

# The stars and the Earth

Astronomy 101  
Syracuse University, Fall 2021  
Walter Freeman

September 2, 2021

# The celestial sphere of the stars

“I know that I am mortal by nature and ephemeral, but when I trace at my pleasure the windings to and fro of the heavenly bodies, I no longer touch earth with my feet. I stand in the presence of Zeus himself and take my fill of ambrosia.”

–Claudius Ptolemy, from the *Almagest* (c. 150 CE)

Schema huius præmissæ diuisionis Sphærarum.



“Ooh, the wheel in the sky keeps on turning // I don’t know where I’ll be tomorrow...”

–Journey, “Wheel in the Sky” (1978)

# Some announcements

If you missed class Tuesday:

- Course website: [walterfreeman.github.io/ast101/](https://walterfreeman.github.io/ast101/)
- The syllabus, exercises, homework, readings, etc. are all there
- Use the invite link there to join the Discord server if you wish
- Email for information: [wafreema@syr.edu](mailto:wafreema@syr.edu)
- Extra colored cards will be available each class, but they cost us a bit of money, so try to bring yours
- Prelabs have been printed and put in the Physics Clinic
- Having trouble installing Stellarium on your Mac? See the website for details.

Office hours:

- Wednesday, 2-4 PM
- Friday, 10-12 AM
- Subject to change occasionally when people more important than me schedule meetings I have to be at

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- I am not very important :(

## Some announcements

Lab section changes are tricky because things are very full. We can't run lab sections over capacity; there is physically no room.

I can't do anything to override this or help you swap sections. If you need to swap sections, you can do it on MySlice.

If you sometimes come to the other *lecture* section than the one you signed up for, we won't probably even notice. Feel free to do this once in a while.

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What should we do with these?

# Where does science start?

We will study the nature of science in depth later in our course.

The most fundamental property of science: **empiricism**.

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<https://youtu.be/85pRKD9EVqQ>

# The night sky and the celestial sphere: overview

- What's the night sky look like?
- How have we affected the night sky?
- How does the sky move each night?
  - The celestial-sphere model
  - Why it works, and when it doesn't
  - The first *Lecture Exercise*

# Light pollution

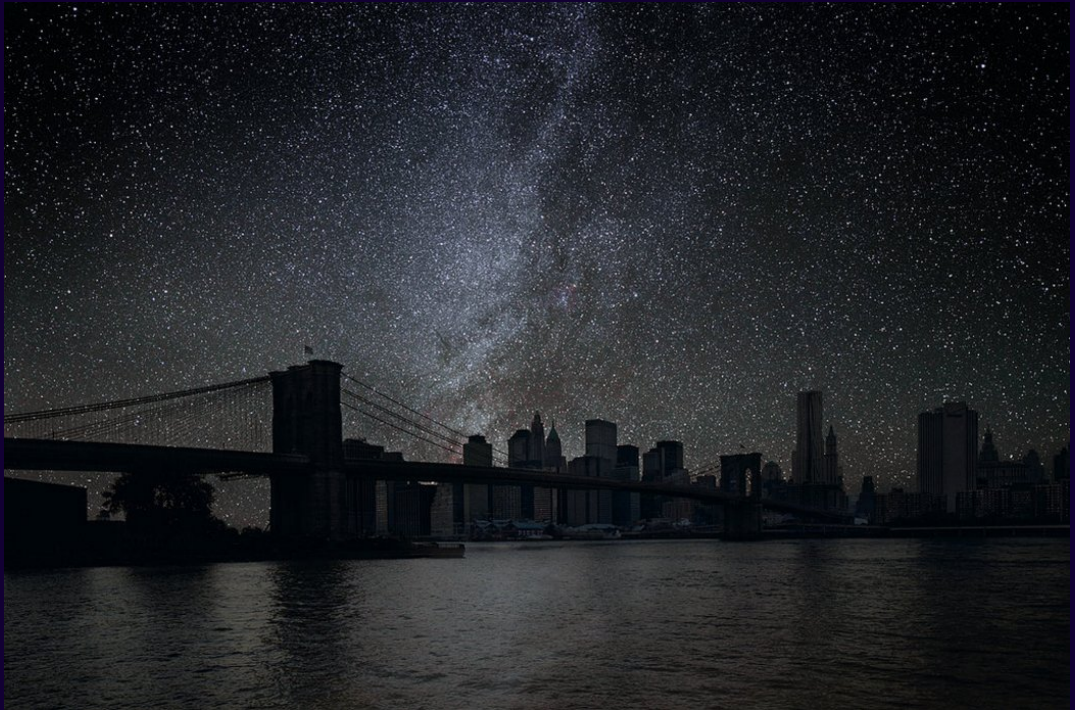
What do you think about this picture?





# Light pollution

This is what we could have instead!



*(Thierry Cohen, published in the New York Times)*

# Alamut, Iran



Photo by Babek Tafreshi. Alamut was the home of Nasir al-Din al-Tusi, the first to surmise that the Milky Way was made of many stars in the 13<sup>th</sup> century. The glow is light pollution from Tehran, 100 km away.

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- Haley: The moon is visible north of the “AXA” building, but it's difficult to describe because if I was standing in a different location, then perhaps it would be north of the Marshall residences or North of the Carrier Dome? (11pm)

# Motion and time

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- **In one year** the Earth orbits the Sun.
  - (It takes between a few months and a few decades for the other visible planets to orbit the Sun.)
- **It takes hundreds of thousands of years** for the distant stars to move appreciably relative to us.

In one day, how much does the Earth move around the Sun?

A: Not at all

B: Less than one degree: not enough to notice without instruments

C: About one degree

D: About ten degrees: enough that we notice it readily

E: All the way around

In one *hour*, how much does the Earth move around the Sun?

A: Not at all

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The kind of math I just did is the sort of thing you'll use in this class.

I didn't do anything fancy – just “back-of-the-envelope” estimation.

This kind of math is quite important in astronomy (and physics!)...

... and it's not difficult.

In one *hour*, how much does the *Moon* move around the Sun?

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In the course of a day, the only significant motion that happens is that  
the Earth turns on its axis!

We can simulate the night sky tonight using *Stellarium* – the program you'll need for your prelab.

It's available for free on Linux, Mac OSX, and Windows.

- Ubuntu users: `sudo apt install stellarium`
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- Mac users: see the link on the website (not sure about M1 compatibility yet, someone tell me about this if you don't mind)

The “celestial sphere” model of antiquity:

- All the stars are attached to a sphere, very far away
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- All the stars are attached to a sphere, very far away
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How much of the celestial sphere can we see at a time?

A: All of it

B: More than half

C: Half of it

D: Less than half

E: It depends on your latitude

# How good is this “celestial sphere” model, anyway?

A: It's completely wrong; we know it's not like that!

B: It's pretty close to correct, with a few exceptions

C: It's correct, just look at the sky!

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E: I thought Dr. Freeman was supposed to tell *us* this stuff?

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Discuss with your neighbors: what's wrong with the celestial sphere?

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Actually, (——) rotates, and (——) doesn't move much at all.



# Problems with the celestial sphere: I

Discuss with your neighbors: what's wrong with the celestial sphere?

Is it really true that *every* star in the sky moves in the same way, all together?

Actually, (——) rotates, and (——) doesn't move much at all.

(Lots more on this Tuesday!)

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Is it really true that all the stars are stuck to a sphere, all at the same distance from us?

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No; we just don't have any “depth perception” of things this far away.

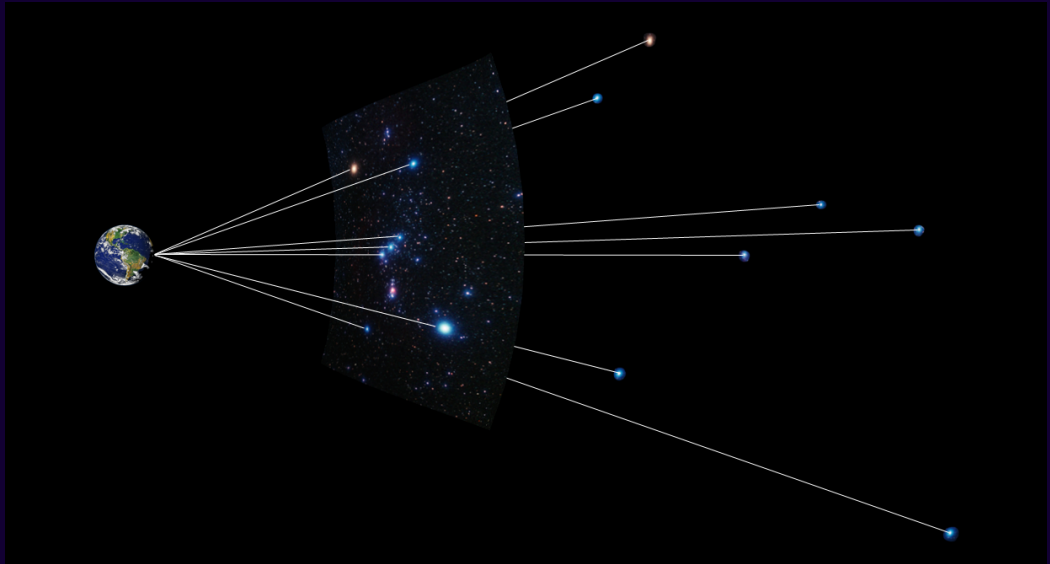
## The constellation of Orion:



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The reality:



# Why the celestial sphere still explains a lot

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- The Moon moves around the Earth

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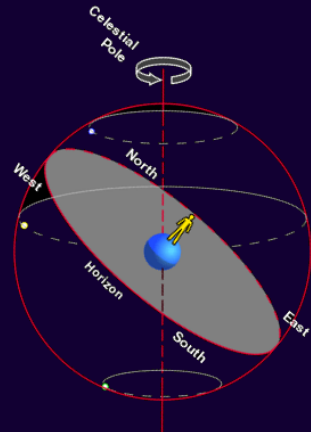
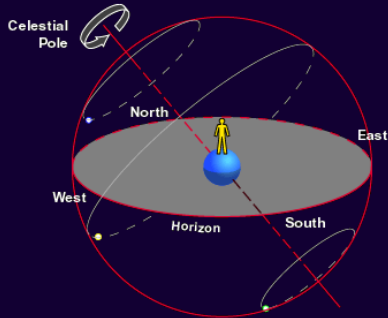
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- The Earth and the planets move around the Sun
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- ... so the model will need some modification for those things over longer times!

# Summary

- We can treat the stars as all rotating together, on an invisible sphere far away
- We expect this to get the stars “right” and the planets and Sun “wrong” over longer times
- The axis of rotation is the same as the Earth’s, and it rotates once per day
- Only half of the sphere is visible, because the Earth is in the way
- **Horizon**: a plane lying along the Earth at our location
- **Zenith**: the point directly overhead
- **Celestial pole**: the point about which the stars appear to rotate



# How many celestial poles are there?

A: One

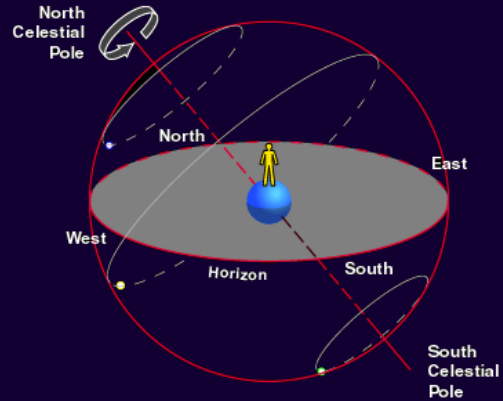
B: Two

C: Three

D: Four

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- A: One
- B: Two
- C: Three
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Complete the handout we gave you on the way in. We will do something else after this.

# Which are true in Syracuse?

- I: Some stars are always visible (at night).
- II: Some stars are only visible sometimes; they rise and set during the night
- III: Some stars are never visible

A: I only

B: II only

C: III only

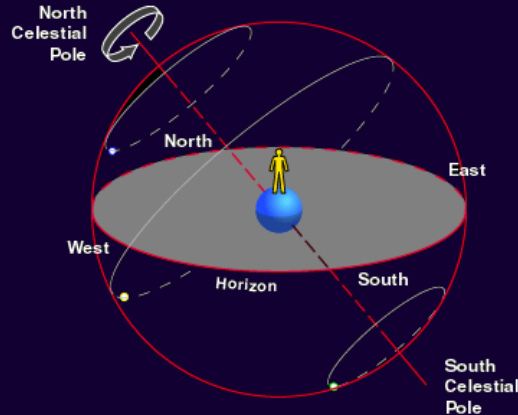
D: I and II

E: I, II, and III



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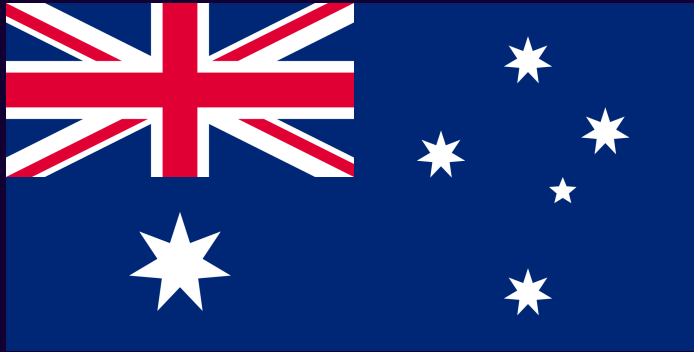
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The Australian flag, with a pattern of stars called the Southern Cross.  
These stars are only visible in the Southern Hemisphere!