The stars and the Earth

Astronomy 101
Syracuse University, Fall 2022
Walter Freeman

September 1, 2022

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)

"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/`
- The syllabus, exercises, homework, readings, etc. are all there
- Use the invite link sent by email join the Discord server if you wish
- Email for information: 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.

Some announcements

Office hours:

- Wednesday, 2-4 PM
- Monday, 10 AM-12 PM
- Walter's office hours: Friday, 2-4 PM (I think)
- 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.

Homework and sundry

Your first homework assignment is included in the Exercises you will get today.

You won't turn your homework in. Instead:

- Each homework set will ask you a series of questions.
- On the day when it is "due", you'll have a quiz in class
- The questions on the quiz will be extremely similar to the homework...
- ... and the homework will say exactly what form they will take.

Where does science start?

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`https://youtu.be/85pRKD9EVqQ`

The night sky and the celestial sphere: overview

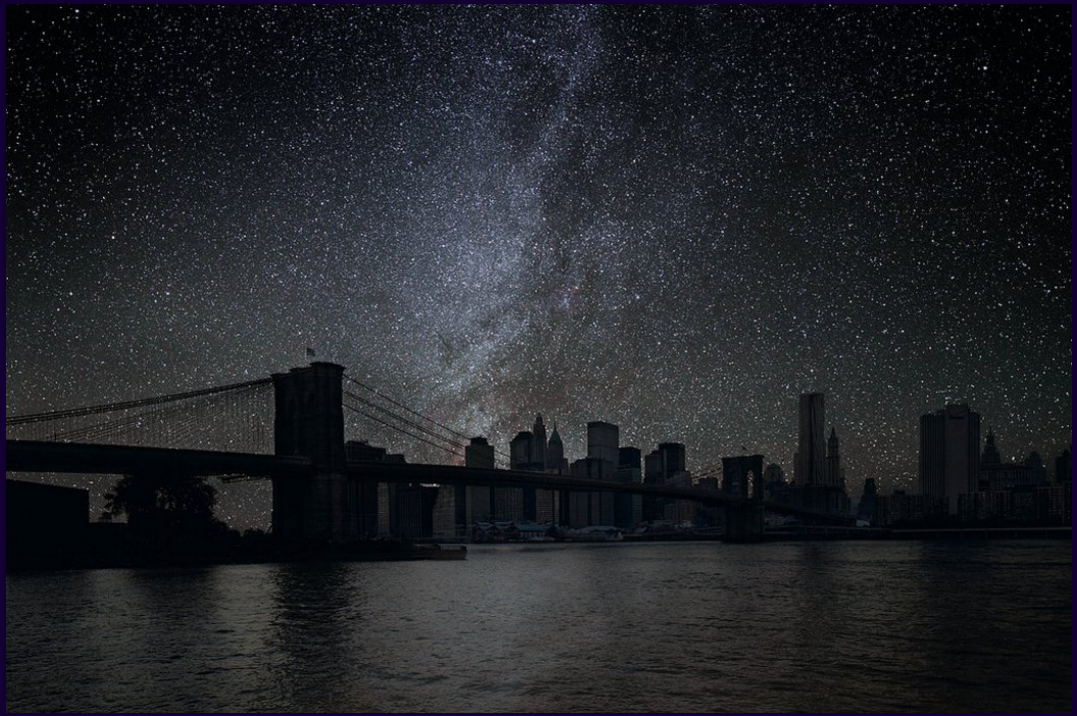
- What's the night sky look like?
- How have we affected the night sky?
- How does the sky move each night?
  - The celestial-sphere model
  - Why it works, and when it doesn't
  - The first *Exercise*

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^{th} century. The glow is light pollution from Tehran, 100 km away.

Canyonlands National Park, Utah

Taken in summer 2017: ISO 6400, f/1.8, 13 seconds

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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)

Virtual planetarium software

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.

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- Mac users: see the link on the website (should be compatible with both M1 and Intel Macs)

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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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D: It explains a lot of things, so it must have *some* use

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.

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(Lots more on this Tuesday!)

Problems with the celestial sphere: II

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

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

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

Depth and the sky

The constellation of Orion:

Depth and the sky

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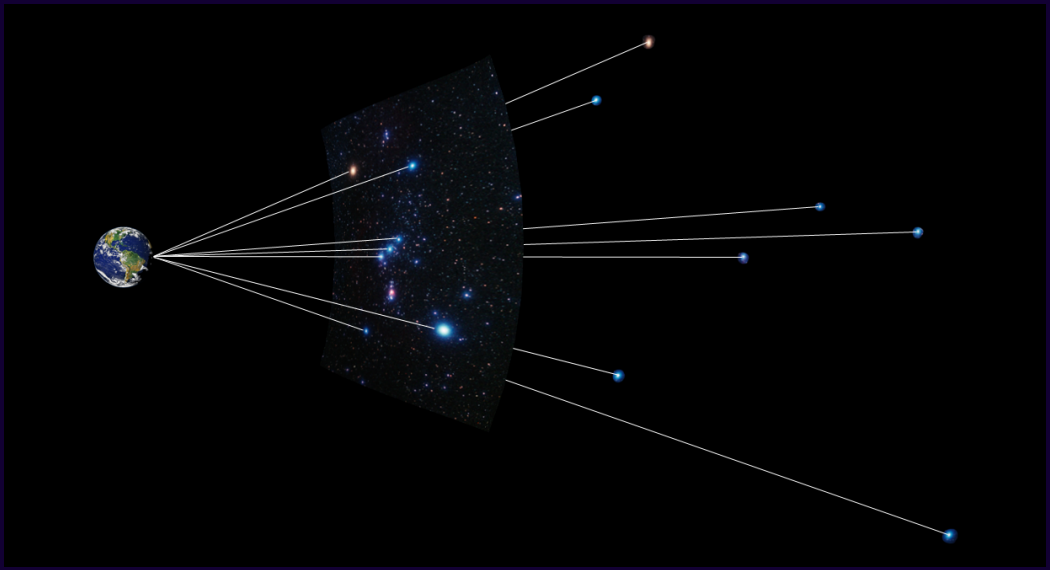
The reality:



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

Drawing the sky: a demo

One critical skill in science is drawing diagrams. Rather than just show them to you, I'm going to show you the process of drawing them.

In-class exercise

Complete the handout we gave you on the way in. We will do something else after this.

Motion and time

Last time we talked about the distance scales involved in astronomy.

It's also important to understand the scales in 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.)

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- In one month the Moon orbits the Earth.
- 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.

Motion and time

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

Motion and time

In one *hour*, 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

A note on math

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.

Why the celestial sphere still explains a lot

Key idea: It doesn't matter if Earth rotates or the celestial sphere rotates: relative motion controls what we see!

- The celestial sphere model is just dizzy!

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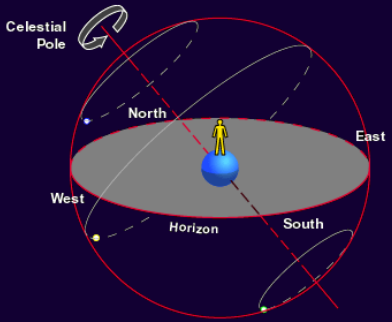
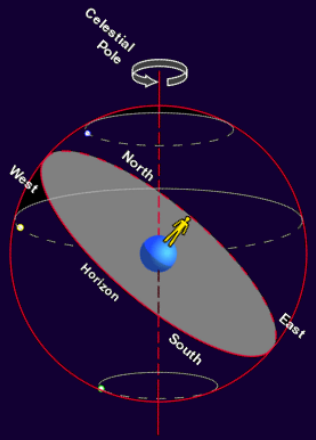
- The Earth and the planets move around the Sun
- The Moon moves around the Earth
- **... so the model will need some modification for those things over longer times!**

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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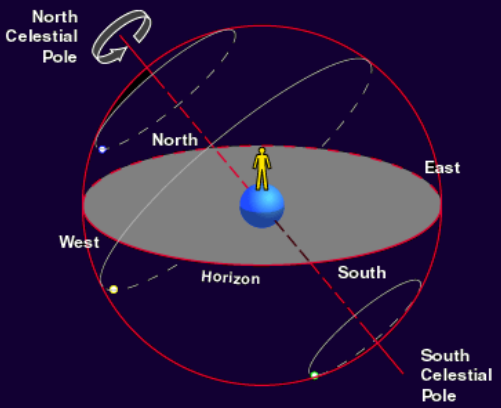

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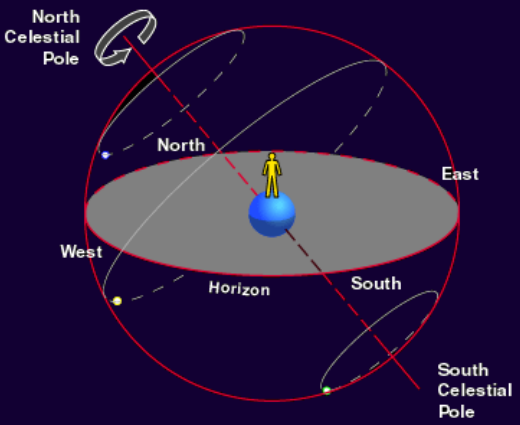

What is this?

What is this?

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