla Price. We now have reconstructed a more complete text of the back door plate, which permits us to characterize it as an "instruction manual", where mechanical terms describing parts of the Mechanism are mixed with astronomical periods and bodies displayed by those parts.

One important part of the front door plate consists essentially by fragment G, which contains one of the most extensive texts lying on the Mechanism. This text was considered as unreadable by previous researchers. The Computed Tomography enables us to read most of its characters, revealing possibilities about lost functions of the Mechanism. Terms like ΑΠΟΚΑΤΑΣΤΑΣΙΣ, ΔΙΑΣΤΗΜΑ, ΣΤΗΡΙΓΜΟΣ, ΠΕΡΑΙΩΣΙΣ, planet names like Hermes or Venus, verbs like ΠΡΟΣΑΓΕΙΝ, ΕΠΕΤΕΙΝΕΝ, ΠΡΟΣΙΕΙ, and numbers like 265, 340, 130, together with the mention of the Sun as a reference for computing, provide a more concrete view about the possibility of displaying distances between planets at a given moment.

MIKE EDMUNDS

THE ANTIKYTHERA MECHANISM IN CONTEXT

As a preparation for the new results which will be presented at the conference, this introduction will try to set the Antikythera Mechanism in time and place. It comes from a rather "dark era" of Greek astronomy, so discovery of its inscriptions and functions should shed some light. Undoubtedly we see the heritage of Babylon. The newly-apparent mechanical sophistication of the Mechanism certainly raises the vital question of the state of Greek technology and learning at the time. Exactly when, by whom, for whom and for what was the Mechanism made? What other technology does it imply? What would have been the influence of mechanical models on the Greek view of the Universe? These questions will be asked in the hope and anticipation that some answers will be beginning to emerge by the end of the conference!

COUNTING TEETH AND SCALES

The statistical methods used in deriving the tooth counts of incomplete gears from X-ray images of the Antikythera Mechanism will be described, together with the results. The importance and difficulties of locating the gear centres will be emphasised. We will show how quite restrictive ranges of tooth count values can be established. The methods are also applied to the scales of the Mechanism. Suggestions for further work will be made.

VASSILIKI FRAGOU

The greek newspapers *ΑΚΡΟΠΟΛΙΣ* and *ΕΣΤΙΑ* between April 1902 and June 1902, and *ΕΛΕΥΘΕΡΟΣ ΤΥΠΟΣ* between May 1902 and June 1902, have been thoroughly investigated, at the archives of the Greek Parliament Library, for articles concerning the Antikythera shipwreck. Several references to the shipwreck and the Antikythera Mechanism have been found with some interesting statements: The first report of the Antikythera Mechanism was on May 22, 1902 in the Newspaper *ΕΣΤΙΑ*. Furthermore, interesting announcements, concerning the involvement of the Principality of Monaco were found together with references concerning an inscription with the words "Sun ray – Ακτίνα ηλίου", its relevance of the Mechanism to astronomical instruments, etc. The investigation is an on-going project. It is expected that it will reveal the apprehension about the Antikythera Mechanism, during those early days.

TONY FREETH

JOURNEY TO THE CENTRE OF THE MECHANISM

1. THE BACK DIALS AND ECLIPSE PREDICTION

In 2005 we completed the data gathering phase of our research, designed to look at the Antikythera Mechanism from a fresh perspective. X-Tek Systems and Hewlett-Packard left us with a rich store of x-ray and surface imaging data and a huge jigsaw puzzle to assemble.

The context of all modern work on the Mechanism is the research by Price, leading to his seminal paper Gears from the Greeks in 1974, with a remarkable model that has defined the Mechanism for a generation. Subsequent models by Bromley and Wright modified Price's scheme. Initial analysis revealed interesting features and deep flaws in all the models.

Price established the overall architecture of the Mechanism, with its Front and Back Dials. This presentation concentrates on the Back Dials.

We reject previous models of the Upper Back Dials by Price and Bromley but strongly support Wright's advocacy of an alternative idea due to Price that they show the 19-year Metonic cycle. We also support Wright's adoption of a Callippic subsidiary dial.

We corroborate Wright's surprising idea that the back dials were in the form of spirals, with remarkable additional evidence from the inscriptions. We demonstrate evidence that identifies the purpose of these spirals.

We reject all previous models of the Lower Back Dials. Close observation, combined with statistical analysis, establishes that the dial is a Saros Dial, based on the 223-lunar month Saros Cycle. The subsidiary dial is a Triple Saros, or Exeligmos Dial.

Price noted (without explanation) mysterious blocks of text and symbols between the divisions of the main Lower Back Dial. We have discovered many more of these in fragments E and F and have dubbed them "glyphs". We identify the glyphs as eclipse predictions. We discuss how these match actual eclipse records and propose a reconstruction of the whole of the Saros Dial, showing the positions of all the glyphs on the 223-month dial. We also identify the probable source of the eclipse data.

This research leads to a unified new picture of the Back Dials, with periods of 19, 76, 18+ and 54+ years.

2. THE GEARS AND THE LUNAR MECHANISM

The identification of the Lower Back Dials as a Saros/Exeligmos system leaves two significant questions about the structure of the gearing. How was the Saros Dial powered? And what is the epicyclic system at the back of the Mechanism? The first question is fairly easy to answer and the second much harder.

We describe M. T. Wright's proposed gear trains for the Metonic / Callipic Dials, noting his surprising assertion that one of the gears has 53 teeth, which is then cancelled out by an additional hypothetical 53-tooth gear later in the train.

Our identification of the Lower Back Dial as a Saros Dial strongly suggested that it was implemented by a fixed-axis train including a gear with 223 teeth. We show how this can be easily accomplished by powering e3 from axis m with an additional 27-tooth gear.

This left us with a huge problem that took another six months to solve. X-Tek's CT confirmed that the gears on the back of e3 are epicyclic. But what was their purpose? First it was necessary to completely rethink the inputs and outputs of the epicyclic system. A giant spreadsheet produced possible outputs, ranging from various types of month to 26,000 years! But the solution remained elusive.

We discuss two important observations by M. T. Wright: that fragment C contains a Moon Phase Mechanism and that fragment A contains a pin-and-slot mechanism on eccentric axes. The latter was rejected as a realization of Hipparchos' Lunar Theory.

We describe the synthesis of a range of evidence that led to a breakthrough on the epicyclic pin-and-slot system. It does in fact realize Hipparchos' Lunar Theory in an astonishingly ingenious way. We also show that this system outputs, not to the back dials as in previous models, but to the front of the Antikythera Mechanism.

This synthesis explains all the known gears of the Antikythera Mechanism (except one) in a coherent and economical way. It shows why the Mechanism contained three gears with 53 teeth and how the prime numbers in the tooth counts of all the gears can be simply derived from the Metonic and Saros cycles.

Our research shows that the Mechanism was even more sophisticated than previously thought, with a remarkable ingenuity of design.

ELIAS GOURTSOYANNIS

THE ANTIKYTHERA MECHANISM IN MATHEMATICS EDUCATION

In this paper, the application of the theory of continued fractions as convergents to specific irrational or rational numbers is presented. There are historical references to the well-known Metonic cycle and a method of possible systematic discovery of simple rational approximations is discussed. These simple rational approximations lead directly to the calculation of the appropriate gear ratios specific to the various astronomical cycles. The mathematics of teeth-cutting in disks using ancient technology is also discussed, in particular the geometric ideas involved. The relevance of the Antikythera Mechanism to Mathematics Education is explored using familiar ideas within the International Baccalaureate Higher Mathematics and / or GCE A-Level syllabi.

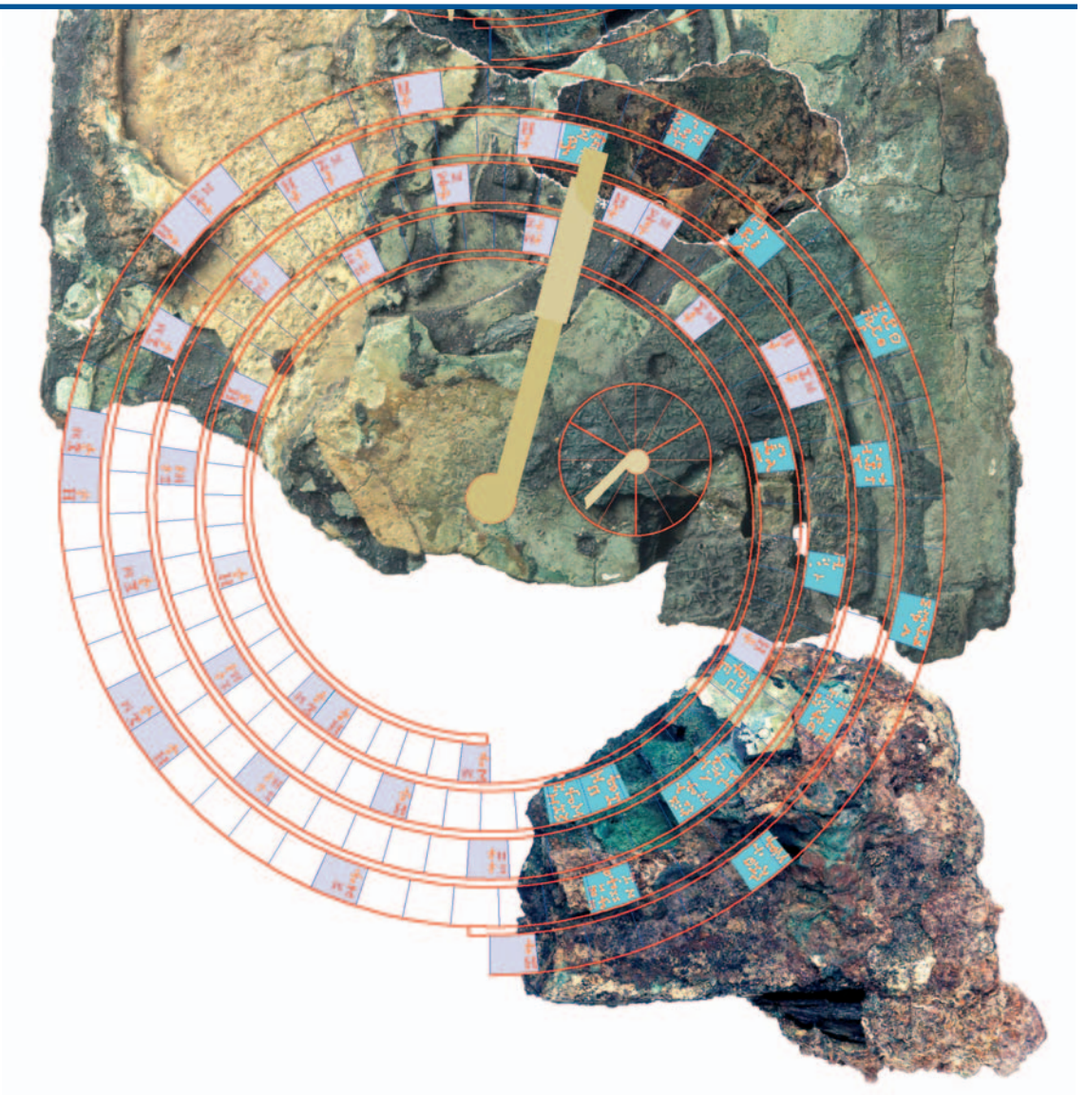
ROBERT HANNAH

PARAPEGMATA, HELLENISTIC CALENDARS AND THE ANTIKYTHERA MECHANISM

Although now recognised more as a planetarium or orrery, the Antikythera Mechanism was originally identified by Price as a "calendar computer", and despite our present concerns with its sophisticated means of predicting lunar positions and eclipses, it still offers abundant means of marking and measuring time. This it was able to do in terms of the Egyptian calendar and a parapegma on the front of the dial, and of the Metonic and Callippic lunisolar cycles of 19 and 76 years respectively on the back, where we also now find the Saros and Exeligmos eclipse cycles. Arguably, local civil lunar calendars could also be correlated to the readings from the Mechanism, since it appears that they were still synchronised with the lunar phases.

In its combination of timekeeping methods, the Antikythera Mechanism is very much a product of its times. In the Hellenistic period we find, for instance, the parapegma incorporated into the Egyptian calendar in a festival calendar from Egypt, or the Metonic cycle used as a regulator for the Athenian civil calendar, or sundial and water-clock technology combined in the Tower of the Winds.

The sheer variety of timekeeping methods in the one instrument is intriguing, but perhaps the most curious method to modern eyes is the parapegma. This paper seeks to set this aspect of the Mechanism within the context of the development of the parapegma as a timekeeping tool, and to investigate the type and purposes of this particular example.



The Saros dial with the reconstructed four-turn spiral and the eclipse prediction glyphs

VELSON HORIE

CONSERVATION FOR USE, NOW AND IN THE FUTURE

The Mechanism is an icon in the development of technology. It needs to be in a fit condition to be displayed for untutored people to appreciate its importance. Equally the Mechanism needs to be available for further study, of which this latest, but not last, investigation is an excellent example. It is our duty to ensure that the next generation of researchers receive the Mechanism from us in at least as good condition as it is now. The Mechanism is primary evidence for history which must not be distorted by damage, chemical or physical. There is always a conflict between the preservation of an object, and making it available for use. One difficulty is that there are many potential uses of an object.

How does this damage occur? How can the evidence be revealed? How can we convey to the public our conviction that this is really important?

Damage: Can we do a risk assessment for the likely causes and effects of damage?

Physical changes: At the extreme, fire and theft lead to complete loss but these should be managed by institutional policies, informed by the conservation needs. Physical damage on a large scale can be caused by earthquakes or simply dropping the object. The Getty Museum has developed strategies and mounts that reduce the damage from earthquakes, while in the UK and elsewhere great advances have been made in designing procedures and producing mounts for carrying, handling, displaying and examining objects. These improvements in handling methods contribute greatly to reducing attrition and un-noticed fracturing during examination and moving. Simple measures can improve survivability – e.g. providing a mount constructed so that the object can be examined without touching. An added benefit is that the attention obviously expended on the object by the museum encourages greater care by both staff and visitors. These are relatively inexpensive measures compared to the cost of repairing the damage or, worse, the loss of evidence.

Chemical changes: The changes caused by the environment are in principle easy to reduce to very low levels – keep it in a box in a good environment. Maintaining these conditions is not always easy in practice. But a good box goes a long way to solve the problem. My most difficult jobs as a practicing conservator usually involve dealing with well-meant but harmful treatments by a conservator or curator in the past. Unquantifiable damage has been done by cleaning and restoration, removing evidence that can never be recovered. Many of the once recommended state-of-the-art treatments have been shown to cause irreversible changes. We now understand that every treatment we undertake will cause loss in the object. We have to quantify and document that loss before considering a treatment.

The techniques for achieving the required protection are scattered across the world with hotspots of expertise in many countries. No institution or individual has the "right" answer. For an object of this importance, I suggest that you can draw upon the expertise and goodwill of many people in many countries.

Evidence: This project has shown that evidence which was unsuspected can be revealed without changing the object at all. A decade ago, this would not have been possible. In another decade, even more latent information will be revealed. The need to physically change an object by micro-excavation is fast disappearing. The realisation of what is lost by this process has become all too apparent. By insisting that nothing is destroyed in the process of discovering information, researchers are impelled to create ever more sophisticated methods of examination, leading to ever more exciting discoveries.

Translation: We are excited by the Mechanism – so should the rest of the world. This is why we are doing this work, exploring and explaining the past to the present. First to ourselves, then in every widening circles. Aesthetically, the fragments have no value or scrap value either. But people are fascinated by stories, the processes of discovery, both ancient and modern. That is why I am here.

ALEXANDER JONES

THE ANTIKYTHERA MECHANISM AS AN ARTIFACT OF HELLENISTIC ASTRONOMY

While long recognized as an important artifact of Greek mechanical technology, the Antikythera Device has not established a significant place in the current accounts of Greek astronomy; in Neugebauer's monumental *History of Ancient Mathematical Astronomy*, for example, it is mentioned only in passing in a footnote. In the light of research done on the device since Price's work of a generation ago, we can now say not only that it is representative of the high end of technical astronomy of its time, but that it has the potential to expand our understanding of that astronomy and its cultural role. The present paper attempts to relate the device to our other evidence for astronomical theory and prediction in the period of Hellenistic astronomy between Hipparchus and Ptolemy.

HELEN KARABATZAKI

ANCIENT TEXTUAL EVIDENCE POSSIBLY CONCERNING THE ANTIKYTHERA MECHANISM

In my capacity as a historian of ancient Greek philosophy, particularly the Hellenistic one, I shall try to clarify some archaeognostic details concerning the Antikythera Mechanism. I shall present some ancient texts referring to astronomical instruments and their inventors, Archimedes, Hipparchus, and Posidonius.

Taking in account the already read parts of the inscriptions on the Mechanism, I shall focus on the astronomical meaning of the term "stirigmos", which appears together with the terms "propodismos" and "anapodismos" in the extant texts of authors of late Antiquity, such as Theon of Alexandria, Iamblichus and Proclus. These terms denote the apparent backward and forward movement of the planets Venus and Mercury on the ecliptic zone.

With every precaution I should like to link the term "hypoleipetai" with the mathematician and astronomer Adrastus, who had influenced Hipparchus.

KOSTAS KARATZAS

A POSSIBLE WEB PORTAL FOR ARCHIVING, PRESENTATION AND USAGE OF THE ANTIKYTHERA MECHANISM PROJECT RESULTS

The proposed web portal should take under consideration the EU guidelines "to improve the interoperability of digital cultural and scientific/scholarly content … and enable multilingual access to it, so as to enhance the crossborder visibility, accessibility, use and re-use of European cultural resources" (see: http://europa.eu.int/information_society/activities/econtentplus/docs/call_2006/ecp_work_programme_2006.pdf) while addressing the citizen and any interested party, with emphasis on the educational and the scientific community. State-of-the-art technologies should be employed that will allow for handling and archiving of the information already collected, or to be collected, seamlessly, regardless of data volume and heterogeneity. The aims should be at enhancing interoperability and usage of the content. The portal should be built on the basis of a content management system, should support push notification services for the promotion of communication and dissemination, should include a proper database of visual content and related data, constructed on the basis of a proper schema and ontology, and should be accompanied by a number of tools and services for data extraction and post-processing. The portal should make use of open source technologies and commonly accepted protocols to minimize access problems. A possible scenario of use indicating the proposed portal structure follows: A Mechanical Engineer student sends a query and receives all information related to the gears of the Mechanism. Then, with the aid of an on-line mark-up tool, the student measures the basic geometrical and engineering properties, translates them into modern gear design data, and applies modern engineering methods for recalculating the geometrical properties of the gears. Then, if he/she wishes, can save the data online, making them accessible to others. A wiki and a blog, hosted by the portal, can support communication and creation of "user communities".

Slices from the computed tomography data showing the inner structure of fragment A and an invisible text inside fragment E (not in scale)

ANTHONY KOLSOUZOGLOU AND YANNIS VENERIS

STUDYING ANTIKYTHERA MECHANISM IN MIXED REALITY

Mixed Reality constitutes the dynamic mergence of physical and virtual space, with the integration of physical and virtual representations of objects that lie in one space into the other. This mutual exchange of representations introduces two new main states of reality: augmented reality and augmented virtuality. In an Augmented Reality space various representations of virtual objects are integrated into the physical space, while in an Augmented Virtuality space physical objects are represented in the virtual space. These new areas of reality demonstrate entirely new characteristics, since properties of the virtual and physical space are being combined in them.

Mixed Reality has already found many applications in Archaeology and cultural heritage, especially on occasions where a restoration was to be implemented. The study and presentation of archaeological findings in Mixed Reality has been augmented with further information, e.g. virtual objects, text, graphics, annotations, sound. Semi-destroyed findings or even entire sites can be dynamically restored, studied and presented in real time. Mixed Reality also offers many alternative reconstructions of the same archaeological finding, which the user can view on his request, being able to simultaneously become part of this very presentation.

Antikythera Mechanism (AM) on account of its being semi-destroyed and of its great complexity proves to be problematic for its study and its presentation to public. Therefore it appears to be ideal for study and presentation in Mixed Reality. In our research we implemented a physical reconstruction of the Antikythera Mechanism as well as a virtual reconstruction according to Derek de Solla Price research. These two reconstructions allowed us to develop applications, ranging from complete physical to complete virtual. The Mixed Reality system we developed consists of a laptop as processing unit, a webcam for capturing the physical space, e.g. our lab, a projector for viewing Mixed Reality in public and a HMD (head mounted display) for viewing Mixed Reality privately. Webcam captures the physical space and transmits the streaming video to laptop, where with the use of suitable software, predesigned virtual objects are being integrated in the streaming video in real time. Virtual objects are spatially integrated into the physical space, thus they take up certain space of it.

In addition, a three dimensional interactive public virtual reality space has been developed so that communication between researchers, in case of studying AM, and visitors, in case of presenting AM, through internet in possible. In this virtual space, each visitor can be represented as an avatar, so that communication between users is more effective. Alternatively, communication with the use of webcams is possible,

transmitting streaming video of the physical spaces where the user are located into the virtual space in real time. Additionally, the use of microphones, makes conversation between users possible.

IOANNIS LYRITZIS AND ALEXANDRA COUCOUZELI

ANCIENT GREEK HELIOCENTRIC VIEWS HIDDEN FROM PREVAILING RELIGIOUS BELIEFS?

Here, we shall put forward the working hypothesis that the heliocentric, rather than the geocentric view, of the solar system was the essential belief of the early Greek astronomers or philosophers. Although most of them referred to the geocentric view, it is possible that established religious beliefs prevented them from expressing the heliocentric view, even though they were fully aware of it. Moreover, putting the geocentric view forward, instead, would have facilitated the reception of the surrounding world, much like the modern presentation of the celestial sphere and the zodiac, where the earth is at the center and the sun makes an apparent orbit on the ecliptic. Such a stance would have set these early astronomers in harmony with the dominant religious beliefs about the sacred character of the Earth, without sacrificing the essence of their ideas.

In late Classical times, the prevailing view was still the geocentric one. The heliocentric theory advanced by Aristarchus (3rd century B.C.) met with great hostility in Athens – Aristarchus was accused of impiety (*asebeia*) and faced the death penalty– and was never established. The textual evidence suggests that the tight connection between religion and the city-state (*polis*) in ancient Greece, as well as the deep religiosity that permeated every aspect of public and private life, would have made any "opposite" view expressed by the astronomers seem almost a high treason against the state.

The astronomical knowledge of the ancient Greeks predates the Presocratic era and appears already in the epic poems of Homer and Hesiod. Such knowledge, used for the purposes of navigation, cultivation and worship, may well have been inherited from the Mycenaean or even the Minoan civilization, via the so-called "Dark Ages".

HELEN MANGOU

A SHORT RESEARCH HISTORY OF THE ANTIKYTHERA MECHANISM SINCE ITS DISCOVERY IN 1902 UP TO THE ANTIKYTHERA MECHANISM RESEARCH PROJECT IN 2005

The Antikythera Mechanism is a unique archaeological bronze object related to the ancient Greek technology. It is a fragmentary, fragile and partly missing calculating device with geared wheels, display scales and Greek inscriptions. Its fragile state is owed to its corrosion by the seawater where it was found and possibly cause of a non-successful stabilization in its early conservation.

It is still a mysterious archaeological object and continues to hide secrets either because of its preservation state or because of the technical limitations of the technologies used for its study.

Each research phase undertaken was progressively deciphering more letters from its inscriptions and at the same time was recovering more structural data based on its preservation state and on the used scientific techniques. The scientists and the techniques used each period reflected the social-scientific status of the period. At the same time each research phase produced controversial views among the scientists concerning the original functions of the device.

In its first research phase (1902-1934) was studied by archaeologists (Svoronos, Stais) as it came from an archaeological shipwreck (dated around 80 B.C.) as well as by navy officers (Rados, Rediadis, Theophanides) as it was found in the sea and philologists (Rehm) as it contains inscriptions. Astrolabe or a complicated device with astronomical function? A first model of the Mechanism was constructed by Theophanidis (1925-1930)

In its second research phase (1953-1974) was studied by mechanical engineers (Price) as it consists of geared wheels. The industrial X-ray radiography applied by physicist (Karakalos 1973) recovered revolutionary structural data, 30 geared wheels. Ancient clockwork before the clock, ancient Greek computer or calendar computer calculating sun and lunar motions in relation to the zodiac cycle as well as to the Metonic cycle of 19 years? A second model (two replicas) was constructed by Price (1974). Many other models based on Price research, have been made until today either handmade as the six Gleave's models or the digitized ones as those of Roumeliotis, Freeth, Casselman and Lysozyme.

In its third research phase (1990- to now days), after a gap of 20 years, the Mechanism was studied again by computer scientists (Bromley and Gardner) as well as by mechanical engineers (Wright). The film images taken by the laborious X-ray linear tomography, the new available technique of this period, and after their working out in a 3D digitized image produced further new structural data for the researchers. Bromley constructed his own model before coming out the new data from the X-ray linear tomography. Bromley's model has structural differences as concerns to the Price's model. Unfortunately he died without finishing his research. The other researcher of this phase, engineer Wright, is going on with his research on the Mechanism based on the new data of the Linear tomography. His partial model shows new gearing at the front of the Mechanism for sun, moon and planets and now is working on a model of the back part of the Mechanism.

In its fourth and last, at the moment, research phase (2005-to now days) the Mechanism was studied by the Antikythera Mechanism Research Project's researchers using the latest new technologies as surface imaging and high resolution 3-Dimensional X-ray tomography. The new structural data taken are announced in the present conference and a new reconstruction model is presented for its multiple functions.

TOM MALZBENDER

REFLECTANCE IMAGING : ENHANCING SURFACE DETAIL ON THE ANTIKYTHERA MECHANISM

The appearance of a 3D object depends on viewpoint, lighting conditions, surface shape and reflectance properties. Photography captures the appearance of an object directly, holding the viewpoint and lighting conditions constant. Although simple to capture, a photograph only samples a single point in this "appearance space", and is poorly suited to quantitative analysis. Conventional photography can be extended by capturing multiple images of an object under different lighting directions. This is a simple and effective way of capturing the spatially varying reflectance properties of a surface. Once acquired, these reflectance properties can be transformed, keeping the geometry of the object constant. We have found that rendering new views of a surface with specular (shiny) reflection properties can greatly enhance one's perception of surface detail, exceeding the amount of detail that can be perceived directly inspecting the surface or object. These renderings can be achieved at real-time rates on today's PCs, and allow interactive control of both lighting direction and reflectance properties. We describe the method, along with our representation for reflectance functions, Polynomial Texture Maps. We show examples from imaging the surface of the Antikythera Mechanism. Demos and tools useful for experimentation can be accessed online at:
www.hpl.hp.com/ptm
www.hpl.hp.com/research/ptm/antikythera_mechanism/index.html

XENOPHON MOUSSAS

THE MOON PHASE MECHANISM AND THE HYPOCYCLOIDAL GEARS

The Moon phase mechanism consists of a complex gnomonion, with a little sphere and a circular dial. An offset circle marks the floor of the dial. The gnomonion is complex with a little hemisphere. The actual spherion, was probably inside the hemisphere.
It is possible that the Moon phase dial had two functions:

(i) rotation of the sphere of the Moon around its axis and
(ii) motion of the pointer together with the dial around an axle. The eccentric circle was important to model realistically the trajectory of the Moon.

The Moon gnomonion has a cylindrical axle. In one end it had the Moon spherion attached. The other end had a cylindrical gear. The rotation of the axle and the silver sphere is made with a cylindrical coaxial gear. Around the axle is a heavy and complex construction of the gnomonion made of several rectangular blades (slabs). The construction of the gnomonion was probably free to move sliding along the axle during its turn to perform the trajectory of the Moon, forced with a mechanism to follow an eccentric circle. Perhaps it is made by the motion of a part of the Mechanism that was above the fragment C. This might be an aspis (ΑΣΠΙΣ, in the text), shield that covers the body.

One possibility is that a cover or another part above fragment C moved around another axis eccentric to the one of the main circle of C and forced the spherion to have a complex trajectory with two components: the eccentric circle plus a constant straight line segment along the radial direction, defined by the heavy construction of the pointer which moves in and out sliding along the rotating axle of the pointer. The composite trajectory of the eccentric circle plus the straight line is ellipse-like (ellipticity 0.06-0.07), close to the Hipparchus one.

Similar dials appear in Medieval clocks. There is continuity of astronomical mechanisms and clocks from Antiquity, starting perhaps with the two mechanisms of Archimedes, Posidonius, Hipparchus etc. Such astronomical mechanisms have been preserved and advanced in the Byzantium and spread in Europe (Crusades, diplomacy, commerce, navigation, scholars).

Two gears (male and female) one inside the other are in fragment D. This Mechanism can perform a complex offset motion (hypocyclical and also epicyclical) which can simulate a celestial trajectory.

MARIA K. PAPATHANASSIOU

REFLECTIONS ON THE ANTIKYTHERA MECHANISM TEXTS

A close look at the fragmentary texts of the Antikythera Mechanism reveals some elements, which could help us to decode its function and use.

The Back Door Inscription seems to give a detailed description of some external parts of the instrument (e.g. the small golden sphere, the spiral and the pointers) and the related instructions for their use. We especially refer to the term "ecliptic" as compared to that in Ars Eudoxi.

The Back Plate Inscription seems to give instructions for the orientation of the instrument so that it can be used in a great part of the Oikoumene. Expressions like "towards Apeliotes" indicate a direction on the horizon towards which we should orientate rather than that of a wind, as winds are named according to the point they come from.

The Front Door Inscription, the most preserved and extensive, refers almost exclusively to the kinds of the stationary points of planetary motion, but only one planetary name is read, that of Venus. After a study of the astronomical texts of Ptolemy, Theon Paulus and Heliodorus related to the stationary points of planetary motion, we arrive at the following conclusion: It seems very likely that the Antikythera Mechanism was constructed apart from other uses a) for the observation of the Sun, the Moon and (at least) of Venus (possibly other planets); b) to model(?) or simulate their longitudinal motions (i.e. only their ecliptic

longitude); and c) in the case of Venus the instrument could also show the stationary points of its path and the retrograde arc between them. The brightness of Venus and its appearance either as morning or evening star may be one but not the only reason for this choice.

EMMANUEL POULLE

L'HERITAGE D'ANTICYTHERE: MECANISATIONS ASTRONOMIQUES
DANS L'EUROPE LATINE AU MOYEN AGE

Il existe, pour le Moyen Âge latin, toute une documentation sur des mécanisations astronomiques ou planétaires, consistant à la fois en textes manuscrits et en témoins archéologiques. Cette documentation est surtout abondante pour les XIVe-XVIe siècles, c'est-à-dire pour la période postérieure à l'invention de l'horlogerie régulée, à la fin du XIIIe siècle. Mais, parmi la documentation écrite, quelques textes décrivent des mécanisations non régulées, soit parce qu'elle sont antérieures à l'apparition de l'horlogerie, soit parce qu'elles sont contemporaines de ses débuts et en tout cas indépendantes du développement de celle-ci.

Elles portent témoignage de la permanence d'une tradition mécanique dont les racines remontent à l'Antiquité classique et qui explique très certainement l'essor précoce de l'horlogerie astronomique, dès 1330, puis de l'horlogerie planétaire, dès la seconde moitié du XIVe siècle.

Régulés ou non, ces textes et ces horloges survivantes constituent une base documentaire precieuse sur les rapports de dentures qui ont été utilisés et sur les solutions techniques qui ont été trouvées pour rendre compte, le plus exactement possible, des périodicités et des dispositifs par lesquels sont figurés les mouvements des corps célestes.

ANDREW RAMSEY

3D X-RAY IMAGING – THE LATEST TECHNIQUES REVEAL THE EARLIEST TECHNOLOGY

Many people's first experience of X-ray Computed Tomography is when they or a friend has a CT scan in hospital. Wonderful 3D images and 2D slices of their internal organs are revealed. Most people are not aware that not only can the same 3D imaging be performed on inanimate objects, but that, freed from the dose restrictions of medical imaging, much higher resolution detail can be seen.

Inspecting such a dense specimen as the Antikythera Mechanism in enough detail to reveal new knowledge about it proved technically a very challenging task. Not only did a completely new X-ray source need to be developed, more powerful for its spot size than any other, but the latest in X-ray detection technology was used – the combination achieving higher resolution for such a sample than ever before.

Computing power, and especially the storage required, was also challenged – we collected 600 gigabytes in two weeks.

But the results speak for themselves, engraved text, no more than 3mm high and 0.2mm deep telling us more about the purpose of the Mechanism than any gearwheel tooth-counting could, as well clearer images of all parts of the Mechanism have now been revealed. What we have, in essence, is a 3D digital representation of the Mechanism which will survive further analysis far longer than the fragments themselves could.

CLIVE RUGGLES

ANCIENT SCIENCE AND ARCHAIC COSMOLOGY:
TOWARDS A BROADER CONTEXT FOR INTERPRETING THE ANTIKYTHERA MECHANISM

I shall attempt to develop some elements of a broader context for interpreting the purpose and meaning of the Antikythera Mechanism, drawing to some extent from ancient Greece itself but mostly from a much broader selection of world cultures. The aim is to identify and briefly address a number of general questions such as the following. How fundamentally did people's beliefs about the world – the cosmos – within which they dwelt vary between different cultural contexts, and to what extent were cultural "world-views" shaped by those contexts? Can we generalize in any meaningful way about the nature and development of calendars? For what range of purposes did people study the skies and celestial cycles, often in meticulous detail and well beyond the obvious needs of regulating annual cycles of activity in accordance with the seasonal changes of nature? What were the social and political as well as the ideological "uses" of astronomical knowledge? To what extent did these involve "passive" watching and recording, and what could motivate a desire to predict what would happen in the future? And to what extent did technical sophistication bear on this? Finally, in classical Greece itself, how did the archaic cosmology that can be traced in deity cults, the timing of religious festivals and the orientation of temples sit in relation to the early development of a predictive science of astronomy?

JOHN SEIRADAKIS

THE PIONEERING USE OF NEW TECHNOLOGY IN ARCHAEOLOGICAL RESEARCH

The invention of carbon dating, in the early 50s, transformed Archaeology from a science of merely attempting to explain the past to an interpretive and descriptive science. Now more than ever, archaeological research is interdisciplinary with close connections to Physics, Chemistry, Mathematics, Architecture, Botany, Forestry and many

other disciplines including Astronomy. Measuring trace and major elements with non-invasive methods, involving spectroscopy and other analytic techniques like X-ray fluorescence, accelerator mass spectrometry, electron spin resonance, magnetometry and others, a wealth of hitherto unknown evidence has been unearthed, leading to a better understanding of our ancestors' lives.

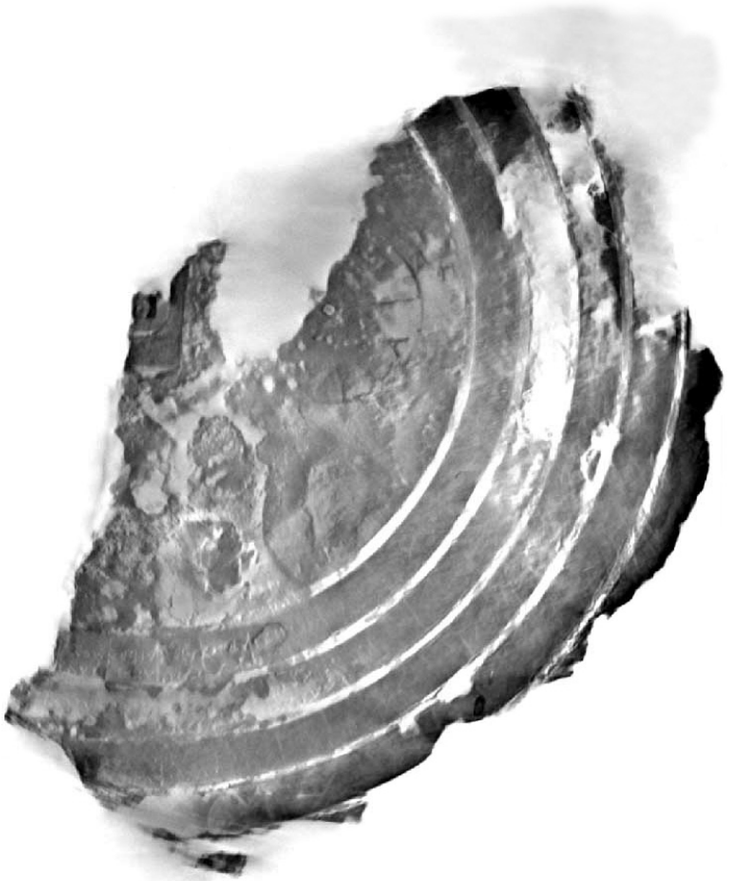
Observational techniques including remote sensing from the sky or remotely operated vehicles and autonomous underwater vehicles of unprecedented positional precision, combined with digital imaging, data management and archiving have given new insights to archaeologists and moved Archaeology closer to general public.

The new investigation of the Antikythera Mechanism was enabled by such innovative techniques developed by scientists, who have invented new methods of monitoring surface and in-depth features of the device, which, bearing the consequences of the shipwreck and 2,100 years in the bottom of the sea, is fragmented, damaged, crumpled and fully calcified.

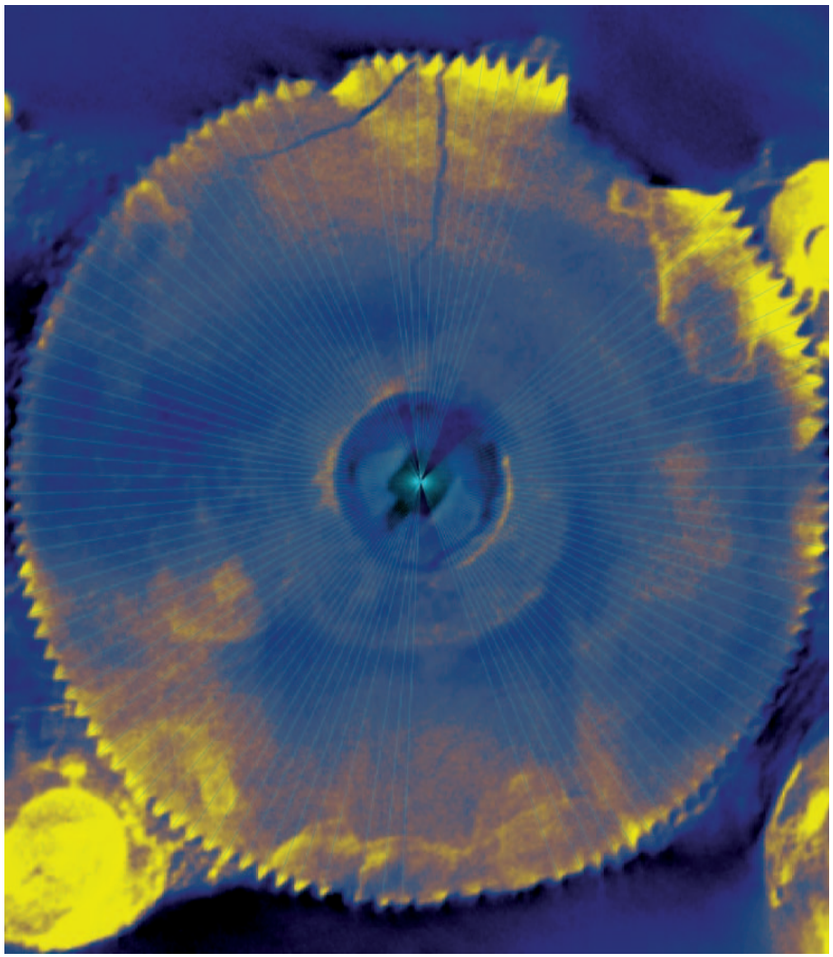
THE ANTIKYTHERA MECHANISM: A CALENDAR OF ASTRONOMICAL EVENTS

The two annuli of the front dial of the Antikythera Mechanism show the twelve Zodiac constellations (inner annulus) and the twelve months (outer annulus). The two annuli seem to be free to rotate independently around their common centre. In the visible part of the inner (Zodiac) annulus, the sequence of the greek letters Α, Β, Γ, Δ, Ε, Ζ, Η, Θ is clearly marked. On the accompanying parapegma a list of precise astronomical events is preceded by a sequence of greek letters (Κ, Λ, Μ, Ν, Ξ, Ο, Π, Ρ, Σ). Taking into account the distance between the letters on the inner annulus, it is obvious that the 24 letters of the greek alphabet covered half the Zodiac annulus.

The parapegma events (e.g. "ΥΑΣ ΕΠΙΤΕΛΛΕΙ ΕΩΙΑ, The Hyades rise at dawn – just before the sun rises in the morning –") describe unique events that happen at a precise day every year. Therefore the user of the Antikythera Mechanism could easily find the day of the year by simply observing one of the events described on the parapegma and simply reading out the day of the year on the outer annulus of the front dial. Leap years were taken into account by the free and independent movement of the two annuli.



Slice from the computed tomography data showing the inner structure of fragment B



Gear count estimation for gear d2

ALEXANDRA SMITH

COMPLEX DEVICES IN ANTIQUITY: THE BRETHREN OF THE ANTIKYTHERA MECHANISM

The Antikythera Mechanism is a unique find from the ancient world – although there are other machines in Antiquity, none seem to rival its technological complexity, especially given that all signs point to its deposition in the ocean in the first century B.C.

This paper examines the place of the Antikythera Mechanism within the technology of Antiquity, and looks at the signs in both the archaeological record and the historical sources that suggest that the Mechanism is not an isolated development, but indicative of the wider technological context. Although the evidence is scant, there are hints that there may have been working machines with cogs made of bronze. Examples include Heron's dioptra, the barulkos, and the hodometer (which emperor Commodus is alleged to have had on one of his carriages). Machines of an astronomical nature are mentioned several times in the literary sources – the most famous being Archimedes' orrery (Cicero, *Republic* 14.21; Ovid, *Fasti* 269-80) – and it seems that "sphere-maker" was a viable occupation in the later Roman Empire (e.g. Pappus, *Mathematical Collection* 8.1-2; Proclus, Euclid, *Elements* 41.3).

The evidence suggests that the Antikythera Mechanism was not a solitary phenomenon, and I hope to demonstrate that there are signs of a more advanced technology in Antiquity than is generally accepted.

JOHN STEELE

THE SOLAR / LUNAR FUNCTIONS OF THE ANTIKYTHERA MECHANISM IN THE CONTEXT OF MESOPOTAMIAN AND GREEK ASTRONOMY

The new analysis of the lower dial on the back of the Antikythera Mechanism by Freeth et al. has shown the function of the dial. Of particular interest are the preserved "glyphs" inscribed within some of the divisions of the dial. The distribution of the glyphs allows us to reconstruct the underlying prediction scheme. This scheme is similar to schemes developed in Mesopotamia in the 6th century B.C. and known about in the Greek world by the first century B.C., probably much earlier. In this talk I will discuss these underlying methods and the relationship between the Antikythera Mechanism's theory and Babylonian and Greek theories.

MICHAEL T. WRIGHT

A REVIEW OF THE EVIDENCE: THE CASE FOR RECONSTRUCTION AS A PLANETARIUM

The author, whose independent investigation into the Antikythera Mechanism remains in progress, will discuss the satisfactory correspondence between his published findings and those now announced by the Research Group.

The Group's interpretation of the inscriptions on the remaining fragments of the lower back dial, significantly augmented by readings from fragment F which was not available to the author, corrects the author's provisional suggestion for the function displayed there. The Group propose modifications to the author's gearing scheme, whereby this output is achieved. The author shows that these modifications are supported by his own published observations.

The same modifications provide functions for two mechanical features which, although their intended purposes were correctly identified, remained redundant in the author's scheme. The solution of these several difficulties, in so economical a way, lends conviction to the Group's proposal. Taking this with other features, over all of which the Group's findings agree with the author's, it appears that the arrangement and function of the back part of the instrument are now established beyond doubt.

The author withdraws accordingly his suggestion that the "redundant" features remained as relics of some alteration to the instrument, but he points to artefactual evidence for the design of the wooden case, of which the Group offer no account, from which he argues that the instrument was indeed altered.

Turning to the front of the instrument, the author argues that other artefactual evidence, indicating the loss of further mechanism, leads to the conclusion that the front dial display included indications of the places of the planets, together with those of the Sun and Moon. If so, a fair impression of the original appearance and function of the instrument may be conveyed by subsuming the Group's modifications into the author's published reconstruction of the instrument as a planetarium.

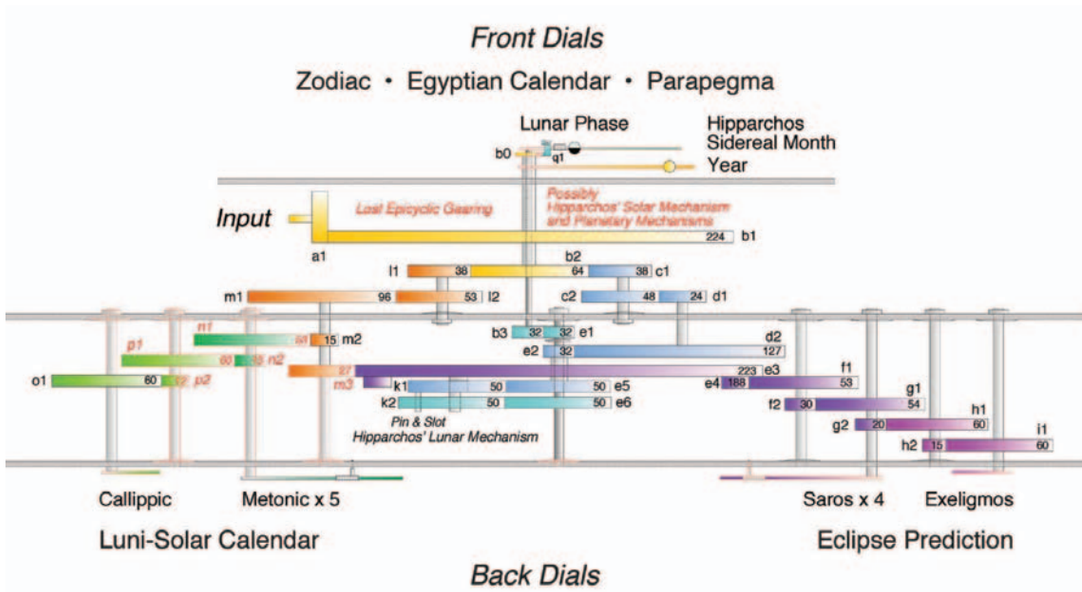
MARY ZAFEIROPOULOU

THE STATUES OF THE ANTIKYTHERA SHIPWRECK AS A "CONTEXT" FOR THE MECHANISM

In the Easter of 1900, just off the tiny island of Antikythera, sponge-fishers from Syme located by chance a very important ancient shipwreck. The difficult task of recovering the objects lasted ten months and during the underwater research the sponge-fishers retrieved 108 objects made of bronze and marble, mainly statues and statuettes, the Mechanism fragments, some pottery, most of it coarse-ware, luxury glass and silver vases, bronze fragments of furniture, wooden parts of the ship and other small antiquities.

The marble statues and the bronze statuettes are copies or classicizing creations dating from the 2nd to the early 1st century B.C.. According to Price, the Mechanism is associated with the School of Poseidonios on the island of Rhodes and it may have been made about 87 B.C.. Further research on the style of writing of the inscriptions, on the old and recently discovered fragments (E, F) could date the inscriptions at the end of the 2nd century B.C. or the early 1st century B.C..

The island of Rhodes occupied a vital strategic position and during the Hellenistic period the new city-state of Rhodes developed into a very important cultural, naval and commercial center. In Rhodes, in the second century B.C., Hipparchos, the father of Astronomy, developed his theory, explaining the irregularities of the Moon's motion.



The gearing diagram showing the new reconstruction by the Antikythera Mechanism Research Project

CONTACT DETAILS

ARGYROPOULOS ALEXANDROS alargyropoulos@aktor.gr
Civil Engineer, National Technical University of Athens, MBA, City University Business School, London
25 Karaoli & Dimitriou Street, Nea Pendeli, 152 36 Athens, Greece (personal)
☎ +30 210 515 6480, +30 694 249 6769

BITSAKIS YANIS bitsakis@gmail.com
Researcher, The Antikythera Mechanism Research Project. Physics Department, University of Athens / Center for History and Palaeography, Cultural Foundation of the National Bank of Greece
6 K. Palaiologou Street, Byron, 162 32 Athens, Greece (personal)
☎ +30 697 408 2062

COUCOUZELI ALEXANDRA acstcm@otenet.gr
Greek Open University
23 Sachtouri Street, 262 23 Patras, Greece

EDMUNDS MIKE mge@astro.cf.ac.uk
Professor of Astronomy, School of Physics and Astronomy, Cardiff University
Queens Buildings, 5, The Parade, Cardiff, CF24 3AA, UK
☎ +44 292 087 4043

FRAGOU VASSILIKI fginie@yahoo.gr
Aristotle University of Thessaloniki, Department of Physics, Section of Astrophysics, Astronomy and Mechanics
541 24 Thessaloniki, Greece

FREETH TONY tony@images-first.com
Researcher, The Antikythera Mechanism Research Project
Cardiff University, School of Physics and Astronomy - Images First Ltd
10 Hereford Road, South Ealing, London W5 4SE, UK
☎ +44 208 579 6848, +44 796 266 3123 (cell phone), +30 697 849 6677 (greek cell phone)

GOURTSOYANNIS ELIAS gourtsoyannis@gmail.com
124 Dimitrakopoulou Street, 117 41 Athens, Greece (personal)
☎ +30 210 729 0167, +30 699 322 5778 (cell phone)

HADLAND ROGER roger.hadland@xtekxray.com
Proprietor and Engineer, X-Tek Systems Ltd
Icknield Ind. Estate, Icknield Way, Tring, Herts, UK
☎ +44 144 282 8700

HANNAH ROBERT robert.hannah@stonebow.otago.ac.nz
Classics Department, University of Otago
PO Box 56, Dunedin 9054, New Zealand
☎ +64 347 98711

HORIE VELSON velson.horie@bl.uk
Research Project Manager, British Library
Collection Care, British Library, 96 Euston Road, London NW1 2DB, UK
☎ +44 207 412 7347

JONES ALEXANDER alexander.jones@utoronto.ca
Department of Classics, University of Toronto
97 St George Street, Toronto, ON M5S 2E8 Canada
☎ +1 416 978 0483

KARABATZAKI HELEN ekaraba@cc.uoi.gr
Assistant Professor, Sector of Philosophy, University of Ioannina
451 10 Ioannina, Greece
☎ +30 265 109 5793

KARATZAS KOSTAS kkara@eng.auth.gr
Assistant Professor – Dr. Eng., Aristotle University, Department of Mechanical Engineering
541 24 Thessaloniki, Greece
☎ +30 231 099 4176

KOLSOUZOGLOU ANTHONY a_kols@yahoo.com
Undergraduate student of Architecture, National Technical University of Athens
66 Finikis Street, Sepolia, 104 43 Athens, Greece (personal)
☎ +30 69 77078176 (cell phone)

LYRITZIS IOANNIS liritzis@rhodes.aegean.gr
Laboratory of Archaeometry, University of the Aegean
1 Demokratias Ave., 851 00 Rhodes, Greece

MANGOU HELEN elmagkou@yahoo.gr
Chief Chemist, Department of Chemical and Physical Research of the National Archaeological Museum
Tositsa 1, 106 82 Athens, Greece
☎ +30 210 821 7717

MOUSSAS XENOPHON xmoussas@phys.uoa.gr
Associate Professor in Space Physics, Director of Astrophysics Laboratory, Faculty of Physics, University of Athens
Panepistimioupolis, Zographou, 157 83 Athens, Greece
☎ +30 210 727 6853, +30 697 879 2891 (cell phone)

MALZBENDER TOM tom.malzbender@hp.com
Hewlett-Packard Labs
1501 Page Mill Rd., Palo Alto, California, USA, 94304
☎ +1 650 857 6760

PAPATHANASSIOU MARO mpapatha@math.uoa.gr
Assistant Professor, Department of Mathematics
Panepistimioupolis, Zographou, 157 83 Athens, Greece
☎ +30 210 727 6383

POULLE EMMANUEL aihs@enc.sorbonne.fr
Secrétaire Perpétuel, Académie internationale d'histoire des sciences
Académie des inscriptions et belles-lettres (Paris)
6 rue Lemaignan, 75014 Paris, France
☎ +33 1 45 89 48 57

RAMSEY ANDREW andrew.ramsey@xtekxray.com
X-ray CT Specialist, X-Tek Systems Ltd
Unit 5, Tring Business Centre, Icknield Way, Tring, Herts., HP23 4JX, UK
☎ +44 144 282 1111

RUGGLES CLIVE rug@leicester.ac.uk
Professor of Archaeoastronomy, School of Archaeology and Ancient History, University of Leicester
Leicester LE1 7RH, UK
☎ +44 116 252 3409

SEIRADAKIS JOHN jhs@astro.auth.gr
Professor of Astronomy, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, Aristotle University of Thessaloniki
541 24 Thessaloniki, Greece
☎ +30 231 099 8173

SMITH ALEXANDRA smitha9@cf.ac.uk
Cardiff University, School of History and Archaeology
Humanities Building, Colum Drive, Cardiff, CF10 3EU, UK
☎ +44 292 087 4821

STEELE JOHN j.m.steele@durham.ac.uk
Department of Physics, University of Durham
South Road, Durham, DH1 3LE, UK

TSELIKAS AGAMEMNON agatselikas@hotmail.com
Director, Center for History and Palaeography,
Cultural Foundation of the National Bank of Greece
3 Skouze Street, 105 60 Athens, Greece
☎ +30 210 322 1337

VENERIS YANNIS
Associate Professor (Applications and Impact of Informatics in Architecture and Planning), National Technical University of Athens
42, Patission Street, Athens, Greece

WRIGHT MICHAEL m.t.wright@imperial.ac.uk
Honorary Research Associate, Centre for the History of Science, Technology & Medicine, Imperial College, London
Room S223B, Level 2, Central Library, Imperial College, London SW7 2AZ, UK
☎ +44 208 748 2222

ZAFEIROPOULOU MARY pmitrop@geol.uoa.gr
Archaeologist-Museologist, Bronze Collection, National Archaeological Museum of Greece
1 Tositsa Street, 106 82 Athens, Greece
☎ +30 210 821 7717

INTERNATIONAL CONFERENCE
30th NOVEMBER AND Ist DECEMBER 2006

LECTURE THEATRE OF THE NATIONAL BANK OF GREECE
KARATZAS BUILDING
82-84 EOLOU STREET, ATHENS, GREECE

SCIENTIFIC ORGANIZING COMMITTEE

Mike Edmunds (Chair)
Yanis Bitsakis
Tony Freeth
Ioannis Lyritzis
Helen Mangou
Xenophon Moussas
Maria Papathanassiou
John Seiradakis
Agamemnon Tselikas
Mary Zafeiropoulou

LOCAL ORGANIZING COMMITTEE

Xenophon Moussas (Chair)
Yanis Bitsakis
Helen Mangou
John Seiradakis
Agamemnon Tselikas
Mary Zafeiropoulou

Booklet Production
GRAPHICON

Proof Reading
Margarita Kremmyda