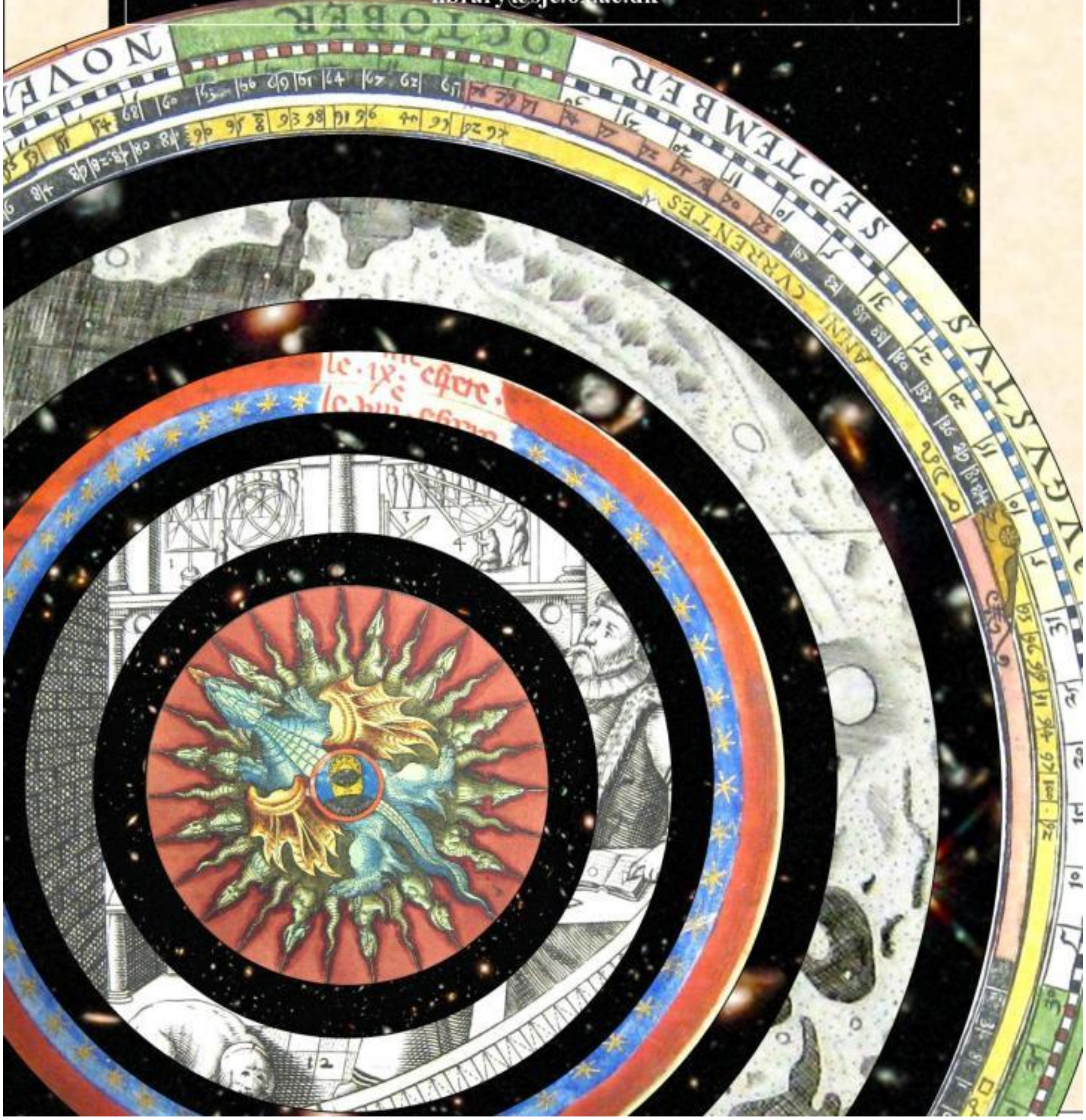
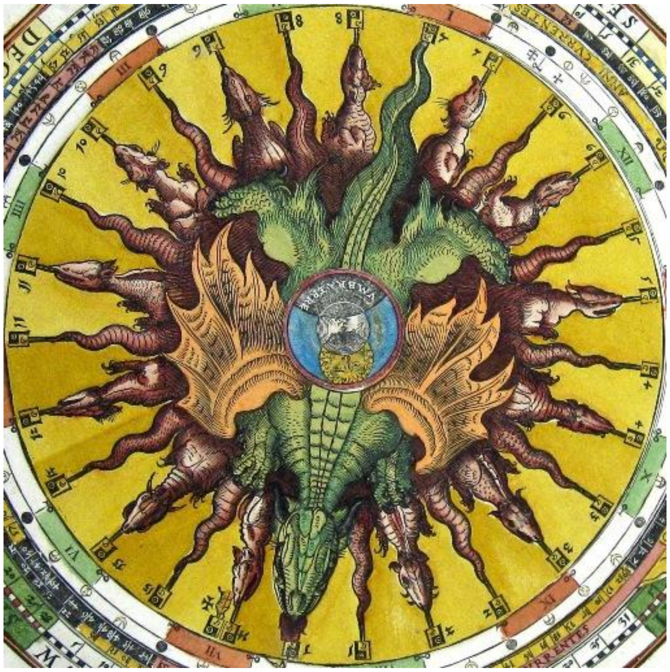
Revolutions

An exhibition of early astronomy in St John's College Library, October 26th-March 31st

Open to College members during Library opening hours. Others contact: library@sjc.ox.ac.uk

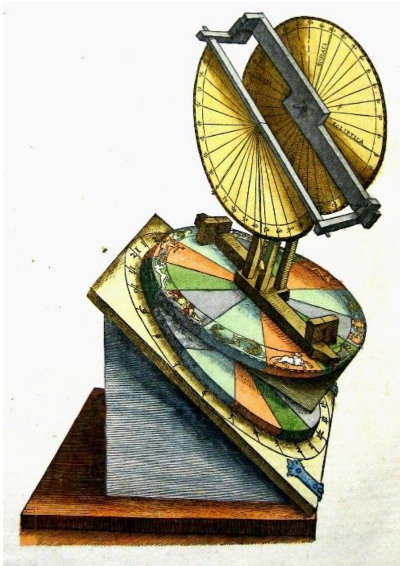


Emperor of the Heavens



Volvelles for the calculation of the motion of the Moon from Peter Apian's *Astronomicum Caesareum* (Ingolstadt, 1540)

If you look closely at the hand-coloured diagrams displayed in this massive and complex book, it becomes apparent that they consist of several rotating parts, fixed by a thread tie. Each one is a huge *volvelle*, a type of analogue computer in paper, used to calculate the time and duration of astronomical and astrological phenomena. Those displayed here relate to the motions of the moon, and form part of one of the most extensive sets of such constructions, including 21 full pages with moving parts. Apparently the threads used to attach the volvelles were originally decorated with seed pearls, but these have long gone. The expense and effort of printing and assembling such a work meant that this was a prestige volume, indeed Tycho Brahe had to pay 20 florins (around £2,000) for a copy in the 16th century. It was produced as a tribute to his patron by Peter Apian, a favourite of, and court printer to the Holy Roman Emperor, Charles V. As the most powerful man in Europe, Charles must have been used to flattery, and throughout this book Apian instructs the reader in the use of his calculators using the birthdays of both Charles V, and of his brother and co-emperor Ferdinand I, as examples. For his troubles Apian was ennobled, made court astronomer, promised 3,000 guilders, and also granted a few more esoteric privileges, such as the right legitimize children born out of wedlock.

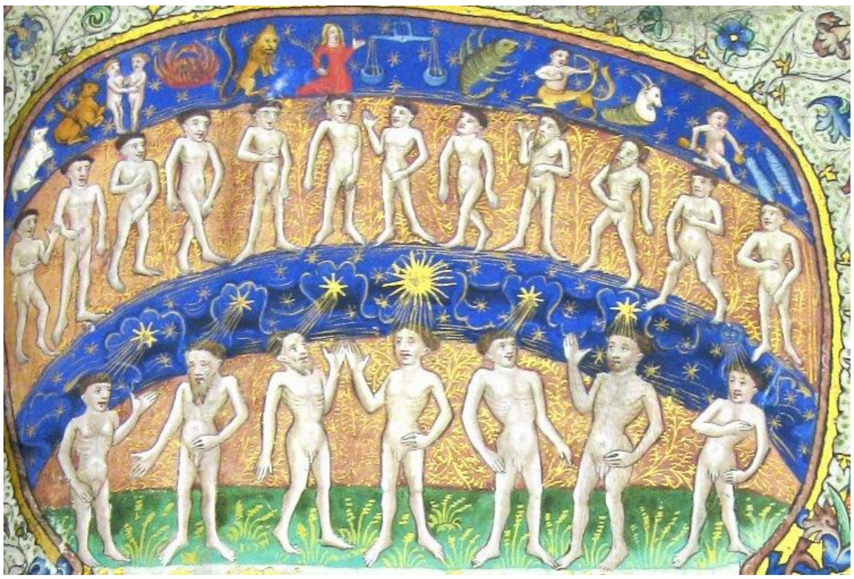


Published just two years before Copernicus' *De Revolutionibus,* the *Astronomicum Caesareum* was one of the last major astronomical works to be produced before the rise of the heliocentric model of the Solar System. Even so it incorporated some pioneering observations particularly regarding comets, such as the fact that their tails always pointed away from the sun. Apian observed 5 comets during the 1530s. One of these observations was used 174 years later by Edmund Halley to predict the periodicity of that comet which was to be named after him, and the date of its return in 1759. (*Cpbd.c.lower shelf.1. Given by William Laud, 1635)*

Under the Spell of the Stars

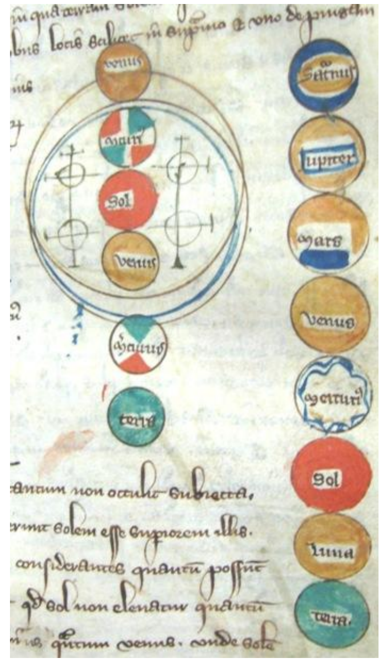
People under the influence of the zodiac and the planets from the opening of Roland of Lisbon's *Reductorium physiognomie*, manuscript produced in England, 15th c.

Two rows of men stand beneath the heavens at the beginning of this 15th century work on medicine. Each man in the top row is associated with one of the twelve signs of the zodiac ranged above him. Each in the second row is struck by the rays of force emanating from one of the seven planets. At the time these were considered to include the Sun (the central star here) and the moon (to the right hand side). This manuscript is a copy of a work commissioned by John, Duke of Bedford, one of the most lavish patrons of English manuscript production in the 1400s, from his personal physician and astrologer, Roland of Lisbon, who was also a master of medicine in Paris.



Historically, astrology permeated many areas of intellectual endeavour, not least the medical sciences, as shown by the frequent appearance of the zodiac man in medieval manuscripts. This was a figure (right, from St John's MS 178) of the human form marked out with the signs of the zodiac, assigned to the parts of the body they were supposed to influence. Thus Arians might be prone to headaches, Pisceans to podiatric problems. The belief in such intimate links between the macrocosm and the microcosm was granted to the medieval world by classical antiquity, and although at points disparaged by the church as associated with paganism and demonology, persisted in the mainstream of intellectual life well into the modern period. Indeed, some later scholars such as Elizabeth I's astrologer, John Dee, attempted to place it on a mathematical and scientific footing. Although astrologers were widely suspected even in the Middle Ages, and later discredited, the model they espoused was an elaboration on the basic observation that heavenly bodies such as the sun and moon exert influence on the earth through forces affecting the seasons and the tides. Professional astrology also required a grasp of complex mathematics and minute stellar observation to allow its practitioners to make their calculations of the motions of the different celestial bodies, meaning that it is a central pillar upon which later astronomy was to build. (*MS 18, Given by William Paddy, 1634)*

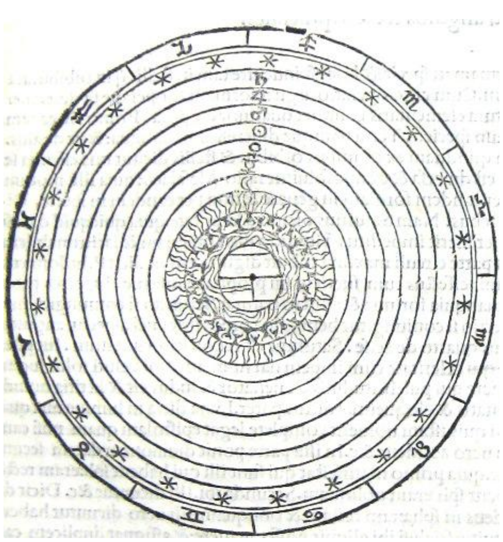
Ancient Learning Recovered



Planets from a copy of William of Conches' *Dragmaticon philosophiae* from a scientific miscellany of the 13th/14th centuries, produced in England

Manuscript 178 is actually six manuscripts bound together in a volume that has accreted over time. All are English and date from the 13th and 14th centuries. The most striking of these is one of the College's two bestiaries, or books of beasts, but the volume also contains numerous other scientific, astronomical and medical works, often with diagrams. These include the zodiac man illustrated in the case to the left, as well as a 14th century copy of Joannes de Sacro Bosco's 13th century treatise *De Sphaera Mundi* (see elsewhere in this case) and this 14th century version of the 12th century *Dragmaticon philosophiae* by the French scholar, William of Conches. Numerous astronomical diagrams have been added to the text including this one of the planets arranged with Saturn at the top, followed by Jupiter, Mars, Venus, Mercury, the sun, the moon, and the Earth. The work was structured as a dialogue between the author and his patron, Geoffrey Plantagenent who had entrusted William with the education of his son Henry (later Henry II of England).The style is lively, as it was intended for popular lay consumption, and ranges over topics as diverse as geography, meteorology and medicine as well astronomy. William was at the forefront of a renaissance of European thought, partially inspired by the translation of Arabic scholarship into Latin that was taking place in the newly re-Christianized areas of Spain. Amongst this newly available learning was a whole slew of classics lost to Europeans for centuries. Amongst these were works of astronomy, although William, in spite of his engagement with much that was coming out of Spain, was writing prior to the translation of Ptolemy. *(MS 178, Originally owned by St Peter's, Westminster)*

A Ptolemaic Textbook



Geocentric model of the Solar System from an early printed edition of Joannes de Sacro Bosco's *De Sphaera Mundi* (Venice, 1499)

Ptolemy's crystal spheres are depicted revolving around the earth in this diagram from a popular cosmological textbook of the Middle Ages. Prior to the 12th century Ptolemy had been a shadowy figure only dimly remembered. In around 1175 the Spanish scholar Gerard of Cremona translated Ptolemy's work on astronomy, known from its Arabic recension as the *Almagest,* into Latin. *De Sphaera Mundi* was written at the University of Paris about 60 years later by a lecturer there, Joannes de Sacro Bosco, or John of Holywood, who was probably English (or possibly Scots or Irish). It became the most popular introductory textbook to the fiendishly complex Almagest. Once in circulation Sacro Bosco's work retained that popularity for centuries until the rise of heliocentrism, as shown by this early printed edition produced about 260 years after its first appearance. Although its geocentric model of the Solar System may seem antiquated, the text gives the lie to the notion, popularized in the 19th century, that medieval scholars believed the world to be flat, as it quite clearly states, even in its title, that the world is considered to be spherical. *(BT / F30 /SAC, Bequeathed by Ivor Bulwer-Thomas, 1993)*

The Wisdom of Kings

Charles V of France in his study with an astronomical instrument, from the opening of Nicolas Oresme's *Traite sur l'espere* produced 1365

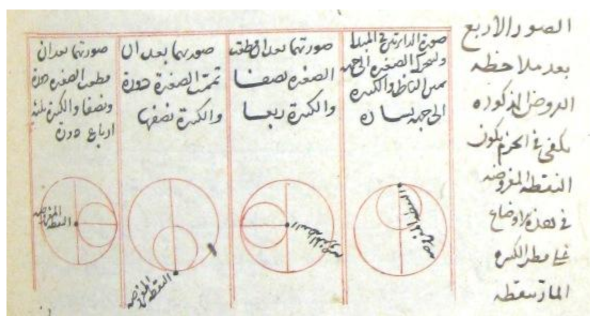
During the 100 Years War, the French dauphin, later King Charles V, managed to regain the initiative against the English for a generation. As part of his propaganda campaign to re-establish the authority and prestige of the French throne after a disastrous beginning, when his father John II was caught and taken hostage to England, leaving him in charge, Charles was desperate to maintain his reputation for learning, cultivation and wisdom. This volume of astronomical treatises, which is noted in a 15th century catalogue of the French Royal Library, formed part of that campaign, presenting him at its opening perusing a book and using an astronomical device. Its author, Nicolas Oresme, was one of a battery of intellectuals cultivated by Charles, and originally employed as a translator of Aristotle. He also wrote treatises of his own, on economics, mathematics, mechanics and other subjects. With regard to astronomy Oresme discussed the arguments for and against the rotation of the earth, and dismissed arguments against the notion that the earth could be moving, notably that there would be a colossal wind blowing over the surface of the earth against its direction of motion, and that the Bible says that the sun moves. This latter he took to be an everyday expression and not to be taken literally. As regards astrology, Oresme believed that its predictive power was negligible, from his work on incommensurate fractions, which when applied to the length of a day or a year, or the courses of planets, implied that the heavens were irregular and therefore it wasn't possible to use them to predict events. In spite of this, a separate pamphlet has been appended to the end of this volume which gives the astronomical charts of Charles V, and his children Maria, Isabella, Louis, and the dauphin and future King Charles VI. It seems unlikely that the chart for the dauphin mentioned that this last would become known as Charles the Mad, and his incapacity would plunge France back into the chaos from which his father had rescued it. *(MS 164, Given by William Paddy, 1633)*

Influence on Copernicus?

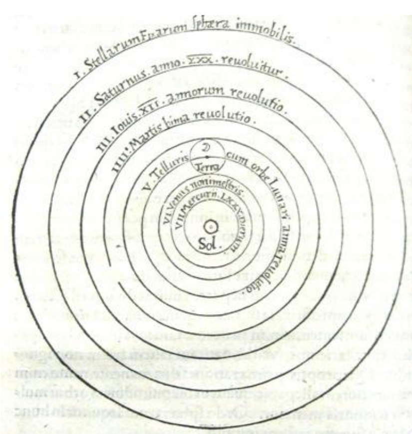
Diagrams of the Tusi Couple from al-Nisaburi's *Commentary on Tusi's memoir,* a manuscript completed 4 Ramadan 752 (25 October 1351) possibly in Istanbul

The four diagrams on the right hand leaf of this volume showing a smaller circle rotating within a larger circle have become known by the name of their original formulator Nasir al-Din al-Tusi (1201-1274) as the 'Tusi couple'. The foremost astronomer of the medieval period Tusi was born in Khorasan (now in Iran) to a Shi'a family and devoted his early life to study, before being swept up in the Mongol invasions of the region and joining the ranks of the Mongol commander and founder of the Persian Ilkhanate, Hulegu. The first Ilkhan was a ruthless nomadic warrior who sacked Baghdad, destroyed the Assassins, and whose funeral featured human sacrifice, but Tusi managed to persuade him to build a state of the art observatory at Maragheh, which allowed him and a generation of scholars to stand at the forefront of astronomy.

Tusi originated this model, which generates linear motion from the sum of two circular motions, to explain the anomalous movement of the planets in their deviation from a circular course, in opposition to Ptolemy's model which used a highly unsatisfactory device called an equant. Copernicus used a device identical to the Tusi-couplet in his pioneering *De Revolutionibus* prompting speculation that he had access to Islamic astronomy in some form, although an exact chain of transmission has yet to be established. Tusi also believed that the cloudy appearance of the Milky Way was a result of blurred light of many distant stars beyond the resolution of the naked eye, a belief confirmed by Galileo's observations with the telescope. This 14th century manuscript is the earliest known copy of al-Nisaburi's commentary on Tusi's work, and passed through the hands of numerous owners including an Ottoman sultan, the English courtier and diplomat Kenelm Digby, and finally the Archbishop of Canterbury, William Laud. *(MS 103, Given by William Laud.)*



Revolution in the Heavens



Heliocentric model of the Solar System from the 2nd edition of Nicolaus Copernicus' *De revolutionibus orbium caelestium,* (Basel, 1566)

In spite of its reputation as one of the most revolutionary works in history Copernicus' *De Revolutionibus* remained a relatively obscure work for several decades after its first publication in 1543. Copernicus was a rather reticent canon from a small town in northern Poland (Frombork), who'd been mulling over his idea that the sun was central to the Solar System for thirty years. He was persuaded to let the work go to print only because of the enthusiasm of a young professor of astronomy from Wittenberg, Johannes Rheticus, and died shortly afterwards. The rather modest print run of 400 copies failed to sell out, and it was over twenty years before this second edition appeared. This was virtually identical to the first, except for one or two minor additions, one of which was Rheticus' *First report*, a non-technical prospectus to the work. Even the ideas in it failed to set the world on fire for 60 years, in spite of occasional sniping by the odd Protestant and Catholic theologian or astronomer. It was only with the trials of such notable heliocentrics as the heretic Giordano Bruno, and, subsequently, Galileo, during the 1590s and early 1600s, that the idea attracted a barrage of attention, both negative and positive. By this time Copernicus' brand of the doctrine seemed quite old-fashioned. Although he'd made the revolutionary move of putting the sun centrally he retained the notion that the orbits of the planets were perfectly spherical and that each was mounted in a concentric system of crystal spheres. Indeed Copernicus' was a theoretical model that was only later adapted and made to work by the observational work of Brahe and Kepler decades later. *(6.d.5.3, Given by William Paddy, 1602)*

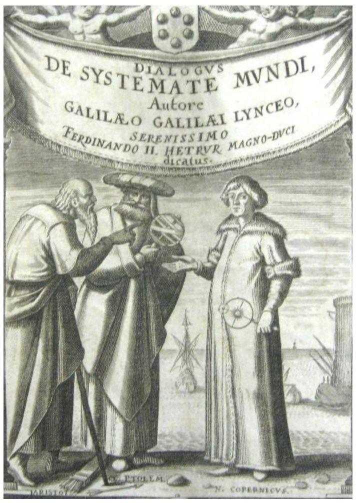
The Man with the Silver Nose

The Great Mural Quadrant at the Uraniborg Observatory from an edition of Tycho Brahe's *Astronomiae instrauratae mechanica*. 2nd edition. (Nuremberg, 1602)

The wealth and influence of a successful astronomer in the 16th century can be gauged from the life of Tycho Brahe (1546-1601). Brahe was born to a Danish noble family, and adopted/kidnapped at the age of two by his uncle who ensured that he became a scholar. He abandoned his studies at law for astronomy, his wealthy background ensuring that he could afford the time and equipment to pursue the rigorously systematic observational regime he set himself. His observations were made without the use of the telescope, but he still managed to compile an astronomical dataset of unprecedented size and accuracy in his *Star Catalog D*. In 1574 Tycho went on a tour of central Europe, intending to set up shop in Basel. Fearing the loss of such a prestigious scientist, King Frederick II of Denmark gave Tycho the island of Hven on which to set up an observatory. Tycho duly built Uraniborg on the island, which became a kind of astronomical research centre. Unfortunately Frederick's successor, Christian IV, was less accommodating, and in 1597, after several confrontations, Tycho left Denmark for Rudolph II's court in Prague. The following year Tycho published this work, almost as a monument to his defunct observatories, and certainly as a portfolio to present to his new employer, detailing their construction and the instruments they contained. The illustration displayed shows his huge mural quadrant, a great brass arc attached to the wall with sliding sights – the surface behind it decorated with frescoes.

At one point in his life Tycho was supposed to have owned 1% of the land in Denmark. Such vast resources only seem to render his misfortunes more bizarre. He lost the bridge of his nose in a duel and resorted to a silver prosthesis. His pet moose drank too much beer, fell down the stairs and died during a visit to impress another nobleman. His disciple, Kepler, reported that he died because he considered it a breach of etiquette to ask to be excused to relieve himself at a banquet, leading to acute bladder problems. This is now disputed as recent investigations imply that Brahe died of mercury poisoning, whether intentionally or unintentionally. If the former then suspected culprits include Kepler himself, who was desperate to get at Brahe's data, or the abandoned Christian IV of Denmark. *(Δ.3.25, Given by William Harrison, 1615)*

Beyond Papal Jurisdiction



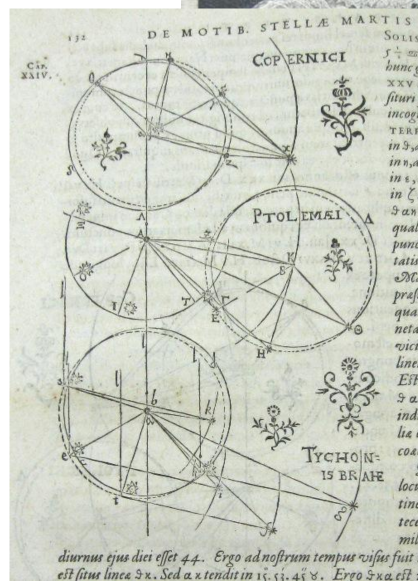
Ptolemy, Aristotle and Copernicus dispute with each other from the title page of the 1st Latin edition of Galileo Galilei's *Dialogue concerning Two World Systems* (Strasbourg, 1635)

When first published in the original Italian in 1632, this work landed Galileo in a lot of trouble with the Catholic Church. It is structured as a dialogue between a supporter of the Copernican model of the Solar system named Salviati, and a supporter of the Ptolemaic model named Simplicio, with interjections from a supposedly impartial observer, Sagredo. Increasingly Sagredo lends his support to the heliocentric Salviati against Simplicio, ostensibly named after the ancient Greek commentator Simplicius, but with the implication of simple-mindedness. Galileo had in fact been given permission to write the book by Pope Urban VIII himself in 1624, on the condition he compare and contrast it with the Ptolemaic system neutrally. Galileo, however, overplayed his hand when he finally got down to publishing the book. The papal censor was relatively happy with its content, and gave permission for publication on condition that a preface and conclusion were added spelling out the hypothetical nature of its conclusions. This Galileo did, but in such a way that it was obvious that these were not the author's own views, by allotting them to Simplicio. He had also included some digs at his Jesuit rivals, particularly Christoph Scheiner, and while the Pope had enjoyed similar jokes in Galileo's previous work, it didn't seem so funny to Urban when they pointed out to him that his words had been put in the mouth of a character whose name implied he was a simpleton. The Inquisition was duly invoked, and the subsequent investigation sentenced Galileo to house arrest. Even so he managed to get this Latin translation published by outsourcing the work clandestinely to the German philologist Matthias Bernegger, a protestant refugee from Austria, who was holed up in the Free City of Strassburg, beyond the reach of the Catholic Church. To hide Galileo's involvement in the preparation of the translation a story was fabricated that a scholar had smuggled the book back to Strassburg without Galileo's permission. *(3.c.3.4, Given by Gratian Owen, 1654)*

Dismantling the Spheres

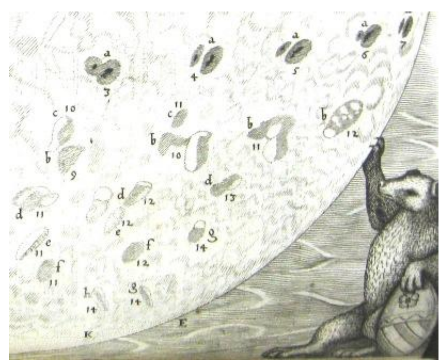
Comparing models of the Solar System from the 1st edition of Johannes Kepler's *Astronomia nova*, (Prague, 1609)

The three models of the Solar System widely discussed at the beginning of the 17th century are here compared with one another in one of the most important texts of modern astronomy. Kepler examined the models of planetary motion espoused by Ptolemy (geocentric), Copernicus (heliocentric) and Tycho Brahe who had developed a synthesis of the two, where the planets orbited the sun, which in turn orbited the earth. Although much of his work was based on the data amassed by Tycho, whose position as court astronomer to Rudolph II he had taken over on Brahe's death, and although he accepted some of Brahe's hypotheses, particularly the rejection of the notion that the planets and stars rotated on crystal spheres, Kepler found all three systems wanting. All three predicted broadly similar observations, and were therefore indistinguishable, and the observations they did predict did not match the data that Kepler had access to. Kepler asserted that all the planets orbited around the sun, and that they did so in an elliptical set of orbits, a structure so simple that he'd initially ignored it because he assumed someone would have already discounted it as a model. These two propositions taken together formed his first law of planetary motion. He also outlined his second law in the text, and conjectured the existence of an attractive force between heavenly bodies that kept them in motion. *(Δ.2.7, Given by John Edwards, 1620)*

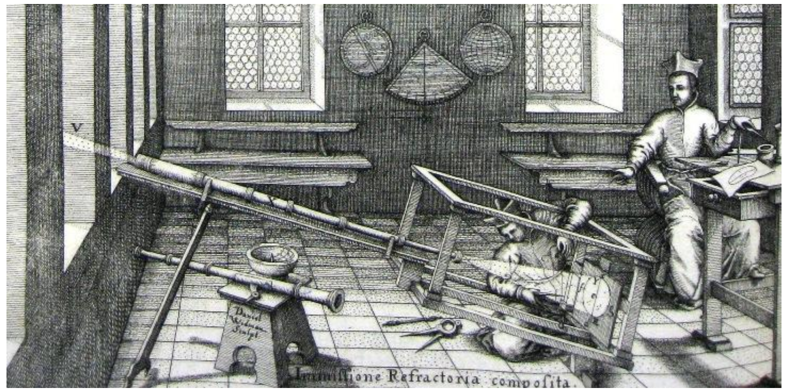


The Sun, ...

Sunspots from Christoph Scheiner's *Rosa ursina, siv, Sol,* (Bracciano, 1626-30)



In spite of its rather cuddly appearance, bedecked as it is with bears from its title to its ornamentation, this book was part of a spiky astronomical feud. The bears, whether they be undertaking astronomical observations, supporting the disc of the sun, or simply sleeping, were a play on the name of work's patron, Paolo Giordano Orsini, Duke of Bracciano. The duke was a keen amateur astronomer, who had the work printed on the private press he had installed in his castle. The author was the Jesuit astronomer, Christoph Scheiner, whose first publications about sunspots had led him into dialogue, and later conflict, with Galileo. Scheiner and Galileo had disputed the nature of sunspots, Scheiner initially maintaining that they were the shadows of solar satellites rather than blemishes on the face of the sun. Although by the time of the publication of Rosa Ursina, Scheiner had accepted Galileo's point of view, Galileo had made remarks about certain people trying to claim precedence for his discoveries, which Scheiner took to mean himself. The enmity between the two men was exacerbated by disputes over Galileo's advocacy for a heliocentric Solar System, and there were rumours that the inquisitorial proceedings against him were partially instituted by Scheiner's dislike, although there is no evidence for this. Regardless of this, *Rosa Ursina* remained the major work on sunspots for over 100 years, partly due to the intervention of the Maunder Minimum, a period of very low sunspot activity from the mid-17th to early 18th centuries. *(Δ.2.8, Given by William Paddy, 1659)*



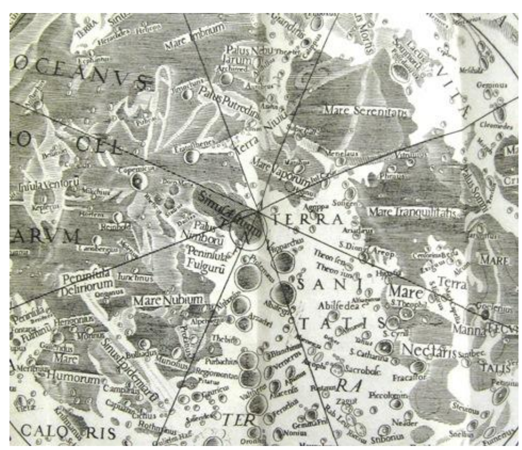
... the Moon ...

Discussion of the possibility of travelling to the Moon from John Wilkins' *A discourse concerning a new world & another planet* (London, 1640)

A future Bishop of Chester might seem an unlikely proponent of the discoveries of Copernicus, Galileo and Kepler, but this work in two parts, was an immensely successful work of scientific popularization. The first part, *The first discovery of a new world, or, A discourse tending to prove that 'tis probable there may be another habitable world in the moon*, had appeared in 1638, and by the time it was reprinted here less than two years later with a new companion piece, *A discourse concerning a new planet, tending to prove, that 'tis probable that our earth is one of the planets*, it had already reached its third impression. As well as effectively explaining new astronomical discoveries, Wilkins also indulged in his own speculations as to what the inhabitants of the moon might be like:

Campanella's second conjecture may be more probable, that the inhabitants of that world, are not men as we are, but some other kinde of creatures which beare some proportion, and likenesse to our natures. Or it may be, they are of a quite different nature from anything here below, such as no imagination can describe; our understandings being capable only of such things as have entered our senses, or else such mixed natures as may bee composed from them.

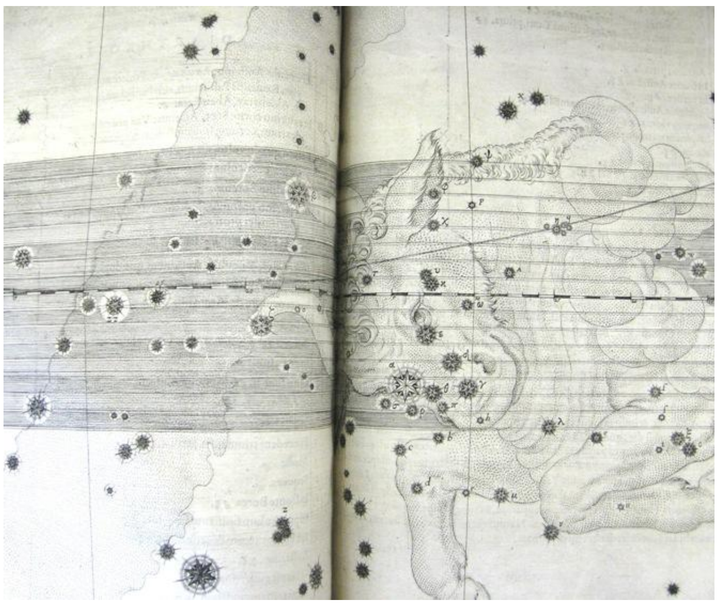
He also speculated, as here, as to how it might be possible to have commerce with them. In spite of obstacles such as gravity, the thinness of the ethereal air, and the dearth of inns on the way, he remained convinced that future generations would succeed in reaching them. *(3.c.2.27, Previously owned by William Brewster)*



Selenograph from Giovanni Battista Riccioli's *Almagestum Novum,* (Bologna, 1651)

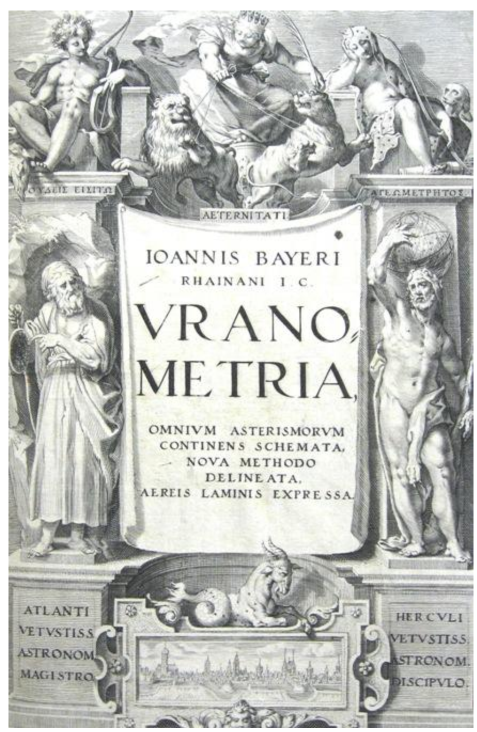
Taking its name from the Arabic translation of Ptolemy's astronomical work, meaning 'The Greatest', this work by a 17th century Jesuit scholar became the standard encyclopaedia for astronomers across Europe, used by Flamsteed, and even Lalande 100 years later. Riccioli worked with another Jesuit, Francesco Maria Grimaldi, to produce these 'selenographs', which are based on work by earlier astronomers as well as their own observation. To label the different features of the moon Riccioli developed a Latin terminology, which in translation is still in use today. Consequently this map marks the first appearance of the *Mare Tranquilitatis* or Sea of Tranquility, amongst other features. In spite of their ardent geocentrism Riccioli and Grimaldi christened several craters after Copernicus, Kepler and Galileo. There has been speculation that they did this to indicate a support for heliocentrism that as Jesuits they couldn't express publicly, but this seems doubtful. Riccioli was also sceptical regarding speculations about lunar inhabitants of the kind exhibited by Wilkins, including an assertion of the moon's sterility in the caption to this map. In this he was at odds with the 15th century scholar Nicholas of Cusa, as well as Giordano Bruno and Kepler. *(Δ.2.2, Given by Robert & Nicholas Bayton, 1664)*

... and the Stars



Taurus from Johannes Bayer's *Uranometria,* (Augsburg, 1603)

Published in his home town, this stellar atlas linked Johannes Bayer's name indissolubly with the cataloguing of stars. It consists of 52 star charts depicting 60 constellations making it the first such atlas to cover the entire celestial sphere. Bayer had to make up names for 12 of these, as they appeared only in the southern hemisphere, and were therefore unknown to Ptolemy. To construct his charts Bayer had to make use of the massive amounts of observational data compiled by Tycho Brahe, which, although not published by Kepler until 1627, had been circulating in manuscript form and had also been used to construct celestial globes. Bayer, however, used other sources as well, as his total star list notes 1,200 bodies – more than Brahe observed – including observations by Amerigo Vespucci and other early navigators. The stars were depicted against a grid to allow accurate positioning, and then overlaid by a depiction of the constellation. To keep track of all his stars, Bayer developed a system of stellar identification, creating star names from the Latin designation of the constellation preceded by an individuating Greek letter, usually ordered in terms of brightness. Thus one of the brightest stars in the constellation of Centaurus became Alpha Centauri. This system is still in use today, although with the advent of telescopes that can see



objects beyond the scope of the naked eye, it is no longer adequate to describe the multitude of bodies that have been discovered recently. *(Cpbd.b.2.lower shelf.4, Given by William Laud, 1634)*

Sainted Stars

A chart of the constellation Taurus reinterpreted as St Andrew from Julius Schiller's *Coelum stellatum Christianum,* (Augsburg, 1627)

While Bayer's stellar mapping was highly successful, that of his protege and fellow resident of Augsburg, Julius Schiller, was rather less so. Bayer helped Schiller complete this stellar atlas in the year of Schiller's death. It provides a Christian reinterpretation of the constellations, replacing the zodiacal constellations with the twelve apostles, those of the Northern Hemisphere with figures and symbols from the New Testament, and those of the Southern Hemisphere with figures and symbols from the Old Testament. Thus Taurus is here depicted as St Andrew, the Ship of the Argonauts becomes Noah's Ark, Canis Minor becomes the Paschal Lamb, etc. Even at the time this atlas was considered merely a curiosity, although this copy was valued enough to be given a lavish gold-tooled binding incorporating the Royal Arms of Charles I. Whether this indicates a Royal provenance, or was a demonstration of loyalty by its owner, Archbishop William Laud, it is difficult to say. *(Cpbd.b.2.lower shelf.7, Given by William Laud, 1634)*