Dance of the Planets,
or a potted history of how to model the Universe

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The Geocentric Way: It's all about ME!

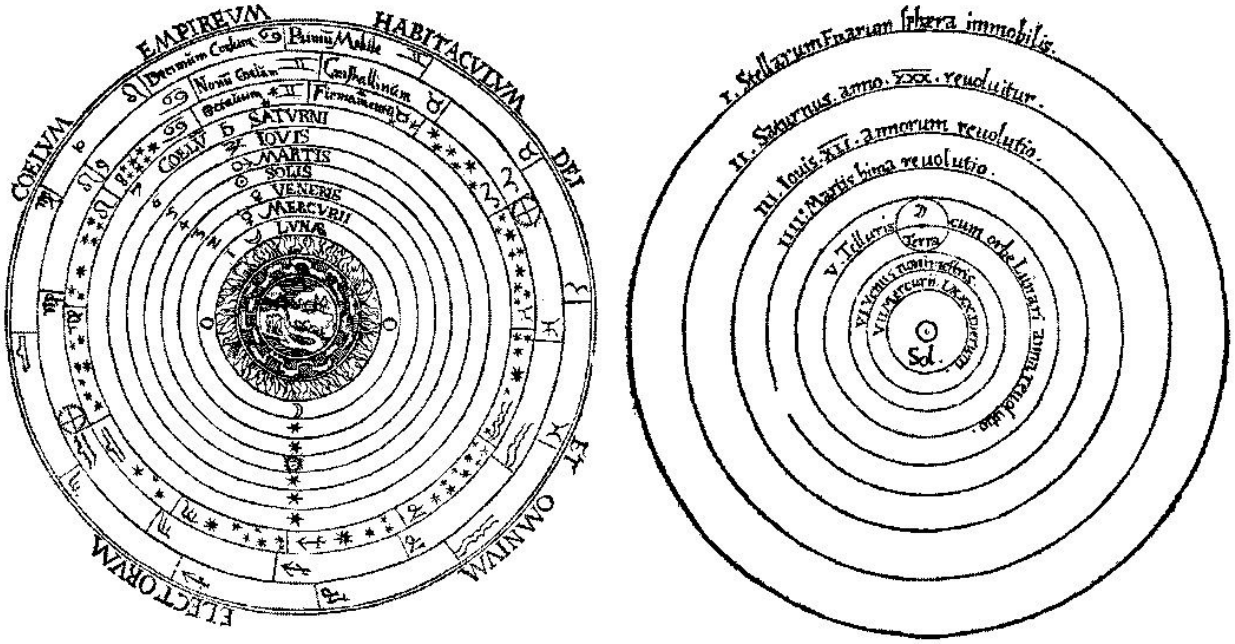
> *In the centre of the universe there is a central fire, the principle of life…surrounded by the earth, the moon, the sun, and the five planets. The distances of the various heavenly bodies from one another are conceived to correspond to the proportions of the musical scale. The heavenly bodies, with the gods who inhabited them, are supposed to perform a choral dance round the central fire. The spheres are conceived to be crystalline or glassy fabrics arranged over one another like a nest of bowls reversed. In the substance of each sphere one or more of the heavenly bodies is fixed, so as to move with it. As the spheres are transparent we look through them and see the heavenly bodies which they contain and carry round with them. But as these spheres cannot move on one another without friction, a sound is thereby produced which is of exquisite harmony, too fine for mortal ears to recognize.*
>
> Pythagoras

Pythagoras and Ptolemy, Archimedes and Aristotle and a whole host of other Greek thinkers were convinced that all within the heavens was ordered, perfect and unchangeable, and all within and of the Earth was mutable, corruptible and prone to decay. Their astronomical theories were to greatly influence European thought following their reintroduction in the 12th century via Arab translations, coinciding with a mishmash of astrology, philosophy, mysticism, alchemy and other diverse subjects. Ptolemy's geocentric model, with the Earth at the centre , followed by the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn, held sway for 1500 years.

> *I know that I am mortal by nature, and ephemeral; but when I trace at my pleasure the windings to and fro of the heavenly bodies, my feet no longer touch the earth: I stand in the presence of Zeus himself and take my fill of ambrosia, food of the gods.*
>
> Claudius Ptolemy

Ptolemy's windings to and fro became increasingly complex. He started off with the idea that the heavens, including the planets, the Sun, Moon and the fixed stars, revolved at uniform speed around the Earth in perfect circular paths. Then, noticing that this model didn't quite fit the observations, he progressively changed the model to include smaller epicycles that allowed the planets to spin in individual circles off-centred within their orbits. The number of additional circles eventually grew to more than 50. It still wasn't a perfect model, but it was near enough for a number of centuries.

> *If the Lord Almighty had consulted me before embarking on the Creation, I should have recommended something simpler.*
>
> (re the Ptolemaic System)
> Alfonso X, King of Castile & Leon from 1252



Ptolemy's geocentric model, with all the heavenly spheres; the Copernican heliocentric model

The Heliocentric Vision: The Sun's in my eyes

> *For a long time then, I reflected on this confusion in the astronomical traditions concerning the derivation of the motions of the universe's spheres. I began to be annoyed that the movements of the world machine, created for our sake by the best and most systematic Artisan of all, were not understood with greater certainty by the philosophers, who otherwise examined so precisely the most insignificant trifles of this world. For this reason I undertook the task of rereading the works of all the philosophers which I could obtain to learn whether anyone had ever proposed other motions of the universe's spheres than those expounded by the teachers of astronomy in the schools. And in fact I found in Cicero that Hicetas supposed the earth to move. Later I also discovered in Plutarch that certain others were of this opinion. . . . Therefore, having obtained the opportunity from these sources, I too began to consider the mobility of the earth.*
>
> Letter to Pope Paul III: Preface to *De Revolutionibus*, 1543, Nicholas Copernicus

Copernicus tried using the appeal of the ancient authorities to give greater weight to his concept of the Sun-centred solar system, whereby all the planets spun around the Sun, with only the Moon travelling around the Earth; the latter clearly was not "set firmly in place" as the Psalms would have it, but rotating on its own axis. The appeal to Greek wisdom didn't help uptake of his ideas — the whole thing was ignored so profoundly that the Catholic Church didn't even get round to adding Copernicus' work to the Index of Prohibited Books until 73 years after its publication!

> *This fool seeks to overturn the whole art of astronomy But as the Holy Scriptures show, Jehovah ordered the Sun, not the Earth, to stand still.*
>
> Martin Luther (1483-1546)

Interestingly, it was around this time that the term “revolution” gained its new non-astronomical meaning of an upheaval in the affairs of men (Tillett, pg 120), reflecting the huge psychological, religious and scientific change that the Copernican revolution eventually produced by taking us out of the centre of Creation.

Italian cosmologist Giordano Bruno spoke up for Copernicus' view, and went further, claiming that the stars were spread through an infinite space, and there were infinitely many inhabited worlds. Bruno was burned at the stake in 1600. While the religious debate burned fiercely, widespread scientific support for the model didn’t catch alight until the 17th-century observations of Galileo, Kepler and others helped to cement the heliocentric model as the best one for the job.

Copernicus’ model, as it happens, was not that much simpler than Ptolemy’s because he still believed in the still very popular Aristotelean notion of perfectly circular orbits. But his model was far superior in explaining the motion of the inner planets and predicting their positions, something which made it popular with astrologers. Many historians of science have argued that the choice between the Ptolemaic and the Copernican systems rested on aesthetic criteria, principles of harmony, symmetry and simplicity, rather than on science and observation.

The two main objections to Copernicus’ model — objections which had been raised against a similar proposal by Aristarchus 1,800 years earlier — were that no-one could feel the Earth moving, and no-one could see any parallax effect on the stars. Copernicus thought that the latter was simply because the stars were too far way, and he was right, though it took another 300 years to prove it.

The Tychonic turn-around: the best of both worlds

The concept of the perfect and unchanging nature of the heavens took a hard knock in 1571 when a new star suddenly appeared, blazing during the day, and then fading over the space of a year or so. Danish astronomer Tycho Brahe emphasised its philosophically unpalatable arrival terming it a “nova stella”, publishing his observations which proved it was beyond the solar system and thus proof that the heavens could contain new objects. His work *De Stella Nova*, was not wholly considered with astronomical aspects of the new star however:

> *The star was at first like Venus and Jupiter, giving pleasing effects; but as it then became like Mars, there will come a period of wars, captivity and death of princes, and destruction of cities….*

The Greek idea of the perfection of the celestial spheres continued to hold sway. In 1596, Shakespeare described the night sky this way, in the *Merchant of Venice* (V,i,54-65):

> *……. Look, how the floor of heaven*
> *Is thick inlaid with patines of bright gold;*
> *There's not the smallest orb which thou behold’st*
> *But in his motion like an angel sings*
> *Still choiring to the young-eyed cherubim.*
> *Such harmony is in immortal souls;*
> *But, whilst this muddy vesture of decay*
> *Doth grossly close it in, we cannot hear it.*

The old ideas started to crack under new observations and approaches. Tycho's careful observations led him to discover that comets were not a decay product of the Earth's upper atmosphere but objects further away than the Moon, freely passing through what were supposed to be crystalline spheres.

But even with his brilliance, Tycho couldn't shake the influence of the Greeks and he proposed a compromise between the geocentric and heliocentric models, whereby the Moon and Sun orbited around the Earth, and the other planets spun around the Sun. It was a model that competed surprisingly successfully with the Copernican one for almost a century, and was even supported by the Jesuits as a suitable model for Catholics from 1633.

In 1609, Tycho's assistant and astronomical heir, Johannes Kepler figured out how to explain all the movements and discrepancies with his Three Laws of Planetary Motion, the most obvious difference being that the planets didn't move in perfect Greek circles, but in ellipses. In that same year, Galileo Galilei observed other non-perfect, non-Greek things about the heavens: the mountains and craters of the Moon, the disks of planets and the pinpoints of stars, four large moons circling around Jupiter, the phases of Venus, spots on the face of the sun. The solar system wouldn't be seen the same way ever again.

A Modern Model: Just plain nutty

Tycho Brahe's accurate measurements and years of observations started to give astronomers the notion that we were in a much bigger universe than had hitherto been suspected. The Greeks had thought the Sun was only 20 times as distant as the Moon, with the 1,000 or so visible stars not much further past Saturn. We know now that space is "big, really big, vastly, hugely mind-bogglingly big", as Douglas Adams put it.

So, to provide a modern model — and an idea of the distances and scales we now know to exist, here's the classic peppercorn and nut model of the solar system (beads work too):

Take one ball of around 23 cm in diameter and put it at the end of a long field.
Take 10 paces away from the ball, and put in a pin: the pinhead represents Mercury; each metre-long pace represent 6 million kilometres.
Take 8 more paces, and add a peppercorn for Venus.
Seven paces brings you to Earth, another peppercorn; add a pinhead 6cm away for the Moon.
Take 13 paces from Earth, and poke in a pin for Mars.
Ninety-two more paces gets you to Jupiter, represented by a chestnut.
Another 108 paces and you reach the outermost planet known before 1781, Saturn, which can be modelled with a hazelnut.
If you want to carry on and do the whole solar system, you'll need about another kilometre (240 paces to Uranus, represented by a peanut; 271 paces to Neptune, a peanut; 234 paces to Pluto, a pinhead). If you want to represent the nearest star, it'll be 6,700 kilometres away….

References

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