Empires and exact sciences in pre-modern Eurasia

Pre-modern Asia's diverse intellectual traditions shared a scientific enterprise in the development of mathematical astronomy and astrology. Inspired by the prospect of foretelling the future, and by the mathematical beauty of heavenly motions, scholars in the dominant cultures of Asia and Europe constructed a remarkably complex system of calculation, observation and prediction that became the springboard for modern physical science.

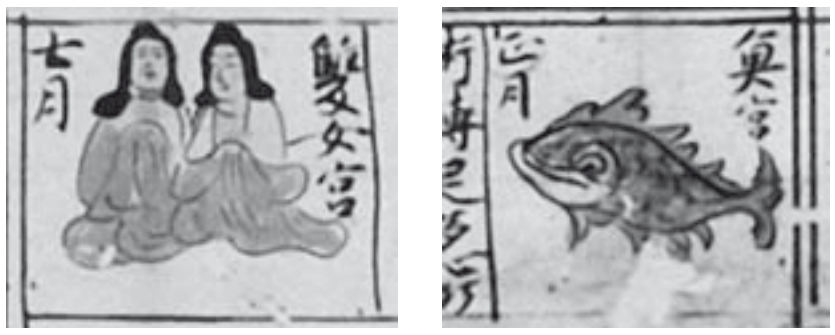

Figure 1: The zodiacal signs Virgo and Pisces in Japanese Buddhist astrology.

Photographs from Yano 2004, used with permission.

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The global diffusion of scientific ideas is sometimes regarded as an exclusively modern phenomenon; but the ancient and medieval history of science in Europe and Asia, where imperial power often served as the transmission vector for scientific theories, contradicts this notion.

Reading the future in the skies

It may startle the modern reader to see astrology lumped with mathematics and astronomy under the name 'science'. Astrology has been excluded from that status by the modern definition of scientific method and is nowadays decisively classed as a pseudoscience. However, in earlier times it was considered one of the standard quantitative systems for understanding the physical world – the so-called 'exact sciences' – and most mathematicians and astronomers were astrologers as well.

The Babylonians of the early second millennium BCE believed that certain celestial phenomena such as eclipses and conjunctions of planets were messages from the gods to the rulers of humanity, warning them of crises and trials to come. This belief persisted even as Babylonian scribes grew more skilled at describing the periodic recurrences of such phenomena mathematically. Even when sophisticated late Babylonian mathematical astronomy had made the apparent cycles of the heavens almost completely predictable, astronomers still took their ominous significance very seriously.

But by then Mesopotamia was under the control of the Persian and Macedonian empires, who took little interest in celestial warnings from Babylonian deities. So the astronomers turned to forecasting the future for individual patrons rather than for the state. They appear to have invented the concept of the horoscope, a prediction of the fate of an individual based on the positions of the stars and planets at the moment of his or her birth. The allure of such glimpses into the future launched the disciplines of mathematical astronomy and astrology on their far-flung wanderings through the subsequent millennia.

Dissemination of exact sciences

Greek scholars encountered Babylonian astronomy and celestial omens in Ptolemaic Egypt in the second half of the first millennium BCE. They superimposed the spherical cosmology of their own philosophical systems onto some of the Babylonian algorithmic schemes for mathematically predicting astronomical phenomena. This combination developed over the next few centuries into the famous system of nested celestial spheres, all revolving around a stationary spherical earth, that we know as 'Ptolemaic' astronomy.

The geometrised Ptolemaic universe served as the model for probably the most important scientific instrument of pre-modern times, the plane astrolabe (see sidebar). Greek science also adopted Babylonian 'proto-horoscopes' and expanded them into a full-blown system of horoscopic astrology.

In the flourishing trade of the Roman empire in the early first millennium CE, the Hellenistic exact sciences spread eastward to India, where they developed into the astrology and spherical astronomy of the classical Sanskrit tradition. These Indian sciences then rippled outward to enrich the astral knowledge of cultures in pre-Islamic Iran, China and Southeast Asia.

The complex multi-cultural layering of such knowledge is illustrated in Figure 1, which shows the iconography of the zodiacal signs Virgo and Pisces as represented in a mandala in the Toji temple in Kyoto. Here we see Japanese versions of Chinese versions of Indian versions of the signs of the celestial zodiac adapted by Greeks from its original Babylonian form. (Note that in the process the single maiden representing the sign Virgo has become two, and the two fish representing Pisces have become one.)

Figure 2: A diagram of the celestial spheres in an Indo-Arabic manuscript.

Photograph by the author.

The rise and expansion of Islam in the 7th century continued the development and transmission of the exact sciences. In addition to many influences from India and Sassanian Iran (such as the decimal place-value numerals and various mathematical, astronomical and astrological methods), science in the Islamic world incorporated the Hellenistic Greek theories of ancient authors such as Euclid, Archimedes and Ptolemy. Embodied mostly in Arabic and Persian texts, these new syntheses of mathematical astronomy and astrology were carried to India, Central Asia, China, Byzantium and the Latin West. There they came into contact with different versions of the exact-sciences tradition, sometimes stimulating efforts by scientists to compare, assess and reconcile their variants.

Figure 2 shows an example of one of these second millennium cross-cultural transmissions: an Arabic manuscript, written in India, explains the cosmology of nested heavenly spheres derived ultimately from Greek philosophy. In the western world, such interactions between variant traditions helped form the Renaissance science that eventually replaced the Ptolemaic systems of astronomy and astrology with the heliocentric cosmos of early modern astronomers like Copernicus, Kepler and Newton. <

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The seminar 'Empires and Exact Sciences in Pre-modern Eurasia' was held in Leiden, 29-30 May 2006, in memory of one of the 20th century's leading scholars of the cross-cultural development of pre-modern science, David Pingree. It was sponsored by CNWS, Brill Academic Publishers and IIAS. For the program and participants see: www.iias.nl/iias/show/id=53893. The proceedings will be published in a forthcoming issue of the journal East and West of the Istituto Italiano per l'Africa e l'Oriente in Rome.

The astrolabe

The plane astrolabe was invented in Hellenistic Greece (or its sphere of influence), but the details of its origin are lost. It is an ingenious form of analogue computer for predicting the appearance of the heavens at any given time, or conversely for telling time from the observed positions of the heavenly bodies. In an astrolabe, the zenith, horizon and other reference points for a particular terrestrial latitude are mathematically mapped onto a flat circular plate, in much the same way as the spherical globe of the earth can be mapped onto a flat surface. Then an openwork lattice showing the positions of the fixed stars is laid on top of the plate so that it can turn freely. As the lattice turns, it mimics in two-dimensional form the rising and setting of stars and their changing positions in the sky as the earth rotates. The time corresponding to any particular configuration of the heavens can be read on the graduated scale on the astrolabe's circular rim.

Astrolabes were greatly admired and prized in Islamic, Indian and European astronomy, often as objects of artistic beauty and as useful scientific tools. Figure 3 shows a (somewhat dilapidated) astrolabe with charming bird-shaped star-pointers, constructed in India where the astrolabe was known in Sanskrit as yantra-raja, 'king of instruments'.

Figure 3: A second millennium Sanskrit astrolabe from India.

Photograph by Alexander Walland.