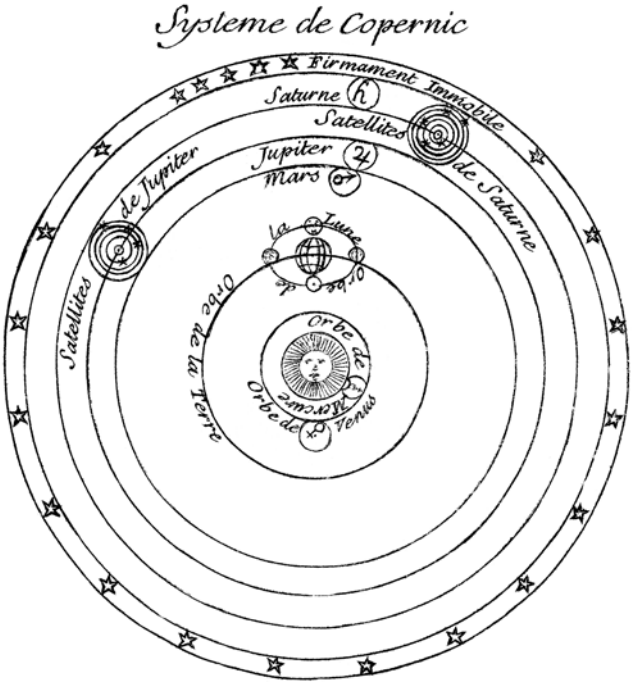
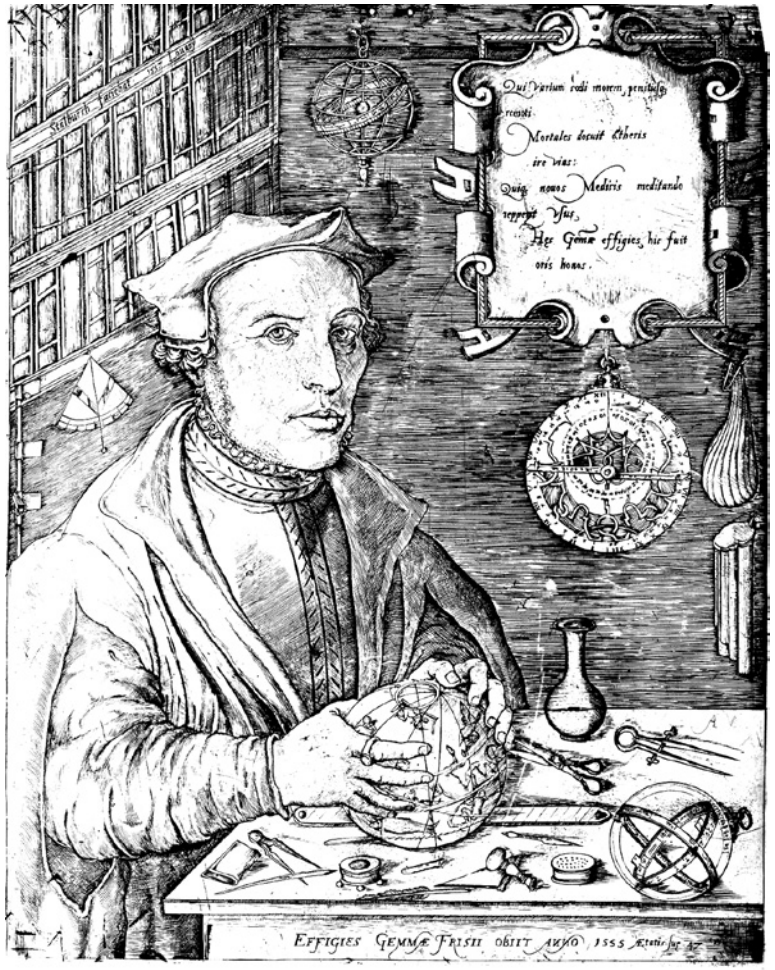
# Revolution(s)

A brief history of celestial measurement
told through some of the
astronomical instruments in the
Musée d'histoire des sciences of Geneva






*Gemma Frisius, engraving by Stalburgh, 1555, Royal Albert 1st Library, Brussels*

*Gemma Frisius (1508-1554,) a Flemish maker of scientific instruments, in his workshop. He is holding a celestial sphere. An astronomical circle lies on the table. Hanging on the wall are an armillary sphere and an astrolabe.*

*Cover : Nicolas Bion, l'usage des globes terrestres et célestes, Paris 1728*
*Library of the Musée d'histoire des sciences*

# Révolution(s)

This booklet briefly describes the origins and use of some of the instruments in the collections of the History of Science Museum. The instruments were exhibited in the Revolution(s) exhibition which was held at the Museum in 2006. They can now be seen in the permanent exhibition rooms on the ground floor of the Museum (Globes and Planetaria room ; Sundial room and the Grand Salon).

The instruments we are concerned with are noteworthy for their beauty and the quality of the craftsmanship. They were all designed to measure the heavens and to reproduce the real or apparent rotation of the earth, planets and sun.

Until the Renaissance, the universe was shown in a circular rotation around an immobile earth much as our senses perceive it today… and making a good deal of basic common sense. This view was not an obstacle to learning how to locate oneself on the earth, establish a calendar or tell the time : with the appropriate instruments one could watch the sun and the stars during their apparent movement.

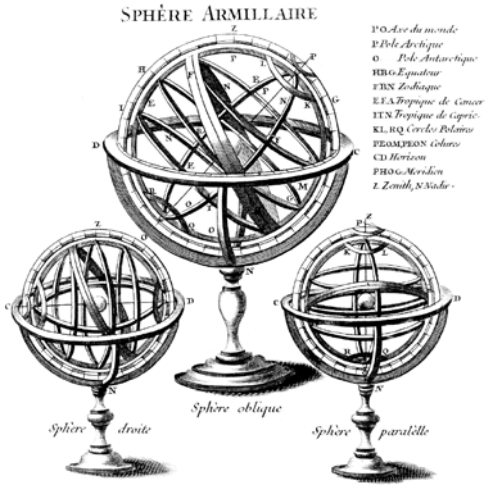
The Copernican revolution divested humans of their privileged place at the centre of the world. On the other hand, Newtonian determinism gave us new mathematical laws, and thereby the power to predict at any moment the relative position of any celestial body and to become, in a new way, the rulers of the world.

# Armillary sphere

➤ The instruments shown : Ptolemaic armillary sphere ; armillary spheres of Copernicus (Globes and Planetaria room)

The armillary sphere is one of the oldest instruments to represent the universe. It was probably invented by Archimedes in 250 BC. The Greek astronomer Ptolemy* wrote about it in his work Almagest in about 150 AD. The armillary sphere made it possible to show both the sky and the earth from wherever the observer was located. In order to keep a clear picture, the instrument is constructed of rings (armilla meaning bracelet in Latin) representing the principal circles of the heavens (ecliptic*, meridian*, tropics*, equator*, polar circles*, etc.) as well as their stars (sun, moon, planets). There are two types of armillary sphere : Ptolemaic spheres representing a geocentric universe and Copernican spheres which place the sun at the centre of the universe.

In Europe, armillary spheres became very popular at the dawn of the Renaissance in the 16th century. Not only were they able to determine the position of the stars at different times of the year, they were also useful for astronomical demonstrations. Towards the end of the 17th century, the use of armillary spheres as scientific instruments ended and they became luxury decorative objects in copper or engraved gold gracing the salons of princes and emperors.




*Armillary spheres, after Delamarche, les usages de la Sphère et des Globes, Paris 1791*

* see glossary, p. 9



# Astrolabe

➤ The instrument shown : Hispano-Moorish astrolabe (Sundial room)

This luxurious, beautiful and complex instrument symbolised the power of knowledge. It was invented by the ancient Greeks before being taken up by the Arabs and then by the west at the end of the Middle Ages. Its applications are numerous : measurement of the altitude of stars, determination of the position of the stars according to the day of the year, prediction of sunrise and sunset, surveying, etc.

With regard to astronomy, the astrolabe gives a "flat" representation of the celestial sphere according to the stereographic projection developed by Ptolemy*. The map of the heavens is symbolised by the framework, an intricately engraved and cut mobile trellis on which each point indicates a star. The framework turns above a plate, or tympan, on which the main celestial coordinates* are marked (altitude, azimuth) in relation to an observer at a specific latitude on earth. The rotation of the framework over the tympan reproduces the movement of the sky around the earth (assumed to be stationary) every 24 hours.


*Ptolemy and the astrolabe, after Peurbach, Theoricarium Novarum Textus, Paris, 1515*

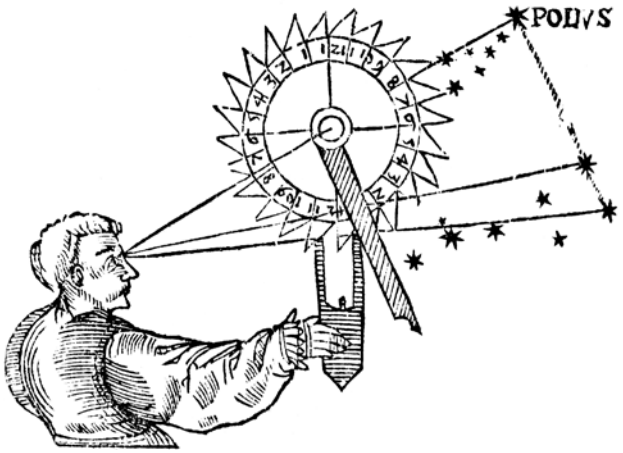
* see glossary, p. 9

# Nocturnal

➤ The instruments shown : nocturnals (Sundial room)

This instrument indicates the time at night by observing the position of certain stars (usually the pointer stars Dubhe and Merak of the Great Bear constellation, and the two bright stars at the extremities of the Little Bear) around the North Star or Polaris. Because of the earth's movement, the stars give the impression of rotating once every 24 hours around a fixed point : the North Star.

Invented by Gemma Frisius around 1530, the nocturnal was part of essential navigational equipment until the 17th century before being abandoned in favour of mechanical marine chronometers which were much more precise. The nocturnal is composed of two discs one on top of the other and a mobile arm. The largest disc is marked with months while the smaller one has an hour scale. A small hole at the centre of the two discs is oriented to the North Star ; the mobile arm is then moved until it is aligned with the chosen stars. The lower part of the arm shows the hour on the time scale.




*Use of a nocturnal, after Apianus, Cosmographia, Antwerp, 1564*

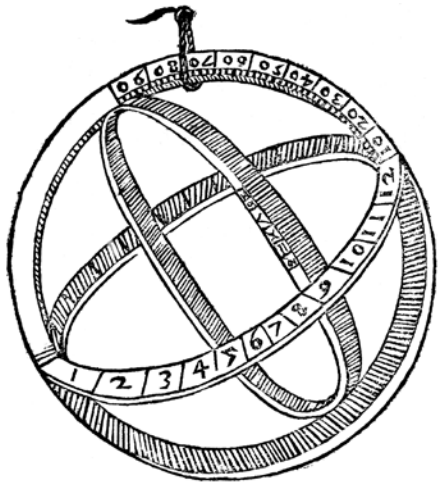


# Astronomical ring

➤ The instruments shown : astronomical rings (Sundial room)

The design, shape and construction of this type of sundial are clearly reminiscent of an armillary sphere. In addition to its main function of indicating the time, an astronomical ring is also able to identify the position of certain stars at night.

Astronomical rings were invented in the 16th century and continued to be made until the 18th century. They are usually composed of two or three metal rings. The exterior ring, which is equipped with a suspension loop, serves as the meridian of the observation location. Perpendicular to the meridian ring, the equatorial ring is marked off in hours. Finally, the third and innermost circle, when it exists, pivots and is equipped with a viewer : it represents the solar meridian. In order to determine the time, the mobile meridian must be orientated so that the sun's rays pass through the viewer and strike the graduated hour scale marked on the equatorial ring.



*Astronomical ring, after Gallucci, Della Fabrica et uso …, Venice, 1598*

# Terrestrial globe

➤ The instruments shown : terrestrial globe (Grand Salon) ; terrestrial globes and pocket terrestrial globes (Globes and Planetaria room)

From the 4th century BC, it was thought that the earth must be the most perfect shape in the universe : a sphere. The first terrestrial globe was probably made at that time. In Geographia, Ptolemy* gives guidance on their construction.

In the West, it was not until the discovery of America by Christopher Columbus in 1492 that cartography, and thus the building of globes, developed. Like celestial spheres, the first globes were made of metal and engraved wood. With the advent of printing, these were replaced by wooden globes covered in bands of paper. Terrestrial globes showed the earth viewed from outside while celestial spheres show the sky viewed from within.


*Terrestrial globe, after Martin,*
*The description and use …, London, 1736*

* see glossary, p. 9



# Celestial globe

➤ The instruments shown : celestial globe (Grand salon) ; celestial globe and pocket celestial globe (Globes and Planetaria room)

Celestial globes portray the topography of the sky. The constellations and stars are shown as they appear to an observer on earth in the centre of the sphere.

The first celestial globes date from antiquity. In 150 AD Ptolemy*, following the work of Hipparcos, drew up a catalogue of over 1000 stars and grouped them into 48 constellations. The Greek astronomer explained the rules which should be followed in making globes : stars must be shown in yellow and red on a dark background and stars in the same constellation must be linked to each other with a line and should not be part of the figurative representations used for calculations. Celestial globes were initially made of wood or engraved metal. Following the development of printing, printed paper was glued onto wooden globes. Printed celestial spheres became very popular in the 16th and 17th centuries when they were often made in a matching pair with a terrestrial globe.


The celestial globe, after Martin,
*The description and use...*, Londres, 1736

* see glossary, p. 9

# Planetarium, tellurian

➤ The instruments shown: planetarium (Grand Salon); telluria (Globes and Planetaria room)

The planetarium represents the movement of the planets in the solar system. The tellurian simply shows the orbits of the earth and the moon around the sun.

Copernicus and Kepler each tried to make a planetarium portraying his own concept of the solar system. In 1682, the astronomer and physicist Huygens constructed a mechanical planetarium at the scale of the solar system and the six planets known at the time (Mercury, Venus, Earth, Mars, Jupiter and Saturn).

Planetaria were very popular in the 18th century and became indispensable decorative objects in physics laboratories and cabinets of curiosities. They operated through a complex system of gears and pinions and beautifully illustrate Newton's mechanical view of the world described in Principia Mathematica at the end of the 17th century.

*The planetarium, after Adams, Astronomical and geographical essays, London, 1789*



## Glossary

- Polar circles: Imaginary circles parallel to the equator at an angular distance of 23o27' to the poles which corresponds to the inclination of the ecliptic. The polar circles mark the limits of regions in which on at least one day of winter the sun does not rise and on at least one day in the summer the sun does not set.
- Celestial coordinates: The position of a star in the sky can be identified by an observer on earth by its altitude above the horizon and its azimuth (the horizontal angle between the direction of the object and the geographical north).
- Ecliptic: The circle followed by the sun in the sky in its apparent path around the earth. The ecliptic makes an angle of 23 o27' relative to the equator which corresponds to the angle of inclination of the earth on its orbital plane around the sun.
- Equator: An imaginary line around the earth on which all points are equidistant from the two poles. The equator separates the northern from the southern hemisphere.
- Hipparcos (around 190 BC to 120 BC): A Greek astronomer and mathematician, Hipparcos drew up one of the first star catalogues. It is possible that he also invented the first astrolabe.
- Meridian: An imaginary line joining the two poles.
- Ptolemy (AD 90 – around AD 168): A Greek astronomer, astrologer and geographer who lived in Alexandria. He is the author, amongst other works, of an astronomical treatise Almagest and another on geography, Geographia which strongly influenced Arabic and western science.
- Stereographic projection of the sky: A method of projecting the celestial sphere on a plane (the equator) for an observer located at the south pole.
- Tropics: The two imaginary circles parallel to the equator and above or below it where the sun achieves an elevation of 900 alternately during the solstices.

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