Astronomical Typography

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Our earliest ancestors, from deep prehistory, gazed up at the sky in awe. We soon determined through repeated observations that the celestial bodies appear to follow prescribed paths and that their positions in the sky coincided with or produced effects on earth. For the Egyptians, Isis' tears over the death of Osiris made the Nile rivers swell but this annual flooding could be predicted with considerable precision based on the heliacal rising of the sky's brightest star, Sirius. Moreover, the sun determined days and nights and years and seasons and regulated the plantings and harvests of agricultural civilization. If the sun, for most of history considered a planet, had such profound effects on the earth and its inhabitants, then it followed, quite reasonably, that the other wandering stars or planets produced similar effects too.

Aristotle's Crystalline Spheres

The universe as conceived by Aristotle (384–322 BC) comprised concentric, nested crystalline spheres – a beautiful concept but profoundly flawed as it could not account for the retrograde motion of the planets and variations in their apparent brightness. The solution was proposed by, among others, the founder of trigonometry, Hipparchus (*c.*190–120 BC), and formalized by the great mathematician and astronomer, Ptolemy (*c.*100–*c.*170 AD) in Alexandria, Egypt.

left: Ptolemy's geocentric model with planetary retrograde motion described by an epicycle (red circle) on a deferent (white circle); right: Copernicus' heliocentric model

describing the same retrograde motion.
The Ptolemaic system retained Aristotle's concentric spheres and comprised a stationary Earth at the center, encompassed by the spheres of Moon (☽), Mercury (☿), Venus (♀), Sun (☉), Mars (♂), Jupiter (♃), Saturn (♄), the fixed stars or firmament comprising the twelve signs of the zodiac, and beyond that a tenth (sometimes the ninth) sphere, the Aristotelian *Primum Mobile* that imparts motion to all the other spheres, and beyond that, the *coelum empireum habitaculum dei omnium electorum*, the dwelling place of God and the elect. This system, but for minor revisions was accepted for the best part of 1400 years.

Woodcut from Peter Apian's *Cosmographia,* illustrating the Ptolemaic, earth-centered cosmos. Printed in Antwerp by Gillis Coppens van Diest & Arnold Birckmann, 1540. Image courtesy of HathiTrust. [USTC: 404023]
It is not at all surprising that ancient observers assumed an immobile earth at the center of the cosmos. The night sky, as it passes overhead traces a sphere and like us, the ancients did not feel the earth moving underfoot; rather, it appeared that the heavens revolved about them. To Aristotle and most of his contemporaries, it was incomprehensible that the earth should move. According to Ptolemy, if the earth moved or rotated then it risked 'falling out of the heavens.' But for earth to remain immobile and central in the cosmos demanded the construction of a complex geometrical system of epicycles, deferents and equants, their ratios and positions determined arbitrarily to correspond with observation. It is claimed that the Spanish monarch, Alfonso X of Castile (1221–84) remarked, "had I been present at the Creation, I would have given some useful hints for the better ordering of the universe."

Astronomicum Caesareum

↙ Gingerich, Owen, 'Apianus's Astronomicum Caesareum, *Journal*

for the History of Astronomy, 2 (1971), pp. 168–177 (p. 168)
Has this blog has been hijacked by a lunatic astronomer? If not, then what does astronomy have to do with typography? It is related to today's featured book, Peter Apian's *Astronomicum Caesareum* (Astronomy of the Caesars), a lavishly illustrated, large folio volume first published in 1540 and for which he was author and printer. It is arguably the most typographically impressive scientific manual of the sixteenth century. Owen Gingerich claimed it, "the most spectacular contribution of the book-maker's art to sixteenth-century science."↗ This magnificent book is beautifully illustrated with remarkably complex and detailed woodcuts, usually attributed to Michael Ostendorfer, including numerous woodcut initials and more than twenty volvelles, some with as many as six paper discs rotating on different axes. The volvelles serve several purposes: astronomical, astrological mathematical and even medical. The volvelle, from the Latin *volvere,* to turn, was first introduced into printed books by the very first astronomer-printer, Regiomontanus (1436–76), although they appear in manuscript books from the thirteenth century and likely originate with even earlier Arab astronomers.

"No man is so utterly dull and obtuse, with head so bent on Earth, as never to lift himself up and rise with all his soul to the contemplation of the starry heavens."
Seneca, *Physical Science in the Time of Nero,* Book VII Chapter I, p. 271
Peter Apian (1495–1552), the son of a shoemaker, was a German mathematician and astronomer. He began his studies at the University of Leipzig, later transferring to the University of Vienna where he studied mathematics, astronomy and astrology. Apian had caught the attention of the emperor Charles V, who rewarded him with printing privileges in the form of monopolies, a knighthood, gold (lots of it) and appointed him his court mathematician. Apian's *Astronomicum Caesareum* is dedicated to the Emperor, with every page worthy of such an illustrious patron. The splendid dragon volvelles, one of

which is reproduced below, were used to predict lunar eclipses, with the head and tail of the dragon depicting the lunar nodes, or the two times that the moon crosses the ecliptic – especially important as lunar eclipses only occur within close proximity to these lunar nodes.

Page from Apian's *Astronomicum Caesareum,* rotated through 90 degrees clockwise). Hand-colored woodcut. Image courtesy of Sotheby's.

Another impressive and rather complex looking volvelle is used to calculate the size and duration of lunar eclipses. Apian describes the use of this particular volvelle with reference to two example eclipse calculations: the first, a partial lunar eclipse on Emperor Charles V's birthday, November 5, 1500; the second is the partial lunar eclipse of October 15, 1502, on the birthday of King Ferdinand I, brother to Charles V. This volvelle has no moving parts besides two strings attached at the center, that originally would have been threaded with small beads that functioned as sliding markers to transfer radial distances.

Volvelle for calculating duration and size of lunar eclipses, from Apian's *Astronomicum Caesareum,* 1540. Image courtesy of Bayerische Staatsbibliothek. 36.6 × 51.5cm

Title page from *Astronomicum Caesareum,* 1540. Image courtesy of Sotheby's.

The *Astronomicum Caesareum* is, for the most part, a compendium of current astronomical knowledge, although it does include the new notion (at least in the West) that the tails of comets point away from the sun – this at a time when the nature of comets and their distance from earth was not at all

understood. Also included are observations for five comets, including Halley's (1531); in chapter thirty, for the first time the author recommends the use of colored or black glasses to observe eclipses of the sun.

Spread appearing towards the end of the book outlining instructions for the construction of various astronomical instruments, from Apian's *Astronomicum Caesareum,* 1540. Image courtesy of Bayerische Staatsbibliothek.
Apian was instrumental in popularizing such paper instruments and they appear with increasing frequency throughout the sixteenth and seventeenth centuries. In fact, they became so popular that the makers of traditional scientific instruments sought to prohibit the sale of these "paper frauds", claiming they were "a mere deception through which the buyer is cheated." (From a Nuremberg Statute of 1608.)

[embedded content]

An astronomical folly?

One might assume that the book's publication, just three years before Copernicus' *De revolutionibus orbium coelestium,* would have made Apian's didactic masterpiece obsolete. However, it continued to be used for its relative ease of use as a manual, and because Copernicus' heliocentric model was no more accurate at predicting planetary motions than the Ptolemaic geocentric system expounded in *Astronomicum Caesareum*. Much greater accuracy was achieved only from the beginning of the subsequent century with Johannes Kepler's laws of planetary motion that elegantly reimagined Ptolemy's circular orbits and uniform motion with elliptical orbits and planets that moved faster, the closer they approached the sun.

* John North, *Cosmos: An Illustrated History of Astronomy & Cosmology,* p. 262.

Kepler called Apian's *Astronomicum Caesareum* a waste of time and ingenuity.* But Apian's work was not intended for the likes of mathematical astronomers like Kepler. Rather it was, as Apian made clear in his preface, a book for the layperson, and was intended to make astronomy more accessible to a broader audience. In that, Apian succeeded; and in producing an enduringly magnificent typographic book — well, he succeeded in that too.

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