Session I: Practices, Reconstruction and History of Early Modern Magic Lanterns in the light of the Kassel collection
Day 2: Tuesday, 20. September
9.30-10.00, Gartensaal

Dr. Klaus Staubermann
(*National Museums Scotland, Edinburgh*)

Understanding Early 18th century Magic Lantern Practice

In 2010 the Royal Society celebrated its 350th anniversary with a wide range of public activities and events to stimulate the public's interest in science and its history. National Museums Scotland was able to secure a RS350 grant to commission an early 18th-century magic lantern replica in order to better understand historic projection practices and make them accessible to a wider audience. This paper explores the performance with this replica and tries to situate it in a broader culture of optical experimentation and projection technology during the late 17th and early 18th century. It will especially look at different traditions of designing and employing magic lanterns and their changing roles in public spectacle.

Session I: Practices, Reconstruction and History of Early Modern Magic Lanterns in the light of the Kassel collection
Day 2: Tuesday, 20. September
10.00-10.30, Gartensaal

Wolfgang Engels
(*Universität Oldenburg*)

On the Replication of a Magic Lantern

Within their genre the magic lanterns are some of the most spectacular pieces of the Cabinet of Astronomy and Physics in Kassel. For several reasons one of them is likely to be one of the oldest surviving lanterns worldwide, originating from the late 17th century.

What was this instrument about? To better understand historic practices of visual culture, the reproduction of original experiments often proves useful; however, experiments and demonstrations generally may not be conducted with the original material sources themselves. Moreover, the magic lantern in Kassel is not in a working condition – some parts are missing, while others are damaged or misfit – so that it could not be used in such an experiment.

In order to revitalize the visual impression of lantern projection the instrument has been replicated as closely as possible to the original and put into working order. The replication was very thorough; financial limitations only caused some negligible restrictions.

In manufacturing one single instrument it turned out that the original lantern at least partly had been produced by customized tools. This realization may generate a new approach to the history and the origin of the instrument. During the course of replication and experiments the missing parts could be identified and some operating skills could be discovered. The experimental and experiential performance of the reconstructed magic lantern also allows some conclusions to be drawn about the environment in which it was used and the audience before which it was demonstrated.

Session I: Practices, Reconstruction and History of Early Modern Magic Lanterns in the light of the Kassel collection
Day 2: Tuesday, 20. September
10.30-11.00, Gartensaal

Bjoern Schirmeier
(*Museumslandschaft Hessen-Kassel, Cabinet of Astronomy and Physics*)

The Magic Lanterns in the Collection of the Cabinet of Astronomy and Physics in Kassel: The Device, the Pictures, and a Sort of Public Presentation

The magic lanterns in the collection of the Cabinet of Astronomy and Physics in Kassel may well be the oldest still extant devices of their sort. Two of them appear to have been made before 1702, and it is probable that the optician Ludwig Temmen was their constructor. He is known to have made slides and moving slides for magic lanterns, so it likely that he also made some of the lantern slides that still survive in the collection of the museum.

This talk will try to situate the magic lanterns in the scientific situation of Kassel ca. 1709 as well as to show how early magic lantern presentations might have looked like in these days. This kind of instrument was well established in cabinets in the late 17th and early 18th century. Was magic lanterns seen as scientific instruments, or what were the reasons why they could be found in the Optical Room of Landgrave Karl's cabinet in the *Kunsthaus*?

These early modern optical instruments also pose a challenge to modern exhibitions. How can such instruments be linked to a modern exhibition when they are now widely seen as bemusing artifacts from the past?

Session IIa: Early Modern Optics
Day 2: Tuesday, 20. September
11.30-12.00, Gartensaal

Giorgio Strano
(*Museo Galileo – Istituto e Museo di Storia della Scienza, Florence*)

Galileo, Reliable Observer: Astronomical Accuracy and the Optical Limits of the Telescope

Historians of science usually depict Galileo Galilei's observational activity in connection with the dismissal of geocentric in favor of heliocentric cosmology. As a consequence, Galileo's observations are usually studied from the philosophical and the scientific points of view. In both cases, the strict association between the performance of the early telescopes, Galileo's observational diaries, and the sky are passed over in silence.

The analysis of the structure of Galileo's existing telescopes, and the repetition of observations with replicated instruments, shows that interesting optical properties of these telescopes are still unknown. By combining such optical properties, the observational diaries, and the sky, it becomes possible to look behind the scenes of the *Starry Messenger* and other printed works. In particular, it becomes apparent that the reliability of Galileo's records often depends upon the scientist's ingenuity, as well as upon earlier, pre-telescopic records or even theoretical extrapolations.

Session IIa: Early Modern Optics
Day 2: Tuesday, 20. September
12.00-12.30, Gartensaal

Rolf Willach
(*Tägerwilen, Switzerland*)

A Recently Found Telescope by the Augsburg Optician Johannes Wiesel

The discovery of a telescope, intact and signed by the Augsburg optician Johannes Wiesel, is discussed. So far, the only known surviving telescopes by this maker were the two instruments in Skokloster Castle on Lake Mälaren in Sweden; unfortunately these telescopes are missing their lenses.

This new find is therefore of significant historic value, because Wiesel was not an ordinary optician. He was at the crossroads of the telescope's trajectory between the first half of the 17th century and a new age, in which the telescope, from its first unsatisfactory design, had been developed to become an instrument of real scientific power. For this reason the optical design of this newly-found telescope will be discussed in detail and also compared to the telescope that Wiesel sent to the Amsterdam nobleman Vogelaer, the optics of which were described by Christian Huygens.

Session IIa: Early Modern Optics
Day 2: Tuesday, 20. September
12.30-13.00, Gartensaal

Fokko Jan Dijksterhuis
(*Department of Science, Technology and Policy Studies, University of Twente*)

The Burning Glasses of Tschirnhaus in the Republic of Letters, Artifacts, and Savants

On 20 November 1709, the Frankfurt polyhistor Zacharias Conrad von Uffenbach (1683–1734) visited the Kassel mathematics professor Lothar Zumbach von Koesfeld (1661-1727). In the travel diary he published half a century later, *Merkwürdige Reisen durch Niedersachsen, Holland und Engelland* (1753-4), Uffenbach related how Zumbach performed chemical experiments. He used burning lenses that had been made in Saxony by Walther Ehrenfried von Tschirnhaus (1651-1708) and presented to the collection of the Landgrave of Hessen. The experiments themselves were performed at the request of Nicolaas Hartsoeker (1656-1715), who was at that time living in Düsseldorf and professor at Heidelberg University. The experiments were intended to decide in a dispute between Hartsoeker and the Paris chemist Wilhelm Homberg (1652-1715) regarding the question whether metals could be melted to glass. To this pan-European network connecting Dresden and Paris via Kassel and Düsseldorf an additional node should be added: Amsterdam. In this city Hartsoeker had learned of Tschirnhaus's mirrors and lenses. The town had been a regular stop-over for Tschirnhaus on his travels between Saxony and Paris in the 1670s and 1680s, and he had rallied a circle of loyal supporters among the town's savants. They not only had edited and published his first books, but also had collected and marketed his optical instruments. They did so by showing and selling them, by discussing them in articles, reviews and appendices they added to Tschirnhaus's books, and by distributing his own writings and representations. Such were the various means by which Tschirnhaus's glasses traveled all over Europe and they represent the various manifestations an instrument could have. Besides being material artifacts that were both collector's items and experimental apparatus, the lenses and mirrors of Tschirnhaus existed as textual and visual descriptions on paper, as well as geometrical diagrams in mathematical analyses. In this way they aroused the curiosity of savants and travelers and could become a key part in physical and chemical productions and contemplations. In this paper I will discuss the various manifestations of Tschirnhaus's glasses and the way these conjointly gave shape to their use and meaning and made them travel through Europe.

Session IIIa: Curatorial Quandries:
Reflections on Museum Practice
Day 2: Tuesday, 20. September
14.00-14.30, Gartensaal

Jan Waling Huisman
(*Universiteitsmuseum Groningen*)

Instruments, Documentation of a Nobel Prize, and Dan Brown…

One of the best things that can happen to a university is to have a Nobel Prize winner amongst its scientists. Even luckier is the museum that gets the honor to preserve associated artefacts. Or is it?

The museum of the University of Groningen keeps the legacy of Frits Zernike, who received the prize for his work on phase-contrast microscopy. Research documentation, patent requests, newspaper clippings, interviews, and personal memorabilia all survive in abundance. To make a selection of what to keep is a difficult task.

But what makes it al the more interesting is a cardboard box containing home-brew instruments and a small booklet, which gives a Dan Brownish twist to the discovery…

Session IIIa: Curatorial Quandries:
Reflections on Museum Practice
Day 2: Tuesday, 20. September
14.30-15.00, Gartensaal

Stephen Johnston
(*Museum of the History of Science, University of Oxford*)

High-concept Curatorship: History and Fiction in an Instrument Exhibition

In difficult times of dwindling staff and resources, how can attractive exhibitions be created in the absence of big budgets - attractive in the sense of drawing in a general as well as a specialist audience?

This paper presents a current exhibition project due to open in November 2011 at the Museum of the History of Science, Oxford. The working title is 'Stranger than Fiction: the Time Machine of Nicholas of Oxford.' It is an exhibition on time and, for practical reasons of scheduling and cost, it will draw almost exclusively on the museum's collection of time-tellers and time-keepers: from a solitary Roman portable dial to a huge collection of medieval, Renaissance and early-modern sundials, and from turret clocks to radio-controlled timepieces.

There have been many large and successful exhibitions on the grandly-conceived Story of Time. We do not want to create a pale shadow of the well-established narrative of accuracy, progress, and mechanical perfection. Instead, on analogy with the 'high concept' Hollywood movie pitch, can a conceit or twist be found that would give a sufficiently fresh and intriguing spin to a time exhibition?

Time travel is of course a staple of fiction. But rather than travelling backwards from now (the 'Back to the Future' model) is it possible to imagine a genuinely historical vision of time, one that looks forward from the lost past? To try this we are using a fictional medieval guest curator – Nicholas, the cocky, *Almagest*-reading astrological Oxford scholar from the bawdy 'Miller's Tale' in Chaucer's *Canterbury Tales*.

There are significant risks in this approach. It would be all too easy to come up with a trite and ill-informed trivialization of the medieval world-view - either Disney or Monty Python. It would for instance be implausible if he was uniformly amazed and open-mouthed in wonder at the future of time. While he might indeed be surprised and impressed by the time-tellers and -keepers of the future, he could equally express a variety of other responses, ranging from puzzlement and doubt to moral righteousness and religious reproach. Can we respect the integrity and depth of a medieval intellectual's vision, and also use it to generate genuine insight for a modern lay audience?

I hope that between the writing of this abstract and the conference, the exhibition team will have negotiated a route through the many potential hazards of such an enterprise, and that we will have not only a successful exhibition but a 'behind-the-scenes' story worth telling.

Session IIIa: Curatorial Quandries:
Reflections on Museum Practice
Day 2: Tuesday, 20. September
15.00-15.30, Gartensaal

Sara Schechner
(*Harvard Collection of Historical Scientific Instruments, Cambridge*)

Tigers, Teapots, Telegraphs – Thoreau's Turtle – and a Hundred-year-old Tortilla: Scientific Instruments in the World of Tangible Things

The organizers of this symposium have invited us to juxtapose scientific instruments, texts, and images in order to consider how each of these different media can help us understand the meaning of the others in ways that each on its own cannot. Object, word, and image are like different axes of correction in a spectacle lens, and when each is applied justly, our view of a historical moment can be sharper and clearer.

But are the meanings of these historically-connected, scientific things and the categories of knowledge based on those things as fixed or as natural as they first appear? What happens when scientific instruments, artworks, historical relics, and ethnographic artifacts sit down together?

Drawing upon *Tangible Things,* a recent exhibition at Harvard, this paper will question the modern Western intellectual categories that distinguish art from artifact, specimen from tool, and the historical from the anthropological. Examples will include a French printing telegraph whose input device is a piano keyboard, John Singer Sargent's oil palette, a phrenological cast of Descartes' skull, a crystal ball, Edwin Land's 'Mondrian,' a Galapagos giant tortoise holotype, Thoreau's pencil, and a psychology film of pigeons playing ping pong.

Session IIIa: Curatorial Quandries:
Reflections on Museum Practice
Day 2: Tuesday, 20. September
15.30-16.00, Gartensaal

Olaf Slijkhuis
(*Pictura Imaginis bv*)

From the Oldest Museum in the Netherlands to the Most Modern Museum on the Web? A Glance into the Digitization of the 'Ovalen Zaal' of the Teylers Museum and Its Scientific Instrument Collection

In what way can a virtual visitor of a museum website get the same experience as a regular visitor can? With this question in mind we started out with the digitization of the 'Instrumentenzaal' part of the Teylers Museum in Haarlem, the Netherlands, in 2007. Now in 2011 we've repeated this feat by digitizing the 'Ovalen Zaal' of the Teylers Museum. The Teylers Museum is the only museum in the world still in its original state dating from the 18th century. The 'Ovalen Zaal' is the oldest part of the museum where the atmosphere still breaths its history. As a visitor it is like stepping into a time machine. Part of the collection comprises scientific instruments dating back to the 18th century and displayed in their original setting.

An important aspect in digitizing this unique collection was to keep the historical context between the objects and the room in which they are displayed. This is especially the case in the collection of the Teylers Museum. It is very interesting to see how the instruments were and still are displayed in their original display cases.

To keep the visitor focused during their online visit everything can be navigated from one single web page. The site is built around a few levels. Starting with a general overview it is possible to look at the collection in more detail. By scrolling within a panoramic photo the visitor can look around and decide which part he wants to view up close. Every display case situated around the 'Ovalen Zaal' is a so-called hotspot, an object which can be looked at in more detail by clicking on it. Every individual shelf in the display case can be viewed. You can see the original 18th century setting for yourself. The next level will make it possible to view all objects in a so-called roundshot. A roundshot is a digital file by which you can view an object in a 360 degree rotation. It can be viewed from every angle, and because a high resolution is used it is possible to look at every angle in very fine detail.

Every roundshot is provided with metadata and in doing so it is possible to not only look at an object but to also put it in its historical context. Metadata can be added in the form of text, as well as an a audio or video fragment. Metadata also give the opportunity to refer to other information sources. The entire collection of scientific instruments was, for instance, described in 1996 by Gerard L'E Turner. Parts of the book that describe certain instruments can be consulted right away from links in the metadata.

Seeing these instruments in their historical context is a unique addition to a regular museum visit. It not only offers a look at the collection from the comfort of your home but it can also offer a richer experience when visiting a museum. The virtual visitor is given an added bonus by being able to look at the instruments from every angle – something which is not permitted to regular museum visitors.

Session IIIa: Curatorial Quandries:
Reflections on Museum Practice
Day 2: Tuesday, 20. September
16.00-16.30, Gartensaal

Oliver Zauzig
(*Helmholtz-Zentrum für Kulturtechnik, Humboldt-Universität zu Berlin*)

Introduction of a Database for Material Models in University Collections

Models are key instruments of scientific research. While studies on them have primarily focused on their practical use in scholarship and technology, their historical dimension has widely been neglected. Especially the application of these objects in historical teaching and research in universities has barely been analysed. To support the research in this field, data collection is needed.

The Helmholtz-Zentrum für Kulturtechnik of the Humboldt-Universität in Berlin has developed a database for multidisciplinary studies. The structure of the database has now been completed. The subsequent step will be the capture and presentation of three-dimensional material models on this multimedia-based platform, which has been configured for peripheral input.

The project aims to gather material that has seldom been published so far and addresses itself not only to scholars. Everyone who is interested in scientific objects will be able to access to the database. Besides their relevance for research, the objects presented can be considered as objects of cultural value requiring protection. Data-capture and presentation online are therefore the first steps to promote an appreciation of objects which were of great significance in scholarship. This database is going to be introduced in the near future.

Session IVa: The Long Arc of Mathematical Instruments
Day 3: Wednesday, 21. September
9.00-9.30, Gartensaal

Silke Ackermann
(*The British Museum, London*)

Ottoman Science in the 19th Century – An astrolabe-quadrant (re)contextualized

A current research project at the British Museum focusing on Ottoman science in the 19th century was triggered by the acquisition of an extraordinary astrolabe-quadrant (a very sophisticated astronomical instrument) some years ago. The instrument, which was previously in a private collection, had featured in the great Syria exhibition at the Institut du Monde Arabe in Paris in 1993, where it attracted considerable attention. Based on the sophisticated astronomical markings, which make this otherwise quite modest-looking object stand out from other quadrants of this type, scholars had dated it to the late 18th century. However, a reinvestigation of the elaborate perpetual calendar on the instrument, which enabled its user to convert from one of the various calendars used in the vast Ottoman Empire to another, proved otherwise – namely that the instrument must be dated to the late 19th century. Subsequent research into the exchange of astronomical data between West and East in the course of the Napoleonic Wars and the discovery of an Ottoman treatise on timekeeping and calendar regulation from the same period have enabled us to look at the instrument and science in the late years of the Ottoman Empire in a completely different light.

The paper will highlight this new research and also discuss the use of the instrument in an educational context.

Session IVa: The Long Arc of Mathematical Instruments
Day 3: Wednesday, 21. September
9.30-10.00, Gartensaal

Louise Devoy
(*The British Museum, London*)

A Pictorial Puzzle: The Variation of Constellation Pictures on Gunter Quadrants

Seventeenth-century quadrants based upon the design proposed by Oxford mathematician Edmund Gunter (1581-1626) often feature a planispheric volvelle on the reverse. Many of these movable discs are engraved with pictorial representations of key circumpolar constellations such as Ursa Major, Ursa Minor, Draco, Cepheus, and Cassiopeia. Despite having a common purpose of being used to determine the time at night, many of these volvelles have a variety of constellation pictures drawn from different perspectives. In this presentation I will review the variation between these pictorial designs and discuss the implications of this comparative study.

Session IVa: The Long Arc of Mathematical Instruments
Day 3: Wednesday, 21. September
10.00-10.30, Gartensaal

Sreeramula Rajeswara Sarma
(*Prof. em. at Aligarh Muslim University*)

The *Dhruvabhrama-yantra* of Padmanâbha and Its Extant Specimens

One of the fascinating aspects of the history of science is the transmission of ideas and instruments across geographical boundaries, cultures, and languages. The most notable example is the astrolabe. Invented in the Hellenistic antiquity, it was received, preserved, and enriched in the Islamic world, and was transmitted westwards up to Chaucer's England and eastwards to India where it was hailed as 'the king of instruments' (*Yantra-râja*) in Sanskrit.

A reverse case of transmission is exemplified by a Sanskrit instrument called *Dhruvabhrama-yantra* which appears to have inspired the production of the *Shabnumâ-wa-Rûznumâ* by the Muslim astronomers of India. The *Dhruvabhrama-yantra* was invented by Padmanâbha in the first quarter of the fifteenth century in Central India. He composed a manual in Sanskrit verse on its construction and use.

The *Dhryvabhrama-yantra* is a multipurpose instrument that can be used both in the day and at night. It consists of an oblong plate, one side of which is designed as the *Dhruvabhrama-yantra* for use at night and the reverse side fashioned as the sine quadrant that can be used both at night and in the daytime. With the former, one can measure the sidereal time, the point of the ecliptic which is rising on the eastern horizon at that moment, and the point which is crossing the meridian. The sine quadrant measures time, the altitude of heavenly bodies, and solves a number of trigonometric problems.
In the course of a survey of pre-modern Indian astronomical instruments, I have located nineteen specimens of the *Dhruvabhrama-yantra* and two specimens of its Islamic counterpart in different museums in India, Europe, and the USA. These specimens show much variation.

In this paper, I shall first discuss prescriptions for the construction of the instrument as given in Padmanâbha's text and then examine how these prescriptions are carried out in the exact specimens of the *Dhruvabhrama-yantra* and how they were modified in the specimens of the *Shabnumâ-wa-Rûznumâ*.

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Samuel Gessner
(*Centro Interuniversitário de História das Ciências e da Tecnologia, University of Lisbon / New University of Lisbon*)

Images and Texts Featuring the *Quadratum Geometricum* in Lisbon, 1580-1640

The surveying device called the *Quadratum Geometricum*, or geometric square, has been referred to in European literature at least since Gerbert, but it became widely known through Peurbach's canonical description, edited by Stabius (1516), and, with Regiomontanus' comments, by Schöner (1544), as well as by other publications like Apian's *Instrumentbuch* (1533). Throughout the 16th century many variants of the instrument were produced as for instance Schissler's magnificent exemplars in Dresden (1569), Oxford (1579), and Florence (1599).

In a 1606 publication, the Spanish cosmographer Andrés Garcia de Céspedes (1545-1611) remembered having developed instruments while in Lisbon in the service of the first viceroy of Portugal (1583-1594), Archduke Albert of Austria (1559-1621) – among them a variant of the geometric square. Two decades later (ca. 1620) the Jesuit Johann Chrysostomus Gall (1586-1643) presented a similar variant of the geometric square in Lisbon to his audience at the *Aula da Esfera*, where novices of the Jesuit college as well as lay students were taught basic mathematics in the vernacular. In the same institution, about 1638, one of Gall's successors, Simon Fallon (c. 1604-1642), presented still another version of the instrument.

This paper not only attempts to reconstruct the particular forms of geometric squares proposed in Lisbon before and after 1600, based on the sparse textual and pictorial evidence available; it also examines and compares the interplay of text and images in each of the sources, printed or manuscript. The various approaches will be related to the different cultural backgrounds of the court mathematician Céspedes, on the one hand, and the Jesuit college teachers Gall and Fallon, on the other.

Session Va: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
11.30-12.00, Gartensaal

Jim Bennett
(*Museum of the History of Science, University of Oxford*)

The Lost Cabinet of Experimental Philosophy of the University of Oxford

In 1683 a 'School of Natural History' was created at the University of Oxford as part of a building designed also to accommodate the Ashmolean Museum and a chemical laboratory; the building is now the Museum of the History of Science. Despite the rather different meaning of the term 'natural history' today, the subject taught there in the 18th century was experimental philosophy, supported by a collection of instruments built up by successive lecturers. We have a very full record of the collection, made by an expert in the field, the London instrument-maker Edward Nairne, in 1790. By this time it was very extensive and housed in a subject-based series of cabinets. Nothing is known to have survived and the paper will consider the nature of the collection, the circumstances that precipitated Nairne's inventory, and the eventual fate of the instruments. While we naturally celebrate the magnificent collections of instruments that survive from the eighteenth century, it is surely more typical that such cabinets have been 'lost.'

Session Va: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
12.00-12.30, Gartensaal

Sofia Talas
(*Museum of the History of Physics, University of Padua*)

New Light on the Cabinet of Physics of Padua

The chair of experimental philosophy was created in Padua in 1738. It was assigned to Giovanni Poleni, who set up a rich Cabinet of Physics of about four hundred instruments, financed by the Republic of Venice. To analyze how the new experimental physics courses reached Padua and examine how the Cabinet of Physics was set up, new research has recently been carried out on Poleni's correspondence, which includes letters from many scientists all over Europe. We will present in this paper the first results of this research and see how the Cabinet of Physics of Padua was embedded in the spreading out of experimental physics throughout Europe.

Session Va: Making Science Public in 18th-Century Europe: the Role of Cabinets of Experimental Philosophy
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12.30-13.00, Gartensaal

Tiemen Cocquyt
(*Museum Boerhaave, Leiden*)

Failure, Fraud and Instrument Cabinets: Concealed Histories in 18th-century Leiden Experimental Philosophy

In the eighteenth century, the Leiden Cabinet of Physics had a prominent role in making empirical natural philosophy accessible on the Continent. Brought to high esteem in the early decades of the century by ‘s Gravesande, this task was later taken over by Professors Van Musschenbroek, Allamand, and Lulofs. In addition to holding their academic positions, all of these men were engaged in engineering projects. While their concern with technical matters can be seen shining through in their collections and the textbooks they authored, some aspects of their activities did not show up in print. A handful of events presents a picture of how the interaction with industry and society was from time to time far from beneficial. Notwithstanding their expertise, these professors could indeed fall prey to the plans of charlatans and the salesmen of fraudulous projects.

In this talk I will sketch how such ‘failures’ gave shape to the Leiden Cabinet and how they influenced the empirical philosophy that the academics propagated. Naturally, designating such projects as failures can only be done in hindsight, for the professors, and sometimes the engineers as well, had high expectations of the outcomes. In fact, considerable effort was later invested in preventing these events from finding their way to into the annals of science. This makes it particularly worthwhile to have a closer look at these episodes. They reveal much about the risks that accompanied the rising authority of empirical philosophy in the 18th century. In addition to providing insight into the scientific interplay between the academy and society, this talk touches on the role of heritage for our understanding of this background. As it turns out, the combined study of textbooks, instruments, and patent applications is essential for uncovering the traces of these concealed histories.

Session VIa: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
14.00-14.30, Gartensaal

Martin Weiss
(*Leiden University*)

'Monuments of Science':
How Teylers Museum's Instrument Collection Became Historical

In 1804 Kaspar Heinrich Freiherr von Sierstorpff from Brunswick visited Teylers Museum in Haarlem. He was flabbergasted by the immense value of the instrument collection he encountered, and mused that the instruments on display were almost too precious to be of any use for research. Almost prophetically he added that 'this collection will someday serve only to illustrate the history of this discipline [physics].' How right he was: some 100 years later, Teylers Museum was associated with the history of physics as much as it was associated with physiccal research. Just one example from which this can be inferred is the fact that in 1905 the initiators of the Deutsches Museum in Munich invited the Dutch Nobel Prize laureate Jacobus van 't Hoff to give a speech on 'Teylers Museum, and the significance of historical collections for science and technology.' This development is all the more striking if one considers that the museum had originally been conceived as a place of research by its first director, Martinus van Marum. After it was opened in 1784, it was essentially a fine example of an 18th century cabinet of physics. This paper is about Teylers Museum's transition from an 18th century cabinet of physics to a museum for the history of science over the course of the 19th century. Questions that will be addressed are: why was so much of the instrument collection preserved? When and how did it come to be recognized for its historical value? And how did the instrument collection relate to the museum's other collections?

On the basis of visitors' travel reports, internal correspondence concerning museum policy and the museum's acquisition policy, this paper will argue that three factors in particular need to be included in any answer to the questions above. Firstly, van Marum did very little with the instrument collection during the last decades of his life. Secondly, the instruments he had acquired were too precious to dispose of. Probably as a result of these two factors, van Marum's successor Jacob Gijsbertus Samuël van Breda stated as early as 1839 that the old instruments needed to be preserved as 'monuments of science,' and that every scientist would appreciate them, knowing 'how much they had contributed to the progress of science.'

But thirdly and probably most importantly, one must not forget that the instrument collection was just one of the collections housed in Teylers Museum. In accordance with Pieter Teyler's will – in which he had stipulated that his fortune was to serve to stimulate the study of both the fine arts and the sciences and on the basis of which Teylers Museum was founded – a numismatic collection, a geological collection, and a collection of fine art were acquired for the museum as well. And although the instrument collection appears to have been the most prominent initially, as the 19th century progressed Teylers Museum increasingly came to be perceived as an art museum. This paper will therefore pay special attention to the changing role of the art collection within Teylers Museum, and in how far this had an influence on the instrument collection. Were instruments ever considered art, for instance? Was the museum initially an early science museum which left some room for art, while it later became an art museum which also accommodated an instrument collection? And could one perhaps even go as far as to claim that van Marum fortuitously ensured his cabinet's survival through the 19th century because he christened it 'museum'?

Session VIa: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
14.30-15.00, Gartensaal

Hans Hooijmaijers
(*Museum Boerhaave, Leiden*)

Willem Jacob ‘s Gravesande: The Man, His Cabinet of Physics, and His Book

Willem ‘s Gravesande came from a well-to-do family. Although he graduated in law he always had a keen interest in physics. Following an inspiring meeting with Isaac Newton, ‘s Gravesande was even more fascinated. He left his law firm for a professorship in Leiden, where he set up his physics lessons. Together with the Leiden instrument maker Jan van Musschenbroek, he created a whole new set of teaching, demonstration, and experimental tools. With this set of apparatus, ‘s Gravesande was able to turn the book of Newton into a visual lecture series. In fact, ‘s Gravesande wrote a much more popular book, in which he described his lessons in detail, accompanied by numerous explanatory drawings of the instruments he used. With this ‘s Gravesande collected all Newton’s ideas into one book, which became the ‘mother’ of all physics teaching books.

I start this paper with a short biography of ‘s Gravesande. I proceed with the two men who had an important influence on his career change: Newton and van Musschenbroek. Then I will deal with the lessons of ‘s Gravesande: where were they held and who participated in them? I will sketch the development of his cabinet of physics by looking into the instruments that survive and the succeeding editions of his book. Finally I will give an overview of the spread of ‘s Gravesande’s heritage.

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Day 3: Wednesday, 21. September
15.00-15.30, Gartensaal

David Felismino, Marta C. Lourenço
(*Museum of Science, University of Lisbon*)

Between Teaching and Collecting: The Cabinet of Physics of Princes José and João of Portugal (1778-1794)

Little is known about the royal cabinets of physics that existed in Portugal between the seventeenth and nineteenth centuries. They were organized in different periods, together with cabinets of natural history and libraries, for the education of the younger generations of princes and for the entertainment of the court.

Recently, a significant number of scientific instruments – particularly from England, Germany, the Netherlands, and France – has surfaced, producing new insights regarding these cabinets.

One of them was organized by Michele Franzini (17??-1810), a Venetian mathematician. In 1772, Franzini came to Portugal to teach at the University of Coimbra at the invitation of Marquis de Pombal, but he was soon called to court to teach the two young princes D. Jose (1761-1788) and D. João (1767-1826) at Ajuda's Palace in Lisbon. From 1777 to 1794, he had principal responsibility for the acquisition of scientific instruments and books, as well as the organization and development of the royal Cabinet of Physics that would later be dismantled and transferred to Rio de Janeiro in 1807.

In this paper we will describe the purpose, composition, and use of this Cabinet, focusing on issues such as trade, a complementary library, and instrument transfer between this and other teaching cabinets in Portugal, such as the one at the Royal Academy of Sciences (from 1779 onwards) and the *Colégio dos Nobres* (1761-1772), both in Lisbon. We will also present a broader research project that includes the study of this and other royal cabinets of physics in Portugal and Brazil.

Session VIa: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
15.30-16.00, Gartensaal

Inga Elmqvist Söderlund
(*Museum for the History of Science, Oxford/The Observatory Museum, Stockholm*)

Demonstration Instruments at Riddarhuset (Stockholm) in the 18^{th} Century

In Sweden in the 18^{th} century scientific instruments were demonstrated at public lectures on the natural sciences at Riddarhuset in Stockholm. The most well-known lecturers were Mårten Triewald and Johan Carl Wilcke. Triewald had travelled to England between 1716 and 1726, where he witnessed lectures at the Royal Society, and also travelled to the North (Edinburgh?) to perform demonstrations himself. He brought back a number of instruments to Sweden, and also commissioned new ones. He was one of the founders of the Swedish Academy of Sciences, and he held and published a number of lectures. Wilcke was in 1759 employed by the academy specifically for public demonstrations, and a cabinet of physics was formed in order to make these lectures possible. The paper discusses the types of instruments used and how their design relates to demonstration purposes.

Session VIa: Making Science Public in 18th-Century Europe: the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
16.00-16.30, Gartensaal

Karsten Gaulke
(*Museumslandschaft Hessen-Kassel, Cabinet of Astronomy and Physics*)

Courtly Sciences: Teaching and Research in the *Kunsthaus* of the Hessian Landgraves

In 1696 Landgrave Karl of Hesse-Kassel founded the *Kunsthaus* at his court seat in Kassel, transferring to it his voluminous collections of arts, crafts, scientific instruments, technical innovations, and architecture models. In 1709 he combined the *Kunsthaus* with a university-like school, the Collegium Carolinum – an early polytechnical school where the students learned mixed mathematics, experimental physics, anatomy, and natural history. Divided by scientific discipline into various 'rooms,' the *Kunsthaus* was far more a place for teaching and research than simply a pre-modern museum or continuation of the *Kunstkammer*, as it has been characterized. Indeed, the collections served partly as educational devices and partly as tools of research. With the burning lenses of Ehrenfried von Tschirnhaus, for example, some crucial experiments concerning the material quality of gold were undertaken; with the aerial telescope of Campani eclipses of the moons of Jupiter were observed.

In the subsequent 60 years the structure and concept of the *Kunsthaus* hardly changed. But a few years before the French Revolution the Collegium Carolinum was closed; Kassel's ruler, the great-grandson of Landgrave Karl, was a manifest enemy of the Enlightenment. This talk will illuminate new research on the structures and conditions of the *Kunsthaus* as a courtly institution for research and education in the long 18th century.

Session VIIa: Making Science Public in 18th-Century Europe: the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
17.00-17.30, Gartensaal

Huib J. Zuidervaart
(*Huygens ING, Royal Netherlands Academy of Arts and Sciences, The Hague*)

The Emergence of Institutional Cabinets for Experimental Philosophy in the Netherlands during the Long 18th Century

The cabinet for experimental philosophy is a well known cultural phenomenon in Europe during the long 18th century. During the 1730s, performing physical experiments also became very popular in the Dutch Republic. Many privately owned instrument cabinets emerged, especially in the larger cities, where wealthy merchants had the means as well as the opportunity to join the general European trend of emerging curiosity towards experimental philosophy.

In the early days of experimental philosophy, Dutch teaching institutions, like the universities in Leiden, Franeker, Utrecht, Groningen, and Harderwijk, expected their physics professors to collect their own instruments if they wanted to use these during their courses. However, in due time, the high costs and the broad variety of instruments of experimental philosophy caused the founding of institutional cabinets, brought together and with the costs borne by a community. The communities that founded such an institutional cabinet of experimental philosophy were not only teaching institutions, but also local physics societies and even more generally oriented institutions, like the well-known Teylers Society in Haarlem, or the less well-known Felix Meritis Society in Amsterdam.

In my presentation, I will discuss the emergence of the Institutional Cabinet for Experimental Philosophy in the Netherlands during long 18th Century. Questions will pass regarding the reasons why these institutions, at a certain point in time, started to collect scientific instruments. In this process, I will look not only into the content, usage, and maintenance of these instrument cabinets, but also will investigate their funding. By doing so, I hope to convince my audience of the importance of these cabinets, not only for the spread of physical knowledge in the Netherlands, but also for constituting a sense of awareness, in Dutch society, that manipulating nature could open all kinds of technical possibilities beneficial for human society in general.

Session VIIa: Making Science Public in 18th-Century Europe:
the Role of Cabinets of Experimental Philosophy
Day 3: Wednesday, 21. September
17.30-18.00, Gartensaal

Ewa Wyka
(*Jagiellonian University Museum, Krakow*)

Experimental Natural Philosophy Collections in the 18th Century in Poland

The stream of Enlightenment thought, and with it the creation of natural philosophy collections, reached Poland not earlier than the second half of the eighteenth century. Two kinds of collections were created:

1) didactic collections – set up in secondary schools and universities
2) private aristocratic collections.

There was a significant difference between these two types
.
Demonstrative collections were created by the major Catholic colleges: the College of Jesuits in Poznan (1764), the Collegium Nobilium in Warsaw, and by the Universities of Cracow (c. 1780) and Vilnius (c. 1753). Their collections were composed for teaching experimental physics and for public demonstrations. The quality and quantity of instruments did not differ from other European university collections.

Private aristocratic collections were mostly natural history collections. The most valuable were those of Anna Jabłonowska in Siemiatycze and the Gdańsk collections of John Philip Breyn and of Jacob Thomas Klein.

There were then no private aristocratic collections of scientific instruments in Poland. The period of reception of Enlightenment science in Poland occurred simultaneously with the time of political turmoil of the country. The aristocracy was more involved in political conflicts than in intellectual development. However, particular instruments – telescopes, microscopes, electrostatic machines – were kept in many aristocratic courts.

Despite the fact that Poland was rather on the periphery of the development of modern science, a great interest in scientific novelties could still be observed. Public demonstrations of physical experiments, first balloon flights, and astronomical observations all gathered a large audience. Such demonstrations were carried out by both travelling European as well as by and Polish scholars.

Session IIb: Back to the Roots:
Stories of Instrumental Origins
Day 2: Tuesday, 20. September
11.30-12.00, Entrance Hall Orangerie

Terje Brundtland
(*Department of History and Religious Studies, University of Tromsø*)

Air Pumps: Then and Now

This talk gives examples on how the classic problem of leaks in vacuum systems has been perceived and solved through a period of 350 years. Examples will be given from Robert Boyle’s air pump experiments in the 1660s, from commercialized air pumps in the eighteenth century, from vacuum practice in the early twentieth century, as well as from modern vacuum technology. A very distinctive and visible feature of the present-day technology is the ‘Conflat’ vacuum-flange, developed for very low leak rates and high temperatures, using metal gaskets. Today, numerous such flanges are found on large vacuum chambers (receivers). The background and use of these flanges will be given, showing that the modern solution to Boyle’s leak problems has become a symbol of advanced science and technology.

Session IIb: Back to the Roots:
Stories of Instrumental Origins
Day 2: Tuesday, 20. September
12.00-12.30, Entrance Hall Orangerie

Alison Morrison-Low
(*National Museums Scotland, Edinburgh*)

The Origins of the Stereoscope

The stereoscope – an instrument which tricks the human brain into seeing images in three dimensions – was apparently devised by Charles Wheatstone, of King's College, London, some seven years before the invention of photography in 1839. Some ten years later, the irascible Scottish natural philosopher Sir David Brewster produced a lenticular stereoscope, but – according to his own account – had to employ a Parisian optician to build it. Displayed at the 1851 Great Exhibition, Queen Victoria herself was entranced by the images she saw, leading to a craze for the instrument and for its photographs. Brewster's account leaves a number of questions: were the first photographic stereo images daguerreotypes? When were calotype (paper prints) first used, and by whom? Are surviving stereo daguerreotypes of the Crystal Palace taken at the Hyde Park site, or at the subsequent venue in Sydenham where the building was removed in 1854? Has Brewster's attempts to overwrite this episode meant that its true history may never be recovered? This paper will attempt to investigate aspects of this particular 'Bermuda triangle.'

Session IIb: Back to the Roots:
Stories of Instrumental Origins
Day 2: Tuesday, 20. September
12.30-13.00, Entrance Hall Orangerie

Flora Paparou
(Department of Chemistry, University of Athens)

The Baroscope: Associating the Teaching Device with Historical Texts, Experiments, and Stories

In Ganot's 1894 textbook there is a description of a scientific instrument called the 'baroscope' which is utilized to show the buoyancy in air. Ganot comments on the Greek origin of the instrument's name and informs the reader that its first use was to investigate the weight of the air, as its name derives from the words βάρος for 'weight' and σκοπεὶν for 'investigate.' Ganot remarks that the instrument was invented by von Guericke. Basing ourselves on this information we track the history of the instrument in von Guericke's and Boyle's texts and experiments. We also track the idea that led to the instrument's construction in the transition of the notion of buoyancy from liquids to gases, revealed in Galileo's texts. Finally, we track the origin of the instrument in the work of 16^{th}- and 17^{th}-century scientists, such as Della Porta and Galileo, who, inspired by goldsmiths' techniques, re-examined Archimedes' writings and re-interpreted the 'eureka' experiment narrated by Vitruvius.

The whole story helps us to understand that the word 'baroscope' represents different scientific apparatus. It also reveals the fact that Ganot's baroscope, which can easily be found in 19^{th}-century school laboratories, can be utilized to trace the change of scientific notions as a kind of 'relay race' run by scientists of different historical periods as well as to discern the continuity of experimental techniques and the links between science and everyday life.

Session IIIb: Teaching with Instruments
Day 2: Tuesday, 20. September
14.00-14.30, Entrance Hall Orangerie

Marcus Granato[1], Maria Alice Ciocca de Oliveira[2]
(*[1]Museu de Astronomia e Ciências Afins,*
[2]Universidade Federal do Rio de Janeiro)

Instruments, Documents, and Images in the Trajectory of the Collection of Observatório do Valongo (Brazil)

Valongo Observatory is part of Universidade Federal do Rio de Janeiro (Federal University of Rio de Janeiro) in Brazil. It was founded in 1881 with the primary mission of being used for the practical lessons given at Escola Politécnica do Rio de Janeiro (Rio de Janeiro Polytechnic). It has a collection of around 300 objects used in the teaching and research undertaken at the institution, including scientific instruments and accessory apparatus. The objective of this talk is to show how this collection came to be formed, drawing on data gathered on the objects that comprise it that were used in the practical lessons for the disciplines relating to astronomy, geodesy, and topography given at the Astronomical Observatory of Escola Politécnica do Rio de Janeiro, the former name of the observatory, and the practical lessons and research conducted as part of the undergraduate course in astronomy at Valongo Observatory.

The study into the formation of the collection runs from 1874, with the founding of Escola Politécnica do Rio de Janeiro, to the early 21st century, when the collection of science and technology objects from Valongo Observatory was consolidated and recognized as being representative of its institutional memory. The information gathered on the objects in the collection and in archives (including documents and images) yielded knowledge about the social, political, economic, and scientific contexts the objects were part of, contributing not only to an understanding of the trajectory of the collection itself, but also that of the institution, little of which was known before.

Session IIIb: Teaching with Instruments
Day 2: Tuesday, 20. September
14.30-15.00, Entrance Hall Orangerie

Lina Hakim
(*The London Consortium*)

Scientific Playthings: The Afterlives of Scientific Instruments

The 19th century has been referred to as 'the age of wonder of mathematics' (Mueller, 2001): two centuries after all other sciences, mathematics began to produce wondrous objects that filled out its specialized curiosity cabinets. These intricate geometric and surface models were meant to offer mathematics something to contemplate, to learn from by observation – new territories to explore. By the early 20th century, however, these artefacts had already fallen out of grace as new parameters of purposefulness were set for the science.

My research is concerned with what happens to scientific instruments when they are no longer of use to science or scientific education, when they cease to work as direct and unproblematic transmitters of knowledge. I argue that this failure affords them a new opacity and a material plasticity; it opens them up to interpretation and to a 'what if?' kind of interaction, allowing for what Bachelard calls the 'material imagination' to take form through playful engagement.

In this paper, I look at the mathematical ruled surface models of descriptive geometry: how they became scientific instruments for a very limited period of time and in a very constrained context, the kind of knowledge they were meant to hold/contain/reveal/ disclose, and their afterlives when they fail as instruments and are (re)opened to creative interpretation – when they become playthings.Rather than engage in the kind of biography of specific artefacts that follows their movement between owners, I plan here to look at later reincarnations of the models themselves (what Barthes would call their declinations or 'avatars'): at what these do and at how they work.

In the case of mathematical ruled surface models, the journey takes us from Monge and Oliviers's models, through Victorian readings of non-Euclidian geometry, the surrealists' mathematical objects, Gabo's constructivist sculptures, to Mary Boole's 'curve stitch' craft activities that seem to bring us back to an epistemological significance of the objects. The aim is to try and tease out what their failure as instruments and their consequent status as playthings can tell us about the making of scientific knowledge.

Session IIIb: Teaching with Instruments
Day 2: Tuesday, 20. September
15.00-15.30, Entrance Hall Orangerie

Ignacio Suay-Matallana
(*Instituto de Historia de la Medicina y de la Ciencia "López Piñero", Universitat de València*)

Study and Digitalization of Secondary-school Science Collections in Spain: Castellón and Alicante

This paper analyzes the creation, development, and current state of the physics and chemistry cabinets of two Spanish secondary schools. It is the result of a project of digitization supported by the *Scientific Instrument Society* (SIS) and the *Catalan Scientific Instrument Commission* (COMIC).

Modern secondary schools were established in Spain between the 1830s and 1840s. The school curriculum included the teaching of ‘physics and chemistry,’ and the creation of physics cabinets and chemistry laboratories was considered a high priority. The provision of scientific instruments was planned at a national level through the publication of two reference catalogues for universities and secondary schools, respectively. The first purchases were implemented on the basis of an expedition to Paris. Business with Parisian instrument makers was facilitated by the Spanish toxicologist Mateu Orfila (then dean of the Paris Medical Faculty and president of the Academy of Medicine of Paris). This allowed the Spanish commissioners to acquire more instruments than initially expected, thus expanding the range of recipient institutions. Subsequent travels and purchases in the early 1860s allowed Spanish secondary schools to configure good cabinets of physics according the standards of the period.

The focus of the project is the Valencian area, in which three secondary schools were created between 1845 and 1846 and placed in the main villages of its three provinces, Valencia, Castellon, and Alicante. Their rich collections, archives, and libraries have been preserved and they are still at the schools. During the last years there has been a renewed interest in the study and preservation of scientific collections as part as Spanish cultural heritage. In 2002 the University of Valencia organized an exhibition, including some items belonging to the collections of these three secondary schools.

While there is a preliminary study and catalogue for the secondary school of Valencia, the rich collections of the secondary schools of Castellón and Alicante have received less attention and are the focus of this paper. Thanks to a complete catalogue of both collections, some comparative analysis is offered. The analysis of school sources (manuscript inventories and annual school reports) has enlarged our knowledge on the origins of the collections, as well as on the patterns of development which help us to understand the history and present of their rich cabinets.

Finally, in this paper I will also reflect on the problems and improvements in the handling of the on-line database of the *Catalan Scientific Instrument Commission* (COMIC). The aim of this database is not only to register, to photograph, or to describe the scientific instruments but also to integrate them with a wider range of sources such as textbooks, images, and trade catalogues; eventually this could lead to the reconstruction of pedagogical and scientific practices in the school context.

Session IIIb: Teaching with Instruments
Day 2: Tuesday, 20. September
15.30-16.00, Entrance Hall Orangerie

Tacye Phillipson
(*National Museums Scotland, Edinburgh*)

The Small Computer that Played Tunes

In the early 1960s most computers were behemoths, and their time was precious and sparingly dolled out. In this atmosphere Glasgow University took the unusual step of designing a small computer for teaching and student use. This computer, called SOLIDAC, is only the size of a desk. It was built by Barr and Stroud, a local firm who were keen to expand their reputation from optics into electronics. In 1967 T. H. O'Beirne of Barr and Stroud released an LP of Mozart's dice music, tunes where each bar is chosen at random from a selection, both calculated and played by SOLIDAC. This early example of computer music was reviewed in the magazine *Gramophone*: 'Not something one can listen right through a side to; but quite ingenious.' Fittingly for a Scottish computer, it also played bagpipe tunes of its own devising…

Session IVb: The Big League: Precision Astronomical Instruments in the 19th Century
Day 3: Wednesday, 21. September
9.00-9.30, Entrance Hall Orangerie

Paolo Brenni
(CNR, Fondazione Scienza e Tecnica, Florence)

Staunend stand ich nun vor dem herrlichen Kunstwerke… The Fraunhofer Refractor of Tartu: Its History and Its Recent Restoration

The Fraunhofer refractor installed in the Tartu (Dorpat, Estonia) observatory in 1824 is certainly one of the landmarks of astronomy. The instrument, which was the largest of its time (24.4 cm aperture, 4.34 m focal length), presented a series of innovative technical solutions, such as the equatorial mounting and a driving clockwork mechanism. The design (the so-called "German mounting") and the characteristics of this telescope were adopted in a very large number of refractors for more than a century. With it the astronomer Struve examined 120.000 stars and successfully measured about 3000 double stars and various star parallax.

The restoration of the old Tartu Observatory, which as the first point of Struve's geodetic arc was included in 2005 in the UNESCO World Heritage list, began in 2009. For this occasion I was asked to restore the Fraunhofer refractor. The operation was divided into two separate phases. In the first one (May 2009) the instrument was completely disassembled and the separate elements of the instrument were carefully examined. The brass and bronze parts were dirty and sometime oxidized, and traces of rust could be find on the iron elements. The massive wooden stand, made of oak covered with a mahogany veneer, presented several kinds of damage, and the original color of the wooden tube had faded away because of the effect of direct sunlight. Finally, after having been numbered, the components of the refractor were carefully packed and transported into a storeroom.

By February 2011, the observatory building had been completely restored and I began the second phase of the operation. The many pieces of the refractor were cleaned and restored and the instrument was finally reassembled. In my paper I will describe the most important steps of this restoration and I will illustrate some of the most relevant features of the instrument, which today can be admired in the museum of the Tartu observatory.

Session IVb: The Big League: Precision Astronomical Instruments in the 19th Century
Day 3: Wednesday, 21. September
9.30-10.00, Entrance Hall Orangerie

James Caplan
(*Laboratoire d'Astrophysique de Marseille, Université de Provence*)

Instruments for Measuring Astronomical Photographic Images

As photography developed in the 19th century it quickly captured the attention of astronomers, such as François Arago (who in 1839 announced to the French Academy of Sciences the process perfected by Louis Daguerre) and John Herschel (who was himself a photography pioneer). The possible applications to astronomy were obvious, but the difficulties were great. Herschel produced a photograph of the Moon in 1840. The Sun, although a half-million times brighter, was first recorded in a daguerreotype in 1845, by Foucault and Fizeau. A single star was photographed by Bond and Whipple at Harvard in 1850 – in itself not very useful. Technical improvements allowed Miller and Huggins to record the absorption-line *spectrum* of a star in 1863. Finally, in the 1880s, dry-plate photographs began to show stars and nebulae invisible to the human eye, and photography began to replace human-eye observations. A century later, photographic emulsions were replaced by electronic image sensors.

Today, astronomical images, mostly in color, many obtained with space telescopes, are widely distributed, especially by NASA. Some of these modern images are quite spectacular, and serve to illustrate astronomical phenomena that are the subject of current research. Many of these images are of great use to astronomers, who like to actually *see* the objects they are studying.

But in fact, since the 1880s, the *primary* use of photographs (and more recently digital images) is to obtain *quantitative* results, essentially the *position* and *brightness* of astronomical objects. Today, images are both *measured* and *analyzed* by computer software, but until a few decades ago photographic plates (astronomers only rarely used film) were measured with special devices, many first developed in the late 19th century, in some cases in connection with the international Carte du Ciel program. Among these instruments are:

- *measuring engines* for determining rectangular coordinates on a plate (and then, via calculation, positions in the sky),
- *iris photometers* for measuring the brightness of stars, and (in the late 20th century)
- *scanning micro-densitometers*, allowing a finer, high-resolution measurement of the darkening of the photographic emulsion, pixel-by-pixel, over the plate.

I shall present many of these instruments, which were – perhaps even more than telescopes – characteristic of observatory equipment in the mid 20th century, and discuss how the traditions associated with these objects, suddenly obsolete, were incorporated into modern astronomical practice.

Session IVb: The Big League: Precision Astronomical Instruments in the 19th Century
Day 3: Wednesday, 21. September
10.00-10.30, Entrance Hall Orangerie

Françoise Le Guet Tully
(*CNRS/Université de Nice-Sophia-Antipolis/Observatoire de la Côte d'Azur*)

Tracking the History of a Lost Instrument: The Nice Observatory Meridian Circle

Inaugurated in 1887 at the same time as the (briefly) 'largest refractor in the world,' the Nice meridian circle was *destroyed* less than 80 years later, whereas the great refractor was *restored* – and is still being used for scientific purposes. Many questions arise about this lost instrument. Why was it built by the Brothers Brunner, while the other eight French meridian circle installed in a short period of the late 19th century were made by Eichens or his successor Gautier? What was its initial scientific goal and what did this instrument really achieve? Why have all the other French meridian circles survived until today, but not that of Nice? How does the Nice meridian circle differ from the Eichens/Gautier models? Was it a good instrument or, as in the oral tradition dating from its destruction, a poor one? Although some of the answers are readily found in publications, others emerge only after exploration of archival manuscripts and images. We shall show how a comparison of published sources, manuscripts, and photographs helped us to put this instrument into context and to better understand its birth, life, and death.

Session IVb: The Big League: Precision Astronomical Instruments in the 19th Century
Day 3: Wednesday, 21. September
10.30-11.00, Entrance Hall Orangerie

Günther Oestmann
(*Deutsches Schiffahrtsmuseum, Bremerhaven*)

Thirteen Years after Sorø: On the Completion of a Biography of Johann Heinrich Kessels, Maker of Chronometers and Precision Pendulum Clocks

In 1823 Heinrich Johann Kessels (1781-1849) from Maastricht established himself in Altona, and his workshop became the core of chronometer production in Altona and Hamburg. He supplied numerous observatories in Europe and America with his clocks and chronometers, and he corresponded with the foremost astronomers and scientists of his day (e.g., Schumacher, Bessel, and Hansteen).

At the XVIIth SIC Symposium in Sorø (1998) some preliminary remarks on a biography and catalogue raisonné were given. Research work has been completed, and a biography based on primary sources, including Kessels's correspondence, is now available. Moreover, a catalogue raisonné of his works has been compiled for the first time. An outline of the results achieved will be presented.

Session Vb: Instruments on Land and at Sea
Day 3: Wednesday, 21. September
11.30-12.00, Entrance Hall Orangerie

Ivan Tafteberg Jakobsen
(*Lektor em. at Aarhus Statsgymnasium*)

Tobias Mayer's 'Astrolabium' and the Arabian Expedition of 1761-67

The Danish King Frederik V financed an expedition to Arabia, an expedition which was one of the first solely *scientific* expeditions, and which took place from 1761 to 1767. In 2011 and 2012 Denmark will be celebrating the 250th anniversary of the beginning of this expedition with various activities.

The only survivor of this expedition, Carsten Niebuhr from Dithmarschen, carried with him a 2-foot quadrant, an octant made by John Bird, and a so-called 'astrolabium' divided by his teacher in Göttingen, Tobias Mayer. These instruments were to be used for cartographical purposes. The octant and the astrolabium still exist and are on display in the Dithmarscher Landesmuseum in Meldorf, Germany.

This talk will explain why the astrolabium of Niebuhr must be essentially the same instrument as that described by Tobias Mayer in his presentation of 'a new and improved astrolabium' at a meeting in Göttingen in 1759. The description survives (incompletely) in a manuscript and a drawing from Mayer's hand, published by his biographer Eric Forbes in 1971 and 1980. But Eric Forbes apparently was not aware of any extant copies of the astrolabium.

The identification is further underpinned by a description of the astrolabium by Mayer's son, Johann Tobias Mayer in his *Gründlicher und ausführlicher Unterricht zur praktischen Geometrie* 1777, where he also refers to his father's method and invention, first described in 1752, of using the instrument as a repeating circle.

If the identification is correct, the astrolabium in Meldorf is to my knowledge the only extant instrument made under Mayer's supervision and according to Niebuhr divided by him personally. Furthermore it is the earliest example of an instrument used as a repeating circle. Another interesting feature is that it is provided with a micrometer screw, at the time well known from astronomical instruments, but perhaps the first instance of a surveying instrument with this feature.

The astrolabium was used very rarely in the Arabian Expedition, not because it was unsuited for surveying purposes, but for reasons not at all to do with science – I shall explain why in the talk.

The investigations of the Niebuhr astrolabium were done jointly with George Huxtable, FRIN.

Session Vb: Instruments on Land and at Sea
Day 3: Wednesday, 21. September
12.00-12.30, Entrance Hall Orangerie

Azadeh Achbari
(*Free University, Amsterdam*)

Dutch Overseas Riches

The point of departure in my paper is a large number of moldy ship journals. In the middle of the nineteenth century these journals served to construct precious charts of the Dutch colonial waterways. Mapmaking and land-surveying were part of the early nineteenth-century surge of enthusiasm in the measurement of widespread earthly phenomena such as winds and ocean currents, earth magnetism and tides. Typical to these so-called Humboldtian studies were their reliance on accurate observations, systematic measurements, and their grand scale. Vital for research were indeed the valuable navigational and siting instruments that were kept on various ships on their travels to the East Asian waterways. Questions arise as how this process of observing and measuring to assembling data evolved to result in diverse products such as tables, charts, and books. How was agreement reached on the used instruments and scales? Who were the observers? How and were did they obtain the skills to perform precision measurements? And to what extent did surveys serve the interests of the Dutch nation and its colonial/commercial enterprises?

Session VIb: The British Board of Longitude: New Perspectives on Instruments, Innovation and Creativity in the Georgian Era
Day 3: Wednesday, 21. September
14.00-14.30, Entrance Hall Orangerie

Alexi Baker
(*Department of the History and Philosophy of Science, University of Cambridge*)

Basic Tools, Brilliant Curiosities, and Black Boxes: Technology and the Search for the Longitude at Sea

The search for a more workable method of measuring longitude at sea was never simply a competition between astronomy or natural philosophy and technology, since instruments including timekeepers were vital elements of all but the most unlikely or fraudulent of proposals. By the eighteenth century, key innovators began to overcome limitations of materials and techniques that had previously made a centrally artisanal solution seem unlikely, and the British Commissioners of Longitude were consistently providing financial and logistical support for the advancement of technological as well as of astronomical methods. This presentation will discuss the different ways in which instruments and timekeepers were viewed and treated by the European and particularly the British actors and institutions involved in the search for the longitude over the centuries and especially during the existence of the 'Board of Longitude' – with the story mainly unfolding through the books, pamphlets, advertisements and legislation which addressed or accompanied this technology.

Session VIb: The British Board of Longitude: New Perspectives on Instruments, Innovation and Creativity in the Georgian Era
Day 3: Wednesday, 21. September
14.30-15.00, Entrance Hall Orangerie

Katy Barrett
(*Department of History and Philosophy of Science, Cambridge; and National Maritime Museum, Greenwich, London*)

Longitude Inscrib'd: Solving the Longitude Problem through Instrument, Text, and Image

The 1714 Act which founded the British Board of Longitude initiated a flood of pamphlets proposing new methods of measuring longitude accurately at sea. These are one means of looking at how people thought about the 'problem' of longitude in the period before the first minuted Board meeting in 1737. The solutions contained in these pamphlets range from the mechanical to the philosophical, and cover a wide spectrum of plausible success. Yet, a unifying factor for many of them is the presence of an image accompanying the text. Frontispiece illustrations, geometrical diagrams, maps, and particularly illustrations of instruments all play specific roles within these pamphlets, and all might be said to act as 'instruments' for their owners visually to think through and demonstrate their solutions. This paper considers a number of these longitude pamphlets using Bruno Latour's idea of 'inscription' – and the related role of 'immutable mobiles' – to look at the function of the illustrations they contain. It looks at how illustrations of instruments acted as a means of communicating proposed designs to potential patrons, and a means of mobilizing backers to get these instruments made and tested. Equally, new map projections allowed contributors to think about lines of longitude and latitude as themselves contested, but were also the instrument for testing other solutions. Such questions then form the background to the discussions between the Board of Longitude and their most famous applicant, the clockmaker John Harrison, in the 1730s-60s. Questions of inscription, immutability, and mobility were key to their differing attitudes to instruments, to the longitude prize, and to the process of agreeing a solution. Inscribed lines – of longitude, of illustration, of print, and of mechanism – tied together the instruments, texts, and images which collectively articulated that solution.

Session VIb: The British Board of Longitude: New Perspectives on Instruments, Innovation and Creativity in the Georgian Era
Day 3: Wednesday, 21. September
15.00-15.30, Entrance Hall Orangerie

Richard Dunn
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From Mayer's Circle to Maskelyne's Flaps

In 1755, Tobias Mayer, a professor at the University of Göttingen, made a submission to the Commissioners of Longitude concerning his proposals for determining longitude at sea by the lunar distance method. The submission consisted of a new set of lunar tables, a wooden model of an observing instrument (a repeating circle), and a description of the techniques to deploy them. A number of sea trials followed, from which what we now know as the marine sextant emerged, and as a result of which Mayer's widow received an award of £3,000 under the revised Longitude Act of 1765. By tracing what is left of the written, visual, and material evidence from the period, this paper will examine the translations and transmutations that transformed the work of a German astronomer and cartographer who had never seen the sea into a highly successful instrument for marine navigation. In doing so, it will look in particular at issues of instrumental error and accuracy that lay at the centre of the various trials of Mayer's proposals.

Session VIb: The British Board of Longitude: New Perspectives on Instruments, Innovation and Creativity in the Georgian Era
Day 3: Wednesday, 21. September
15.30-16.00, Entrance Hall Orangerie

Sophie Waring
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The Nautical Almanac: An Instrument of Controversy, 1818-1830

In 1818 the superintendency of the *Nautical Almanac* fell to Thomas Young, in addition to the role of Secretary of the Board of Longitude. In the period until his death in 1828, the *Nautical Almanac* was an instrument of huge contention and attempts at reforming the *Almanac*'s contents were connected to larger issues of reform in science in that period. The astronomical tables of the *Nautical Almanac* were essential to the sailor's ability to navigate; they transformed his sextant and chronometer into practical tools. The tables and instructions provided in the *Nautical Almanac* were used to interpret the readings provided by chronometers and sextants, allowing sailors to use the heavens to navigate successfully. Yet the *Almanac* was also an instrument for land-based astronomers; these two different demands on its contents resulted in the *Nautical Almanac* being one of the most controversial instruments of the period. The Admiralty and the newly formed Astronomical Society battled over its tables while larger debates, concerning the state sponsorship of scientific activity and technology, circulated in the periphery.

This talk will attempt to shed light on the *Nautical Almanac* as an instrument right at the focus of debate in this period on the nature of science in the metropolis. This talk will demonstrate how technological developments can be of social as well as scientific importance, effecting state policy in addition to scientific thought. By looking at the various contemporary texts on the *Nautical Almanac* we can hope to discover what it meant in its original setting, as both a scientific instrument and a government-sponsored publication.

Session VIIb: Specialized Research Instruments
Day 3: Wednesday, 21. September
17.00-17.30, Entrance Hall Orangerie

Jean-François Loude
(*École polytechnique fédérale de Lausanne*)

Heinrich Wild's Polaristrobometer: An Early Form of Chemical Polarimeter

The year 2011 having been proclaimed by UNESCO and IUPAP 'International Year of Chemistry,' it seems fitting to have a close look at a physical chemistry instrument, the polaristrobometer, an early form of polarimeter/saccharimeter, at its inventor, the Swiss physicist Heinrich Wild, at its enthusiastic reception by chemists, and at its principal manufacturer, Hermann & Pfister at Bern.

Heinrich Wild (1833-1902) was appointed professor of physics at the University of Bern and director of the (mainly meteorological) Observatory in 1858. Called in 1868 to the direction of the Central Physical (Meteorological) Observatory in Saint Petersburg, he spent the next 27 years in Russia, extending enormously the network of observing stations and working on the improvement and standardization of meteorological instruments. He retired to Zurich in 1895.

His polaristrobometer, first described in 1865, is built around the very sensitive polariscope invented by Savart a quarter of a century earlier. To achieve the measurement of the angle of rotation of the plane of polarisation of monochromatic light by optically active substances, the polariser is rotated until a network of parallel interference fringes disappears, as opposed to the more modern types of polarimeters where one looks for an equality of tint or of luminosity of two or more adjacent fields. This truly original, precise, and practical polarimeter remained the best one available until the end of the 19th century, when it was superseded by instruments less prone to systematic errors and more convenient to use.

That the polaristrobometer was much in demand by chemists and commercially successful is shown by the many citations and images in physics textbooks and, above all, by the long descriptions and detailed instructions appearing in books and articles written by chemists from 1875 onwards, notably by the pioneer of polarimetry H. Landolt. Today, many polaristrobometers can be found, often unidentified, in remote corners of science museums.

Hermann & Pfister (later Pfister & Streit) at Bern became the main, but not exclusive manufacturer of this instrument. A model of reduced size (tubes of 100 mm instead of 220 mm) was first made by J. G. Hofmann at Paris and by Dr. Meyerstein at Göttingen. Both models are also mentioned in the 1896 catalog of Schmidt & Haensch at Berlin.

Session VIIb: Specialized Research Instruments
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Roland Carchon, Sien Cromphout, Alexander Jonckheere, Danny Segers, Kristel Wautier
(*University of Ghent*)

Melloni's Bench: reconstruction and comparison with modern techniques

Macedonio Melloni (1798-1854) played an important role in the scientific thinking of the 19th century, by developing an accurate heat detector and providing a significant contribution through the measurements of heat radiation. His detector, a thermomultiplicator, was based on the thermopile of Leopoldo Nobili (1784-1835), who first used the Seebeck effect to determine heat. Melloni made some crucial improvements and started an extended research program on heat around 1840. In this 'pre-Maxwell' era, there was no evidence that the nature of heat is the same as that of light.

Around 1800 William Herschel (1738 –1822) noticed that, if he moved a thermometer through the spectrum, the deflection rose beyond the red colors. But when he couldn't concentrate the Earth's heat rays until he saw light, Herschel concluded that they must be different phenomena. Fortunately, not everyone was convinced of this pluralistic conclusion: the idea that light and heat could be connected remained appealing, mainly for philosophical reasons. Melloni wanted to clarify this situation and therefore designed his bench, which resembled an optical bench, but for heat instead of light. It is this bench of Melloni that we have investigated.

A well-preserved example was found in the collection of the museum for the history of sciences at Ghent University. When comparing this bench with the descriptions and drawings found in Melloni's most extended book, *La thermochrôse ou la coloration calorifique*, we could identify the four heat sources Melloni had used (candle, platinum wire, black heat screen, and the cube of Leslie with boiling water). Detection was made with a thermopile linked to a galvanometer. The thermopile itself consisted of a radiation-concentrating cone and multiple thermocouples coupled in series to improve sensitivity.

Based on Melloni's report, the measurements were repeated, as far as the historical device was intact and operational. We concentrated on his measurements related to the attenuation of heat radiation on a set of filter plates. Repeating the experiment gave us important additional information about its accuracy and helped us to interpret Melloni's results.

These heat-transmission measurements were also performed using modern means, including x-ray diffraction and electron microscopy for the characterization of absorber samples. To identify spectral sensitivities, we used the Carry 500, performing spectrometry in the wavelength domain between 200 and 3000 nm, and Fourier Transform Infrared Spectroscopy (FTIR) in the wavelength area between 2000 and 25000 nm. With all these data, we could compare the ‘modern’ results with the results achieved by the bench of Melloni and with Melloni’s historical results from 1850.

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18.00-18.30, Entrance Hall Orangerie

Paul Zoller
(*Prof. em. at University of Colorado, Boulder and GNOMIX INC.*)

Nineteenth-century One-of-a-Kind Scientific Instruments: Joule, Rowland, and the Mechanical Equivalent of Heat

The phenomena associated with heat and cold are so important in our daily lives that questions about the nature of heat have always fascinated amateurs and learned people. At the beginning of the 19th century the material (caloric) theory was widely accepted, supported by the prestige of Lavoisier. But qualitative experiments of Count Rumford and Humphry Davy had suggested another possibility: heat could be produced by mechanical work. Starting about 1840 James Prescott Joule, a brewer's son, not supported by an institution of learning, devised his paddle wheel experiments, showing with considerable perseverance that mechanical work could be converted into heat and that there was a constant ratio (independent of substance used) between the heat produced and the mechanical work expended (the so called 'mechanical equivalent of heat'). His results were initially widely ignored by the establishment, but eventually championed by Lord Kelvin.

The existence of a mechanical equivalent of heat changed the thinking about the nature of heat, and was one of the foundations of the general conservation of energy postulate. By 1849 Joule presented 'final' results with a new improved apparatus, and described this latest apparatus in detail. Yet, by 1878 the British Association formed a committee and supplied funds to Joule to look into this question once again. This new apparatus was based on a different principle (similar to Hirn's friction brake), but he old results were essentially confirmed. At about the same time the American Henry Augustus Rowland, first Professor of Physics at the new (1876) Johns Hopkins University in Baltimore, felt it was necessary to re-determine the equivalent, and he used considerable University funds to design and build an apparatus driven by a petroleum engine, yielding much larger temperature effects than Joule's dropping-weight paddle wheel. He paid much more attention than Joule to correct thermometry and applied a variety of painstaking corrections to his raw data. His value differed from Joule's more than Joule had claimed as error limits of his determinations, but Rowland was able to attribute most of the difference to improved thermometry.

The work of Joule and Rowland deserve special attention (together with the work of Regnault in France) as early examples of elaborate scientific investigations, using purpose-built apparatus, almost always scrapped after completion of the work. This is the way science has been done since the later 19th century, and what most of what we call 'scientific instruments' in our books and our conferences, and which some of us collect with a passion, are at best supporting parts of these investigations. I will discuss some of the apparatus and experiments of Joule and Rowland, hoping to reveal the cleverness and perseverance of these men, and the inglorious, even painful nature of experimental research.

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Mari Yamaguchi
(*Graduate School of Arts and Sciences, The University of Tokyo*)

Transforming a Tool: Mueller's Ball Model for the Field Ion Micrograph

The Field Ion Microscope (FIM) made it possible to observe individual atoms in 1955, four years after the instrument's invention. It was the achievement of Erwin W. Mueller (1911-1977), the microscope's inventor, who had pursued this goal of 'directly' seeing atoms. The FIM is a type of electron microscope in which a high negative voltage is applied to a metal tip encased in an evacuated glass tube. The tip is then positioned some distance from a glass screen coated with a fluorescent material. When a rarefied gas is introduced into the tube, the gas atoms, ionized by the tip, strike the screen and form a pattern of the tip surface. Each spot on the micrograph thus represents the image of an atom. Mueller then developed a model with cork balls for indexing the FIM image by comparing it to the expected structure of the tip surface derived from X-ray analysis. Then he painted the protruded sites of the model with a fluorescent dye and photographed it. After comparing the micrograph to the photograph, Mueller found out that the ball model was useful to interpret FIM images. Few researchers followed Mueller's constructional approach, since fabricating such three-dimensional models required too much time. After computer simulations became available, Mueller recognized the advantages of simulations for producing lattice models, enabling a more quantitative interpretation in a much shorter time. Nevertheless, the ball model appeared along with Mueller in magazine and newspaper articles. The model became regarded as a representation of the structure of matter at the atomic level, and eventually was transformed from a tool for the FIM images into an iconic object for the FIM.