Chapter 7

Ptolemy vs. Copernicus: How the facts do not always dictate our theories.

7.1 Homework

Readings – DW 10-14

Study questions – Give a short answer to the following questions:

1. What are Ptolemy's arguments for the idea that the Earth is stationary and at the center of the universe?
2. Explain in more details the problem of stellar paralax
3. Make a list of the empirical facts (observed with a naked eye) which any theory of astronomy has to account for.
4. Explain the line of reasoning that would lead the scientists up until the Scientific Revolution to think that heavenly bodies move in a perfect circular motion.
5. Did the people before 1600 have any strong reason to choose Copernicus' system over Ptolemy's?

7.2 Introduction

The goal of this chapter is to:

1. Study the beginning of the scientific revolution : the systems of Ptolemy and Copernicus
2. Discuss the criteria of theory choice:

- Do the facts dictate our theories? Our answer will be : certainly not always

- What other considerations do we take into account in order to choose our scientific theories? we will discuss in particular aesthetics reasons like simplicity, and the coherence with the current worldview.

7.3 The facts to save: empirical and conceptual

Minimal Requirement for a theory – We have discussed the various "goals" that one can assign to theories, depending on whether we take a realist or an instrumentalist stance towards science.

That said:

A minimal requirement that a scientific theory should fulfill is that it saves the relevant phenomena

In other words: a theory should get the right predictions in its *domain*

IMPORTANT NOTE: It is not required that a scientific theory saves all the phenomena, but only *the relevant phenomena*, that is, *the phenomena in its domain.*

Example: Quantum Mechanics and Relativity

That said, *to be compatible with the current best theories is certainly an additional advantage that a theory can have over its competitors*

The facts to save – Empirical

Celestial Physics – Observations on heavenly bodies:

- Stars and Planet: unchanging, constant motion
- Stars: circular uniform
- Planets (wandering stars):
  - retrograde motion
  - varying brightness
  - Mercury and Venus never far from the Sun
  - No stellar paralax

Terrestrial Physics – Observations on Earth:

- No wind
- "Things stop" principle – no permanent motion
- Earthy stuff goes down
- Objects don't fly off
- The Earth does not move when we jump

The facts to save – Conceptual

The most important conceptual fact is that the heavenly bodies move in a uniform circular motion.

What is the rationale for this conceptual fact?

Constant Motion, and Unchanging motions $\longrightarrow$ Perfection of Heavenly Bodies

Perfection of Heavenly Bodies $\longrightarrow$ Uniform, Circular motion (perfect motion)

7.4 Ptolemy's model: the best model within the Aristotelian Worldview

Ptolemy – the astronomer

- We don't know much about him

- Around the 2nd century C.E.

- No great inventions but a fantastic synthesis of all the knowledge available in one single system and one single book: *Almagest*

Ptolemy – the system : *the challenge is to give all the right predictions about celestial observation with a system in which there are only uniform circular motions*

- Sphere of fixed stars

- Deferent- epicycle system $\longrightarrow$ gives him the retrograde motion

- Eccentrics give him more flexibility for empirical accuracy

- Equants give him the uniformity of motion

Ptolemy's system – Pros and Cons

PROS:

- Gets the predictions right

- Compatible with the best physics available

CONS:

- Problem of equants

7.5 Copernicus's model: Theory and evidence

Copernicus – the astronomer

- 16th century (14 after Ptolemy!)

- Not a revolutionary man: devoted to the Pope, etc.

Copernicus is *not* the man which is sometimes described: the hero who has the courage to speak against the old Aristotelian worldview, and against the Church, because of the overwhelming evidence that his model is a better model.

In fact, every tiny bit of this image of Copernicus is false:

- did not go against the Church, and the Church did not go against him ! His system was taught and used all over Europe without any trouble– Instrumentalism

- did not go against Aristotle's views: if anything more committed than anyone else to the uniform circular motion

- Copernicus' model is not clearly better than Ptolemy's – in terms of predictions, Copernicus' model is arguably less good than Ptolemy's !

Copernicus' motivations – why fix something which is not broken???

- Copernic is a Neoplatonist (Roughly, Christian gloss on Platonism: the Good = God)

- Sun at the center of the universe = God at the center of the universe

- Perfect uniform circular motion = The world is fundamentally mathematical

For Copernicus, the need for equants in Ptolemy's model is a real problem. As a neoplatonist, Copernicus is more committed than the usual astronomer of his times to the uniform circular motion

Copernicus' cosmological model – main features:

- Sphere of fixed stars (both models look roughly the same)

- Deferent, epicycles and eccentrics

- No need for equants to get uniform motion

- Heliocentrism of course

Copernicus' model – Conclusion

You may have thought that Copernicus model was both simpler and more accurate in its prediction than Ptolemy. It is not the case:

Not Simpler – Both models are rather complex. Both need epicycles, deferents and eccentric.

Not better at predictions – If anything, there seems to be a real disconfirming evidence against Copernicus' model: the problem of stellar paralax

Better uniform circular motion – because he does not need the equants, Copernicus' model is closer to the Aristotelian view that heavenly bodies' motion is uniform and circular due to their perfection

Incompatible with the best available physics – on the other hand, Copernicus' model is radically at odds with the current terrestrial physics.

What would *you* do as a scientist? Which model do you choose?

7.6 Comparison: Criteria for theory choice

Ptolemy vs. Copernicus – Comparison

- Both save the relevant phenomena

- Copernicus is better for the conceptual fact of uniform circular motion – No equants

- Copernicus gives a better explanation of the retrograde motion – plus a few things like brightness and the fact that Mercury and Venus stay close to the Sun

- But Copernicus has a big problem with the terrestrial physics

- And Copernicus has a big problem with the stellar parallax : Case of disconfirmation???

Criteria for Theory Choice – theory choice is not straightforward:

- Some theories are *empirically equivalent* – they have the same predictions for the relevant phenomena

- What are the criteria in this case?

* Coherence with the best physics available?

* Simplicity?

- Note that if you are an instrumentalist, you don't need to choose: USE BOTH !