Dawn of Science

11. The Copernican Revolution

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Previous parts:
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Slowly, through philosophic blunders and religious dogmas, to free-thinking.

On 24 May 1543, Nicholas Copernicus was in bed, dying of brain haemorrhage. It is said that a copy of his book *De Revolutionibus Orbium Coelestium* (On the Revolution of the Heavenly Bodies) – the publication of which he had delayed by nearly 30 years – was brought to his death-bed so that he could have a last glimpse of it. In this book he had detailed a system of astronomy with the Sun at the centre and the planets going around it in fixed orbits. Copernicus, so to say, stopped the Sun and set the Earth in motion.

Behind this event lies a fascinating story in the history of science – a story of extraordinary blunders, irresponsibilities and damaging effects of religious suppression of science. To see it in perspective, we have to go back over 2,000 years in history. Around 350 BC there lived a Greek astronomer, Aristarchus, who wrote a short treatise *On the Sizes and Distances of the Sun and the Moon*. In this treatise, he proclaimed that the Sun and not the Earth was at the centre of our world and that all planets revolved around the Sun. His book became a classic of antiquity and he was considered one of the foremost astronomers of his time. Both Archimedes and Plutarch knew about his work. "For, Aristarchus supposed that the fixed stars and the Sun are immovable but the Earth is carried around the Sun in a circle..." says Archimedes; "...that the heaven is at rest but the Earth revolves in an oblique orbit while it also rotates about its own axis," is the reference in Plutarch to the ideas of the Greek astronomer.

Incredibly enough, Aristarchus was forgotten! The geocentric system of Ptolemy, a much more complicated and aesthetically

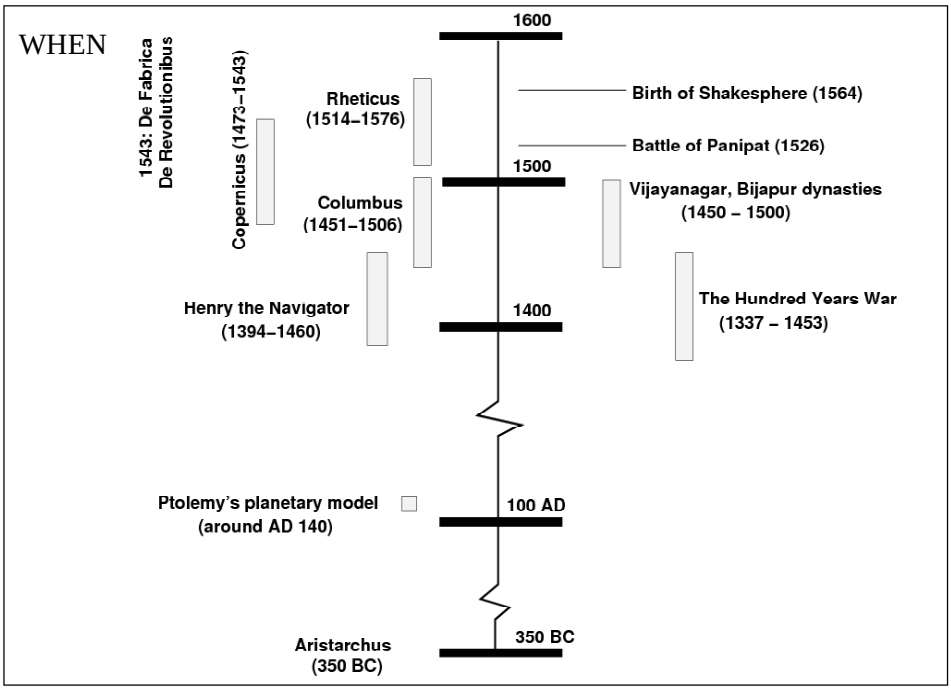

Figure 1.

Figure 2.

unappealing one, held sway even around the second and third centuries AD. From then on, throughout the Dark Ages, there was no hope of revival. Later, as Europe went through the Renaissance, one would have hoped for the right ideas to emerge. But the strong religious dogmas and theological interpretations of Aristotle's outdated ideas suppressed the truth for centuries. Though it was only one step from Aristarchus to Copernicus (or, for that matter, from Hippocrates to Vesalius or even from Archimedes to Galileo), it took centuries in Europe for this step to be taken. As A N Whitehead, an English historian of science, remarks: "In the year 1500, Europe knew less about nature than Archimedes, who died in 212 BC, did." Such was the effect of dogmatic ideas on the growth of science.

The way Copernicus ended up writing his book is another interesting tale. Born in 1473 in Torun in Eastern Poland, Copernicus lost his father early. Thereafter, his uncle brought him up, and he gave Copernicus a very good education. In 1496, Copernicus travelled to Italy and studied medicine and canon law for 10 years. This was when he got interested in astronomy!

Figure 3.
In the pre-Copernican universe, the Earth is at the centre, and the Sun, the Moon, planets and the stars go around the Sun in concentric circles.
Courtesy:
http://en.wikipedia.org/wiki/Almagest

In those days, the positions of the planets were calculated by the system evolved by Ptolemy. In spite of its complexity (and detailed mathematics), this system was cracking up. The predicted positions of planets were getting to be far away from the observed ones in spite of the several ad hoc corrections introduced by later astronomers. It occurred to Copernicus that the calculations could be considerably simplified if one adopted the heliocentric system. Copernicus's genius – if you could call it that – was in putting this idea into practice and meticulously working out the details of the new model. He relied on the observations of others, though, especially because he was not good in this. (His instruments were less accurate than those used in Alexandria 2,000 years ago; and he made a

mistake even in getting the terrestrial co-ordinates of his observatory right.)

Copernicus realised that his model could explain several things, which Ptolemy could not. It must have certainly occurred to him that probably his was the true model – with a moving Earth and all that. But he hesitated to publish it knowing well that he could get into trouble with the Church. A private manuscript that he circulated created considerable interest among European scholars and finally the German mathematician, Georg Rheticus (1514–1576), who was a fan and student of Copernicus, persuaded Copernicus to publish the book. Rheticus also suggested that the book may be dedicated to Pope Paul III in order to pre-empt opposition from the Church. Copernicus entrusted Rheticus with this task.

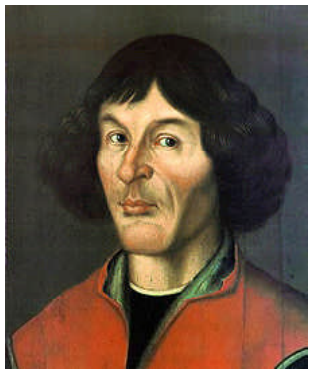

Figure 4. Copernicus.
Courtesy:
http://en.wikipedia.org/wiki/Nicolaus_Copernicus

Unfortunately, Rheticus had to leave town, so he left a Lutheran minister, Osiander, in charge of the printing. Martin Luther (1483–1546) had earlier expressed himself strongly against Copernicus (which goes to show that religious reformists may not always do the right things for science) and Osiander decided to publish the book with the addition of a highly damaging preface.

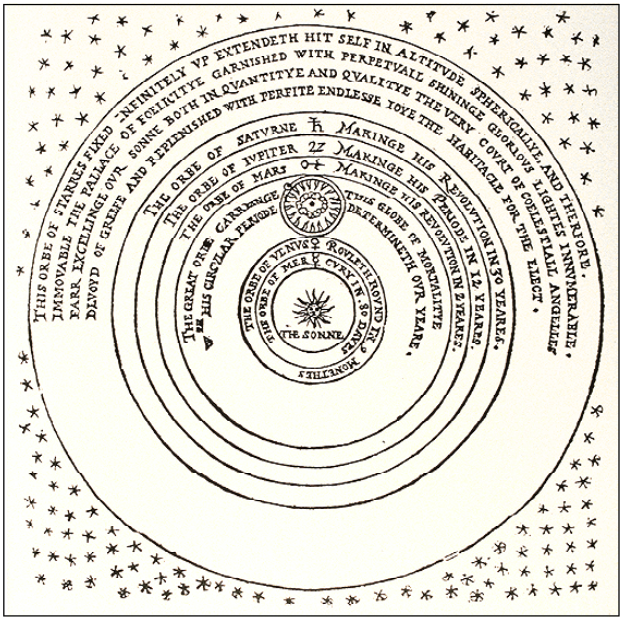

Figure 4. The Copernican universe (as depicted by Thomas Digges in 1576), with the Sun at the centre and the Moon going around the Earth. The stars are not limited to a sphere but are spread infinitely.
Courtesy:
http://en.wikipedia.org/wiki/Universe

Box 1. Clues, Cover-ups and the Climax

There were several tell-tale signs in the behaviour of heavenly bodies, which suggested a heliocentric world. Unfortunately, Ptolemy and his followers were not brave enough to follow up these clues.

To begin with, the estimate of the size of the Sun relative to the size of the Earth was available since the time of Aristarchus (about 300 BC). Though the actual figure he obtained was wrong, it was quite clear that the Sun was considerably bigger than the Earth. It was then rather strange to think that the Sun was going round the Earth instead of the other way around..

Further, the observation of the trajectories of planets revealed some strange anomalies. The planets Mercury and Venus were always seen close to the Sun, just after sunset or just before sunrise and never overhead at night. The other three planets, Mars, Jupiter and Saturn, showed irregular pattern of motion every once in a while. They travelled in one direction for some time, stopped in their tracks and then seemed to move backwards! These features are difficult to understand (in a natural manner) if the planets were moving around the Earth.

Lastly, it was known that the brightness and the apparent size of the planet Venus varied periodically – something which should not happen if Venus was orbiting the Earth at a constant distance.

All these problems disappear if we assume that the planets revolve around the Sun in the order Mercury, Venus, Earth, Mars, Jupiter and Saturn. Because the orbits of Mercury and Venus are closer to the Sun than that of the Earth, they will never appear overhead at night. The retrograde motion of the other three planets is also easy to understand: if the Earth revolves around the Sun at a faster rate than the outer planets, then the Earth will 'overtake' these planets every once in a while. Seen from the Earth, the outer planets will appear to go backwards. Also, since the distance between the Earth and Venus varies quite a lot, the appearance of this planet will be altered periodically.

The Greeks had all the pieces of the puzzle but refused to put them together. So deep-rooted and dogmatic were Aristotle's notions of circular motion that Ptolemy ended up saying: "We believe that the object of the astronomer ... is this: to demonstrate that all the phenomena in the sky are produced by means of uniform and circular motions." To achieve this, Ptolemy had to invoke a complicated system of epicycles in which celestial objects moved in circles, whose centres themselves moved in other circles, etc.

The Copernican idea could at one stroke resolve all the discrepancies mentioned earlier. The only place where Copernicus erred was in sticking to the circular motion. As a result, he also needed epicycles in his model (in fact, Copernicus used more epicycles than Ptolemy did!). And they remained, till Kepler later changed the paths to ellipses, laying to rest the last of the Aristotelian dogmas.

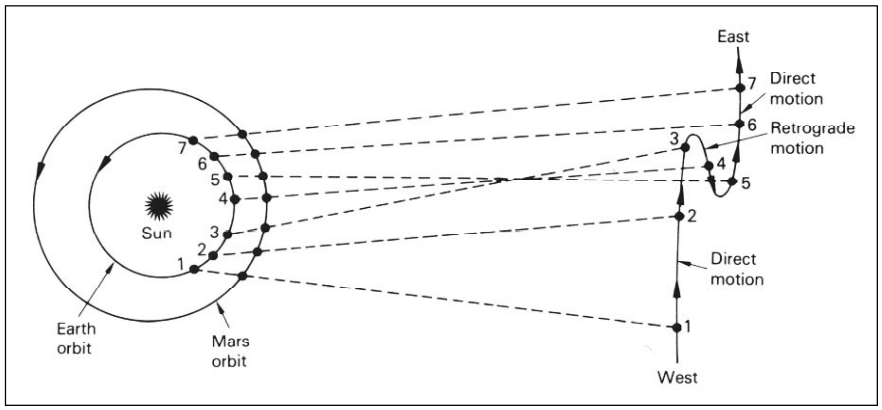

Figure 5. The origin of the 'retrograde' motion of some planets, Mars in this case. Since the Earth revolves faster around the Sun than Mars, at times the Earth overtakes Mars in orbital motion. Seen from the Earth, Mars will appear to move 'backwards' in the sky relative to the Earth.
Courtesy:
http://history.nasa.gov/SP-4212/p3a.html

The preface essentially conveyed the idea that the system described in the book was only a mathematical apparatus and may not represent reality. It explicitly stated that "... these hypotheses need not be true or even probable ...". Historians are unsure whether Copernicus approved of this preface and the issue is still unsettled. (It shouldn't be too surprising if he did, for old Nicholas always knew which side of the bread was buttered; for one thing, never in the book does he mention a note of thanks to Rheticus – a fact which deeply hurt Rheticus.) The book finally appeared with the preface and a dedication to the Pope.

It was eminently unreadable and sold poorly. While several other contemporary books on planetary theory and astronomy were easily reaching 100th reprint in Germany, Copernicus's book stopped with only one print. All the same, it was a milestone in science. It was immediately taken up by those who produced planetary tables and helped to set the heaven in order. What is more, it influenced at least a handful of later thinkers to come out of religious dogmas and think anew. It is this rebirth of free-thinking which heralded the Scientific Revolution in Europe.

Suggested Reading

[1] **Isaac Asimov, *Asimov's Biographical Encyclopedia of Science and Technology*, Doubleday, 1982.**

[2] **Arthur Koestler, *The Sleepwalkers*, Penguin, 1990.**

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