Lecture 9
Copernicus on the Earth's Daily Rotation

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Introduction

- Ptolemy lived about 100–170 CE, in Alexandria, part of the Roman empire.
- Subsequently:
  - The Roman empire disintegrated and civilization declined in the west. Scholarship moved to the Arab world.
  - The Arabs tinkered with details of Ptolemy's system but didn't make fundamental changes.
  - The Arabs conquered Spain and scholarship trickled from Spain into Europe, while it was declining in the Arab world.
  - In the medieval and renaissance periods, Europe had become the center of scholarship.
- Nicholas Copernicus 1473–1543
  - Lived in what is now Poland; studied in Italy.
  - *On the Revolutions of the Celestial Spheres* published 1543.
  - Proposed fundamental change to Ptolemy's system: The sun is at rest in the center; the earth rotates on its axis once/day and orbits the sun once/year.

Possibility of proof

Osiander's foreword

- *On the Revolutions* was published in Nuremberg. Andreas Osiander handled arrangements with the publisher.
- Saying the earth moves went against established opinion and church teaching, hence was likely to provoke opposition. To try to prevent this, Osiander added a foreword to the book.
- Osiander said: *It is the duty of an astronomer to compose the history of the celestial motions through careful and expert study. Then he must conceive and devise the causes of these motions or hypotheses about them. Since he cannot in any way attain to the true causes, he will adopt whatever suppositions enable the motions to be computed correctly from the principles of geometry for the future as well as for the past. The present author has performed both these duties excellently. For these hypotheses need not be true nor even probable.* [XX]

Copernicus's response to Osiander

- Osiander had written to Copernicus, urging him to present his theory this way, not as the truth but merely as a device for calculating observed positions.
- We don't have Copernicus's reply but Kepler saw it and said:

  > *Strengthened by a stoical firmness of mind, Copernicus believed that he should publish his convictions openly, even though the science should be damaged.*

- Nevertheless, Osiander inserted the foreword.

Preface to the Pope

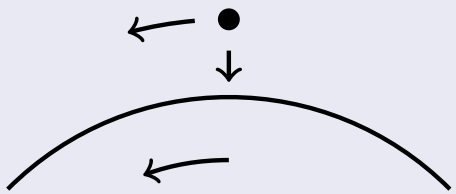
Copernicus wrote a preface to his book, addressed to the Pope. This is his attempt to deflect criticism for saying the earth moves. But he still makes it clear he's claiming the earth really does move and that he has a proof of it.

- *I debated with myself for a long time whether to publish the volume which I wrote to prove the earth's motion.* [3.15]
- *I have no doubt that acute and learned astronomers will agree with me if, as this discipline especially requires, they are willing to examine and consider, not superficially but thoroughly, what I adduce in this volume in proof of these matters.* [5.26]

Criticism of Ptolemy's arguments

Didn't prove the earth doesn't rotate

- Ptolemy's argument: Things not attached to the earth would all appear to move rapidly to the west.
- Copernicus's response for falling bodies:
  - *If anyone believes that the earth rotates, surely he will hold that its motion is natural, not violent.* [15.26]
  - Falling bodies (e.g., stones) are made of earth, so they share in this rotation as well as moving towards the center of the earth. Hence, relative to the earth, they move straight down.



  - *We must in fact avow that the motion of falling . . . bodies . . . is twofold, being in every case a compound of straight and circular. For, things that sink of their own weight, being predominantly earthy, undoubtedly retain the same nature as the whole of which they are parts.* [16.38]

- Copernicus's response for fire, which rises:

  Nor is the explanation different in the case of those things, which, being fiery, are driven forcibly upward. For also fire here on the earth feeds mainly on earthy matter. [16.42]

- For clouds and other things that hang in the air:

  We would only say that not merely the earth and the watery element joined with it have this motion, but also no small part of the air and whatever is linked in the same way to the earth. The reason may be either that the nearby air, mingling with earthy or watery matter, conforms to the same nature as the earth, or that the air's motion, acquired from the earth by proximity, shares without resistance in its unceasing rotation. [16.22]

Didn't prove the earth is at the center

- Ptolemy's argument: We see half the stars at one time, etc.
- Copernicus's response: This only proves that our distance from the center is too small to produce effects visible to us; it doesn't prove we are at the center.

> *Although [the earth] is not in the center of the universe, nevertheless its distance therefrom is still insignificant, especially in relation to the sphere of the fixed stars.* [14.23]

Didn't prove the earth doesn't move as a whole

- Ptolemy's argument: Since the earth is always at the center, it doesn't move as a whole.
- Copernicus's response: Since the earth may not be at the center, it could move as a whole. All that is proved is that the motion is insignificant in relation to the fixed stars.

Arguments that the earth rotates

1. *A rotation in twenty-four hours of the enormously vast universe should astonish us even more than a rotation of its least part, which is the earth.* [13.37]
   - The earth's surface must travel at 1000 miles/hour to rotate in 24 hours. The heavens would need to be traveling vastly faster to do the same.
2. *Immobility is deemed nobler and more divine than change and instability, which are therefore better suited to the earth than to the universe.* [17.28]
3. *Besides, it would seem quite absurd to attribute motion to the framework of space or that which encloses the whole of space, and not, more appropriately, to that which is enclosed and occupies some space, namely, the earth.* [17.30]

Questions

1. What did Osiander say in the Foreword to *On the Revolutions*? Did Copernicus agree with this? Support your answer to the latter question with a quotation from Copernicus.
2. One argument against the rotation of the earth was that falling bodies are seen to fall straight down, which would not happen if the earth were rotating. How did Copernicus answer this objection?
3. How did Ptolemy argue that the earth cannot move as a whole (i.e., from place to place, as opposed to merely rotating in one place)? What was Copernicus's reason for saying that Ptolemy's argument was not conclusive?
4. State three reasons Copernicus gives for believing that it is the earth that rotates once a day, not the heavens.

Reference


Nicholas Copernicus.
On the Revolutions of the Heavenly Spheres.
Johns Hopkins University Press, 1992.
Translation by Edward Rosen.
Numbers in brackets are page and line numbers of this edition.
Text on the web (without page or line numbers).