NICOLAUS COPERNICUS (1473-1543)
PART 2

SLIDE 1  As far as is known, Copernicus was not a prolific writer; there appears to be only four manuscripts of interest to us. They are

- *Letters of Theophylactus Simocatta, published in 1509.*
- *Commentariolus, published ca 1510.*
- *The Letter against Werner, published in 1524.*
- *De Revolutionibus Orbium Coelestium, published in 1543.*

During his tenure as canon of Warmia, he also wrote a number of reports concerning the currency and land ownership.

The first book, SLIDE 2  *Letters of Theophylactus* is a translation by Copernicus of 85 moral, rustic, amorous, and sometimes, erotic letters, from Greek into Latin. Theophylactus Simocatta was a 7th century Byzantine historian. The translation was published in 1509 and was dedicated to his uncle, Bishop Watzenrode. It is interesting because it was simply an exercise for the purpose of teaching himself Greek, so that he could read Greek astronomy texts. It seems he had no particular interest in Theophylactus; it was just a book he came across in a library.

However, today, I want to share some extracts of *De Revolutionibus* with you, using principally, Copernicus’ original, handwritten manuscript, which is held at Jagiellonian University, formerly the University of Cracow. The manuscript is written in Latin, in neat longhand and covers 106 double-sided sheets. However, there are a number of textual
differences between the handwritten manuscript and the first published edition and there is also additional material that Copernicus would not have approved of. It is likely it was completed around 1532 but, despite encouragement from many friends and scholars, he decided to delay publication; it’s not obvious whether he was concerned with the possibility of philosophical objections or whether he was concerned about the reaction of the Church and theologians. Eventually, he handed it to his friend and colleague, Georg Joachim Rheticus, to oversee the project. In 1541, Rheticus transferred responsibility for publication and proof reading to Andreas Osiander a Lutheran theologian.

*SLIDE 3* The title page of the first edition contains a Greek quotation that may well have been added by the publisher to warn readers of the highly technical nature of the book. It is similar to an inscription that appeared above the door of Plato’s academy

“*Let none who has not learnt mathematics enter here.*”

The choice as Andreas Osiander to oversee publication was not a particularly good choice since he was a strict Lutheran, albeit a convert from Catholicism, and was very concerned about the Church’s reaction to the book. He suggested that Copernicus write a preface stating that the theory was not to be taken literally. *SLIDE 4* Naturally, Copernicus refused. So, remarkably, without the knowledge of Copernicus or his friends, Osiander added an unsigned, advisory “letter to the reader” directly after the title page! The letter was unsigned and its true author wasn’t revealed until 50 years later. Osiander concludes his letter ...

“*Therefore, let us allow these new hypotheses to make a public appearance among the old ones which are themselves no more probable, especially since they are admirable and simple and bring with them a vast treasure of very*
skillful observations. As far as hypotheses are concerned, let no one expect anything certain from astronomy, which can show us nothing, lest he accepts as the truth ideas conceived for another purpose, and go away from this study a greater fool than when he approached it. Fairwell.”

One can only surmise how bewildered scholars must have been to be told to take the book as mere speculation! Following Osiander’s letter there is a letter Copernicus had received several years earlier from Nicolaus Schönberg, the Cardinal of Capua. Schönberg, as a trusted councillor of both Pope Clement and his successor, Paul III, was a senior Catholic theologian. In fact, Schönberg had become a “convert” to Copernicanism and even offered to pay for the publication of the book. Having the support of such a senior theologian and other Bishops, together with the enthusiasm of Rheticus, must have encouraged Copernicus to go ahead and finally publish his manuscript. The book was dedicated to Pope Paul III, who was known to be a scholar and admirer of science. It is full of platitudes and apologies as if Copernicus was trying to “soften” the impact of his theory on Church dogma. SLIDE 5

Copernicus wrote:

“I am fully aware, Holy Father, that as soon as some people hear in these these books, which I have written about the revolutions of the spheres of the world and that I attribute some sort of motion to the terrestrial globe, they will immediately raise a cry of condemnation against me and my theories.”

He continues ...

“But my friends made me change my mind in spite of my long continued hesitation and resistance. Foremost among them was Nicolaus Schönberg ... a man distinguished in all fields of learning. Next to him was ... Tiedemann Giese ... a man filled with the greatest zeal for the divine and liberal arts.”
Copernicus also says that he has kept the work hidden for almost four times nine years, i.e., 36 years. He tells Pope Paul III that he was motivated to seek a new theory because earlier philosophers differed among themselves. He said he found his “hint” in some early writings of the Roman statesman and orator, Cicero (106 - 43 BCE), and the Greek historian Plutarch (ca 46 - 120 BCE), who wrote ...

“Some think that the Earth is at rest; but Philolaus the Pythagorean says that it moves around the fire with an obliquely circular motion, like the Sun and Moon. Heraclides of Pontus and Ecphantus the Pythagorean make the Earth move, not in a progressive motion, but like a wheel in a rotation from west to east about its own center.”

Copernicus tells the Pope that was the clue although he admits he thought initially the idea of a moving Earth was absurd! Nevertheless, he adds, after a “long and intense study” he concluded that Earth and each planet revolve around the Sun.

**SLIDE 6** *De Revolutionibus* comprises six books (i.e., chapters) altogether with a total of almost 400 pages in the first published edition; clearly, I can only give you a small sample of the content. The chapters deal with, in turn; [1] the arrangement of the Solar system; [2] a newly arranged star catalogue; [3] precession; [4] the movements of the Moon and the last two [5 and 6] on the motion of the planets. Obviously, the whole basis of the book is the claim that the Sun, not the Earth, lies at the center of the system and the Earth revolves around it. To overcome some of the objections that arose over the latter idea, such as ...

“why, then, are we not surrounded by howling gales?

How come clouds and birds are not left behind?”

Copernicus suggested that the Earth carries the atmosphere with it. As well as explaining his sun-centered theory and its implications, a good deal of *De Revolutionibus* is devoted to
deriving and generating the geometrical theorems he needed to develop his astronomical tables. It is a mixture of both radical and traditional elements. For eexample, although he made a radical re-ordering of the planets, he still adhered to the ancient Aristotelian doctrine of circular motion.

**SLIDE 7** The apparent simplicity of the Copernican system with a central Sun and the planets orbiting in circles has often been misinterpreted from the diagram on page 9v of chapter 1, shown here. In fact, Copernicus makes it clear in the text that this diagram simply shows the *order* of the planets from the Sun,

\[
\text{Mercury, Venus, Earth, Mars, Jupiter, Saturn,}
\]

*not* their relative spacing. The outer sphere is the sphere of fixed stars, which is “immovable”. His theory does not state that the planets are confined to simple circular orbits as a large number of books on astronomy suggest by taking this figure to be literally true! In fact, Copernicus needed a number of circles to explain celestial movements. In addition, the Sun was not positioned at the exact center of rotations, either.

As far as the motion of the Moon is concerned, on the same page of his manuscript he writes

\[
\text{“Fourth in order is the annual revolution of the Earth together with the lunar sphere as an epicycle.”}
\]

Interestingly, in the figure in Copernicus’ handwritten manuscript of the celestial spheres, the Moon’s orbit around the Earth is not shown. **SLIDE 8** But it does appear in the published edition, with the note

\[
\text{“The annual revolution of Earth with the orbit of the Moon.”}
\]

**SLIDE 9** In writing about the position and apparent motion of the Sun, he writes
“I also say that the Sun remains forever immobile and that whatever apparent movement belongs to it can be verified by the mobility of the Earth.”

Copernicus was fully aware of that the Church had long held the view that the Bible supported the idea of a motionless Earth and a moving Sun. **SLIDE 10** For example, Ecclesiastes 1:

[5] *The Sun* ...

Psalm 93:

[1] *... the world* ...

Psalm 104:

[5] *Who laid* ...

And **SLIDE 11** Joshua 10:

[12] *Then spake Joshua* ...

[13] *And the Sun* ...

With this statement he overcomes the objections of those who claim a literal interpretation of the Bible. **SLIDE 12** Later he writes,

“In the center of all rests the Sun. For who would place this lamp of a very beautiful temple in another or better place than this wherefrom it can illuminate everything at the same time?”

He continues,

“Therefore, in this ordering we find that the world has a wonderful symmetry and there is a sure bond of harmony for the movement and magnitude of the orbital circles that cannot be found in any other way.”

Here, Copernicus is stressing the elegance and simplicity of his theory for he believes that, surely, God would not have created such a cumbersome model as that of Ptolemy.
**SLIDE 13** In Chapter 1, section 11, Copernicus describes a threefold movement for the Earth:

[1] A daily rotation about an axis at right angles to the equatorial plane. The direction is from west to east and produces day and night, with the Sun appearing to move from east to west. It also produces the observed rotation of the stars about the pole star.

[2] The second is the annual movement of the Earth around the Sun.

**SLIDE 14** [3] The third is associated with the inclination of the Earth’s axis with the plane of the ecliptic. Copernicus argues that if the angle between DF, the Earth’s axis, and AC remains constant, as in the upper figure, the line DF describes a conical surface and there will be no variation in the length of day and night. So, there must be an additional motion that keeps DF pointing in the same direction, as shown in the lower figure. It is the inclination of DF, the Earth’s axis, that produces the seasons. He did point out that the angle between DF and AEC does vary, but the difference is very slight. However, it does explain why the positions of the equinoxes changes with respect to the background stars.

**SLIDE 15** Copernicus took the traditional belief that all planetary motions were circular. However, after a careful review of earlier astronomical measurements, he concluded that the observed orbits of the planets were not simple circles, but that they could be constructed from combinations of circles. The black circle has the Sun at its center. A planet (red disk) is located on a epicycle whose center lies on the black circle. The center of the epicycle moves around the black circle while the planet revolves around the epicycle. For every revolution of the center of the epicycle, the planet makes two revolutions around the epicycle. The actual motion of the planet, shown in red, is not circular; it is eccentric as the
vertical height is the same as the black circle but the horizontal width is greater. Note also, the Sun is not at the center of this eccentric orbit.

I will highlight some other successes of the Copernican system; an explanation of retrograde motion, the precession of the equinoxes and the radii of planetary orbits. **SLIDE 16** First, an explanation of the retrograde motion of an outer planet when at opposition it a natural feature of the model, as shown in this example of Mars. In fact, the planets never reverse their motion, the observed behavior arises because of the relative motions of the Earth and planets. Since the Earth travels faster than the outer planets, the Earth catches up and passes the planets and as it does so, the planets appear to retrogress against the background of stars. *(Retrograde movie)*.

**SLIDE 17** Second, over history, astronomers had observed that the position of the pole star, about which all other stars appeared to rotate, was slowly changing, as were the dates and times of the equinoxes, i.e., when the day and night are of equal length. At present, Polaris is the pole star; in 12,000 years it will be Vega. **SLIDE 18** This phenomenon was explained by Copernicus. The N-S axis of rotation of the Earth slowly precesses around the precession circle completing one revolution every 26,000 years. It was this precession that was the subject of his *Letter against Werner*, a treatise he wrote in 1524, highly critical of a book published in 1522 by Johannes Werner with the title *The Motion of the Eighth Sphere*. In it, Werner described a method to account for the variations in the rate of precession of the equinoxes and the slow movement of the pole star. Werner claimed it was due to a motion of the so-called outer sphere of stars - the 8th sphere - around a stationary Earth. Copernicus sent the paper to one of his former fellow students for circulation. But,
unknown to Copernicus, Werner died in 1522 and so never saw the critique.

**SLIDE 19** Third, Copernicus was able to deduce the radii of planetary orbits and they are in remarkable agreement to today’s best values.

There are a number of differences between handwritten manuscript and the printed edition, mostly involving some minor reordering and editing. However, there are other passages that do not appear in the printed edition. **SLIDE 20** One example starts at page 11v where Copernicus has struck out several pages. The passage refers to earlier references to a “moving Earth” and the precession of the equinoxes. Some scholars have suggested that Copernicus was attempting to take sole credit for suggesting a Sun-centered system. I am not entirely convinced that’s the case because, as we saw earlier, in dedicating the book to Pope Paul III, he does refer to the Philolaus declaring that the Earth ...

“moves around the fire with an obliquely circular motion.”

Also, on page 4r, Copernicus states

“As a matter of fact, Philolaus ... held that the Earth moved in a circle ...”.

And so there are references to a previous “Earth-moving” theory. So I believe the criticism is a little unfair although I agree he could have said more.

In the mid-16th century, therefore, there were two hypotheses of the cosmos that “saved the appearances”. In principle, the Christian Church had no problems with either mathematical model despite them being contradictory! However, this was a very different matter from taking the position that the Copernican system represented physical reality.
There is no indication of how Pope Paul III, to whom *De Revolutionibus*, is dedicated, reacted to the new theory. However, it seems that Bartolemeo Spina of Pisa, who acted as the Pope’s theologian, wanted to condemn the book, but he fell ill and died before he could carry out his plan. It appears there was no official Catholic reaction to the book during the 16th century, so it was certainly not considered heretical. In fact, the book proved sufficiently popular that a second edition was published in Basel in 1566. But, as we will see in the next lecture, in March 1616, *De Revolutionibus* was condemned by the Holy Congregation and placed on the Index of Prohibited books until it was corrected. Of course, it was never corrected and remained as a forbidden book until 1758, when Pope Benedict XIV removed the uncorrected version from his revised Index.

Nicolaus Copernicus may not have been as colorful a figure as Tycho Brähe and Galileo Galilei, but he rose to the occasion when needed; his contributions to science have proved to be invaluable and we will never forget the quiet man from ‘the remotest corner of the Earth’.