Philosophy of Science Survey

Week 7

PHIL 2160. Ohio University. Spring 2021.

Chapter 11: Astronomical Data: The Empirical Facts

Facts (Review)

- Remember *facts* is our technical term. It will not mean what we mean in everyday contexts!
- Everyday (dictionary) meaning:

fact. n. “A thing that has actually happened or that is really true; the state of things as they are; reality; actuality; truth [fact as distinct from fancy]”

Facts (Review)

Our technical meaning:

A fact is a belief that is *deeply held and well-justified* in a given context of time.

Note:

1. A fact is a kind of belief.
2. A fact is not the same as truth (in our technical sense): A fact is a belief, so it can be true or false.

Empirical and Conceptual Facts (Review)

Our technical meaning:

A fact is a belief that is *deeply held and well-justified* in a given context of time.

- A belief is well-justified if it has good evidence for it.
- We have recognized direct and indirect evidence, so we can recognize varieties of facts based on the source of evidence.

Empirical and Conceptual Facts (Review)

- An *empirical fact* – a belief that is deeply held and well-justified in a given context of time, and the primary source of justification is direct evidence.
- A *conceptual fact* – a belief that is deeply held and well-justified in a given context of time, and the primary source of justification is indirect evidence, that is, the belief's coherence with other beliefs of a worldview.

Instrumentalism and Realism as Attitudes (Review)

- We use scientific theories for:

1. Prediction of the future states
2. Explanation of the data ("explanation" in the minimal sense)
3. Understanding why

- **Instrumentalism:** Theories should aim at prediction (1) and explanation (2), and they are adequate without providing understanding (3).
- **Realism:** Theories should aim at providing understanding (3), so theories should describe what the mind-independent reality is like, including both the observable and unobservable parts of it.

Aims of Astronomical Theories

- Regardless of whether scientists are instrumentalist or realist, adequate theories should do the following well:

1. Prediction of the future states
2. Explanation of the data ("explanation" in the minimal sense)

- So adequate astronomical theories should accurately predict and explain the data. (Review prediction and explanation next)

Instrumentalism and Realism as Attitudes (Review)

Prediction

- We use scientific theories to make predictions about the future states of affairs.

Explanation (in the minimal sense)

- We use scientific theories to explain the available data.
- Explanation in this sense is not fundamentally different from prediction.
  - The difference is only that we are "predicting" something that is already observed (the available data). (Sometimes, this is called retrodiction.)

Empirical facts as data to be explained

- Since prediction and explanation of the data are fundamentally similar, we will be dropping one of the words when the context is clear.
  - E.g., DeWitt says "we need to look at some of the data the theories were primarily designed *to handle*." (Ch. 11)
  - "To handle" means to explain (in the minimal sense).
- But what does DeWitt mean by "the data"?

Empirical facts as data to be explained

- “As we discussed in earlier chapters, whatever else we wish from theories, they must at a minimum be able to explain and predict the relevant data. In other words, generally speaking there will be a body of facts that are relevant to a particular theory, and the theory should be able to explain and predict these facts.” (DeWitt, Ch. 11)
- Empirical facts serve as the relevant data to explain.
- So a theory aims to explain empirical facts.
- This means that a theory does *not* aim to explain every datum.

Empirical facts as data to be explained

- In other words, a scientific theory does not aim to explain every empirical phenomenon you might want to be explained.
- In a given period of time, scientists identify certain things as the relevant data to be explained–i.e., empirical facts to be explained–by their theories.
- This is a subtle but important point: when scientific theories change over time, it's not just the theories that change. The facts to be explained change too. (Example next)

Empirical facts as data to be explained

- It is a fact (strongly held and well-justified belief) that on the Earth, a rock falls towards the ground.
- Why?
- You might say, “because of gravity,” and let’s assume that you mean in the Newtonian sense.
- But notice that “because of gravity” does not answer the question. Gravity just means attraction of two or more bodies.
- That is, your answer is merely redescribing the fact to be explained.

Empirical facts as data to be explained

- In other words, our question is really: “Why does a rock get attracted by or pulled towards the Earth?”
- The Newtonian worldview has no answer to this question, because for the Newtonian physical theories, *gravitational attraction is not what to be explained*.
  - Instead, the Newtonian worldview asserts gravitational attraction as a law of nature that obtains between any two bodies.

Empirical facts as data to be explained

- But the Aristotelians can answer our question. (Review last week)
- “Why does a rock get attracted by or pulled towards the Earth?”
- The Aristotelian answer would go like this:

  > Because the rock is made of the earth element, and the earth element’s purpose or natural place is the center of the universe. And the Earth is at the center of the universe.

- Even if you are not satisfied with this answer, you can still see that it’s not merely a restatement of the fact to be explained.

Empirical facts as data to be explained

- In other words, a scientific theory does not explain everything you might want to be explained.
- In a given period of time, scientists identify certain facts as the relevant data to be explained by their theories.
- In this chapter, we study what the Aristotelians took to be the empirical facts to be explained by an astronomical theory.

Empirical Facts in the Aristotelian Astronomy

- An *empirical fact* – a belief that is deeply held and well-justified in a given context of time, and ***the primary source of justification is direct evidence***.
- ***Direct evidence***: sensory experience, such as naked-eye observations (review Week 2)
- The empirical facts relevant for the Aristotelian astronomy are all justified by naked-eye observations of the sky.

Quiz 5

Empirical Facts in the Aristotelian Astronomy

- "Importantly, this is a chapter on the relevant empirical facts, and so when we are speaking of movement, the emphasis is on the *observed* movement of the sun, moon, stars, and planets. For example, when we speak of the movement of, say, Mars, the issue is not whether Mars moves in an elliptical orbit, or a circular orbit, or any other type of orbit. Rather, the emphasis is on the observed movement of Mars. More specifically, **there is a point of light, visible in the night sky, that by convention we call "Mars." That point of light moves in a particular way.** When we speak of the movement of Mars, then, **we are speaking of the straightforward, empirical, directly observable fact about how that point of light moves across the night sky**." (DeWitt, Ch. 11)

Empirical Facts in the Aristotelian Astronomy

- We today have many beliefs about stars and planets that are justified by more than naked-eye observations (examples next).
- These beliefs prevent us from understanding the Aristotelian beliefs.
- So for now let's talk about "dots" or points of light in the sky.

The rim of Jezero Crater as seen in the first 360-degree panorama taken by the Mastcam-Z instrument aboard NASA's Perseverance Mars rover.

https://mars.nasa.gov/resources/25640/mastcam-zs-first-360-degree-panorama/

The Great Conjunction of 2020 (https://en.wikipedia.org/wiki/Great_conjunction). Taken with a 6" Dobsonian reflector telescope and a SV105 CMOS sensor on December 21st, Image was stacked and processed using PIPP, Registax 6, Autostakkert 3! and Adobe Photoshop. Galilean moons Ganymede and Io are left of Jupiter, and Europa right of Jupiter. Saturn's moon Titan is located top right of Saturn.

https://www.forbes.com/sites/jamiecartereurope/2020/10/10/mars-at-its-brightest-since-2003-as-moon-visits-venus-what-you-can-see-in-the-night-sky-this-week/?sh=2ff10a5c2d13

https://en.wikipedia.org/wiki/Milky_Way

Empirical Facts in the Aristotelian Astronomy

Basic Empirical Facts

1. There are two families of dots in the sky.

a. Dots of the first family move together as a group, maintaining their relative positions. This motion is regular over one night and over many nights.

b. Dots of the second family drift with respect to those of the first family. Over many nights, their relative positions with dots of the first family change.

- This distinction is very important.

Empirical Facts in the Aristotelian Astronomy

Basic Empirical Facts

1. There are two families of dots in the sky.

These dots are called "fixed stars."

a. Dots of the first family move together as a group, maintaining their relative positions. This motion is regular over one night and over many nights.

b. Dots of the second family drift with respect to those of the first family. Over many nights, their relative positions with dots of the first family change.

These dots are called "planets."

Empirical Facts in the Aristotelian Astronomy

Basic Empirical Facts

2. *There are five planets.*

a. The word "planet" just means "wanderer" in ancient Greek.

b. The empirical fact here just means that there are five dots of the second family we just discussed.

- DeWitt presents more details (like brightness), which you don't have to memorize.

Sky Map

- https://in-the-sky.org/skymap.php

Empirical Facts in the Aristotelian Astronomy

Basic Empirical Facts

3. There are the sun and the moon.

4. The sun and the moon move across the sky in particular ways.

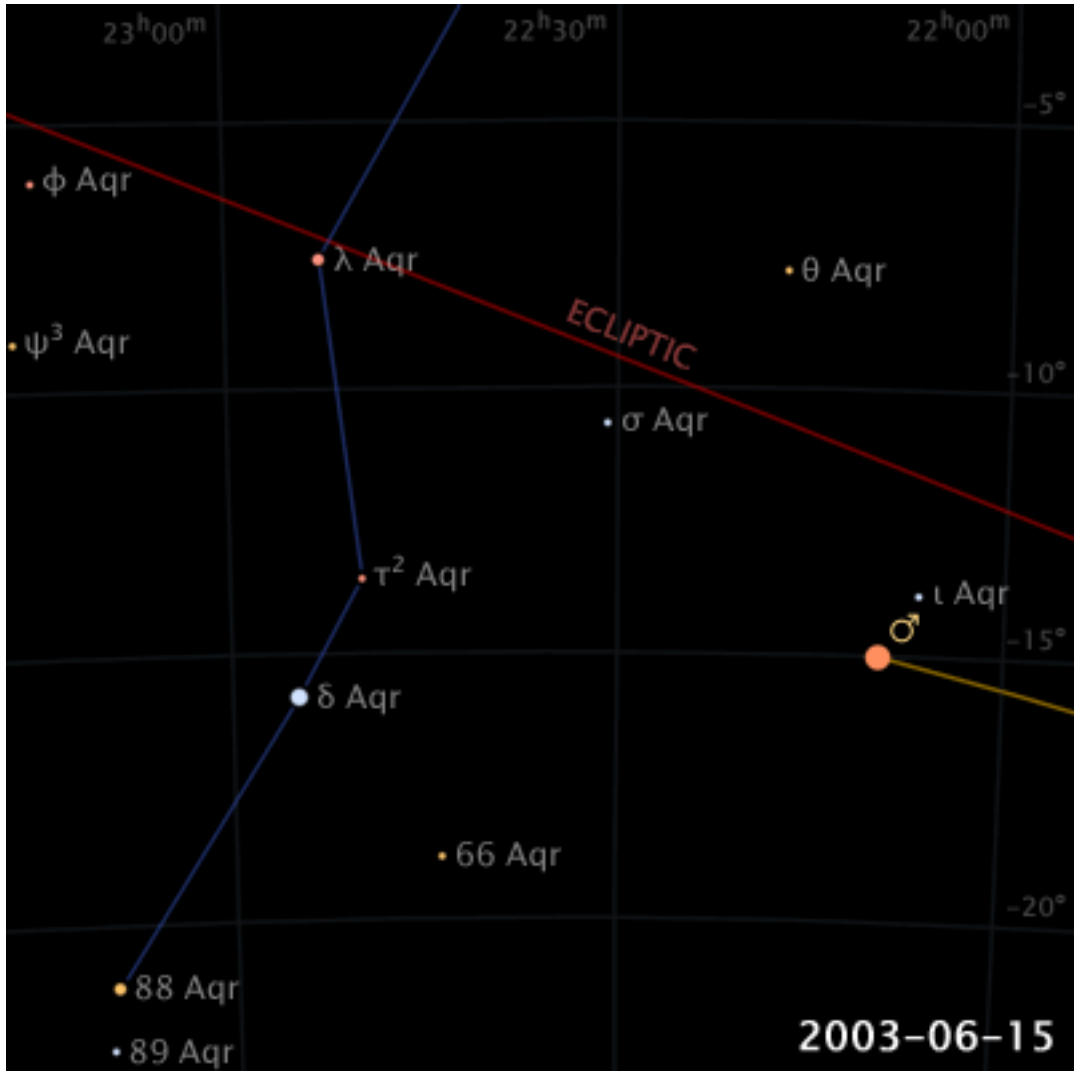
- You are familiar with basic motions, like the sun's daily motion.
- You don't need to memorize details presented in the textbook.

Empirical Facts in the Aristotelian Astronomy

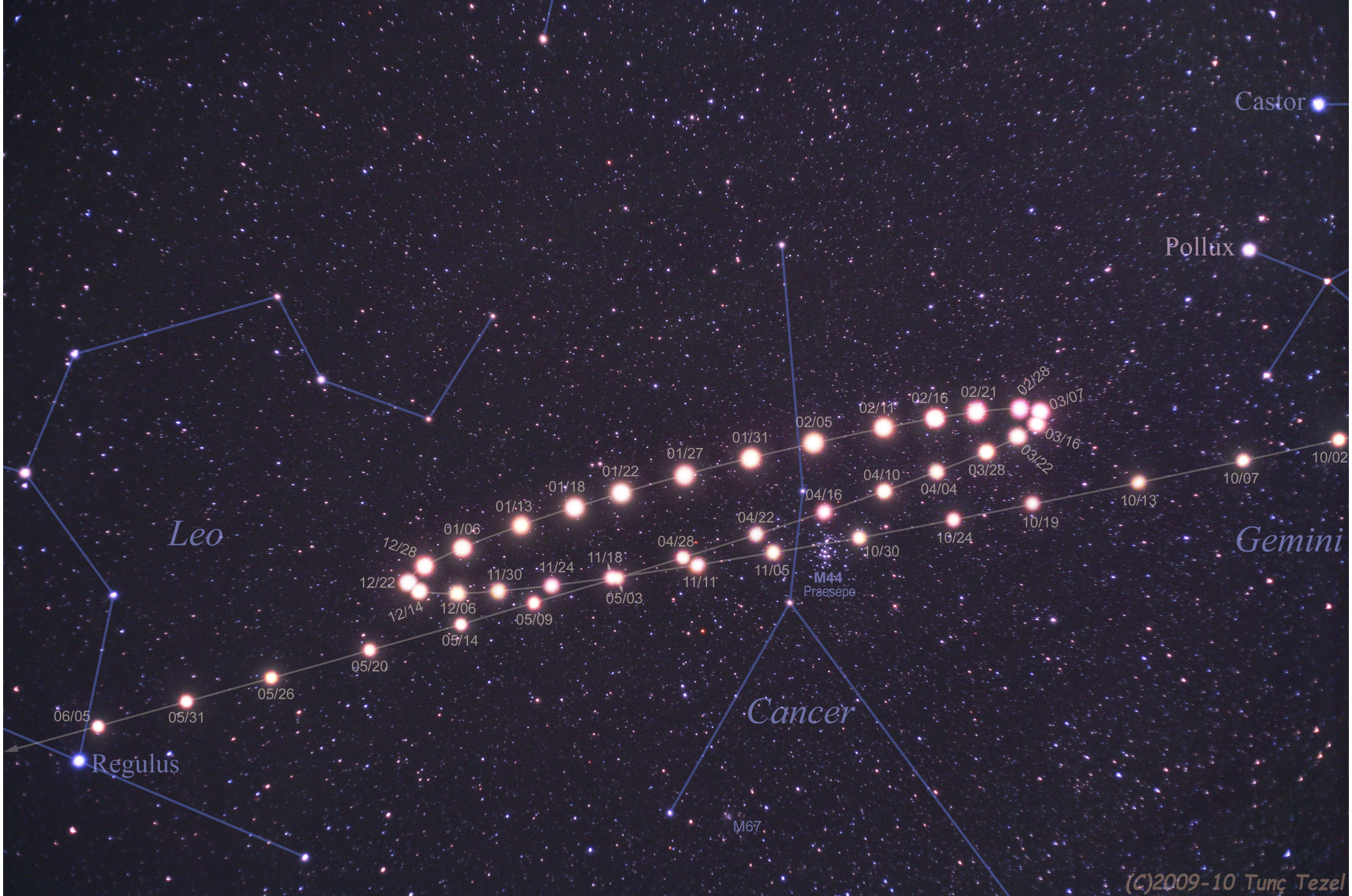
Basic Empirical Facts

5. Planets exhibit retrograde motion.

- This is the most important *observed* motion of planets, and you should be able to describe it.
- Note that "retrograde motion" refers only to *observed motion of the dots in the sky*. We are not talking about whether celestial bodies really move in this way.



Retrograde motion of Mars as seen from Earth (2003)


Castor
Pollux
Leo
Gemini
Cancer
Regulus
M44
Praesepe
M67
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01/13
01/18
01/22
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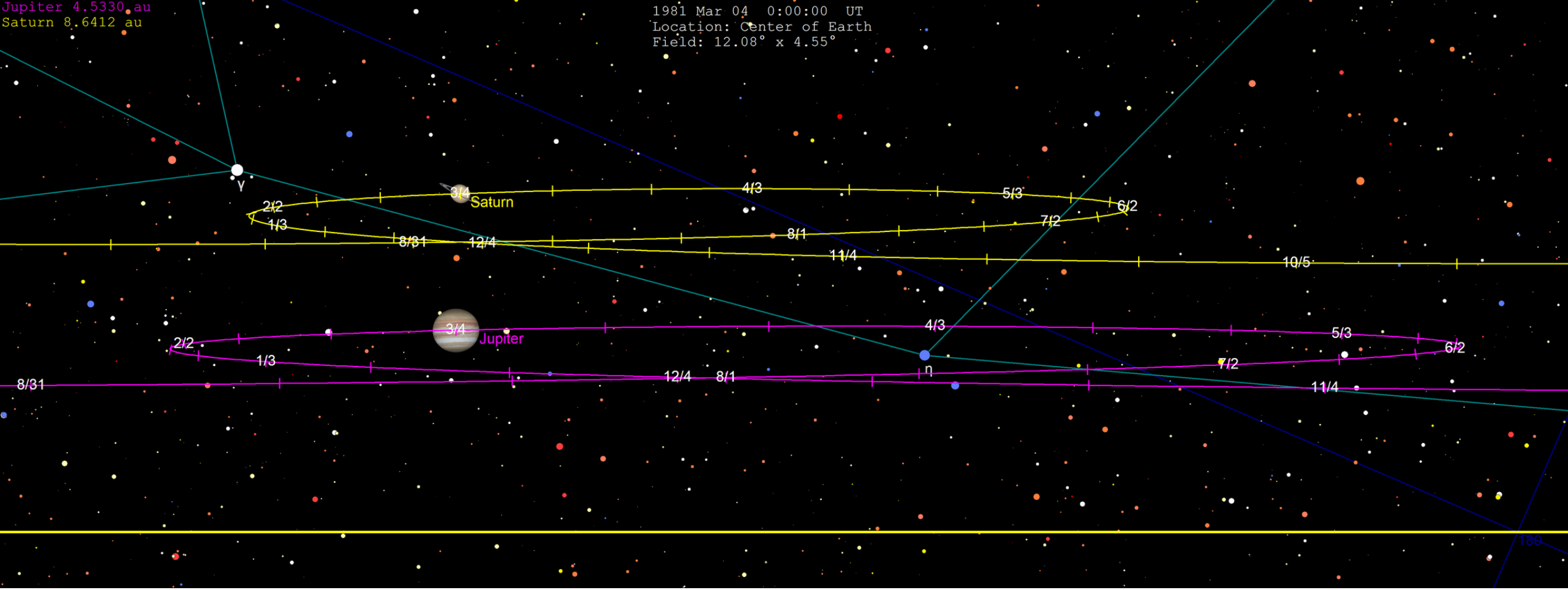

Diagram showing the movements of Jupiter and Saturn during the 1980–81 triple conjunction (https://en.wikipedia.org/wiki/Great_conjunction)

Note the retrograde motions.