What's out there...
... how we learn about it ...
... and why it's awesome.

Astronomy 101
Syracuse University, Fall 2019
Walter Freeman

August 27, 2019

Welcome!

The size and age of the Cosmos are beyond ordinary human understanding. Lost somewhere between immensity and eternity is our tiny planetary home. In a cosmic perspective, most human concerns seem insignificant, even petty. And yet our species is young and curious and brave and shows much promise. In the last few millennia we have made the most astonishing and unexpected discoveries about the Cosmos and our place within it, explorations that are exhilarating to consider. They remind us that humans have evolved to wonder, that understanding is a joy, that knowledge is prerequisite to survival.

I believe our future depends powerfully on how well we understand this Cosmos in which we float like a mote of dust in the morning sky.

–Carl Sagan, from *Cosmos*

Welcome!

When we contemplate the whole globe as one great dewdrop, striped and dotted with continents and islands, flying through space with other stars all singing and shining together as one, the whole universe appears as an infinite storm of beauty.

–John Muir, from *Travels in Alaska* (1915)

Welcome!

Today:

- Who we are
- Who you are
- What this class will be

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- Who you are
- What this class will be
- What the Universe is, too
  (and how we measure it)

Introduction

Course website: `https://walterfreeman.github.io/ast101/`

- Professor: Walter Freeman
- Lead TA: Suman Kumar Kundu
- Other TA's...
- Undergraduate coaches...

My email: wafreema@syr.edu
Suman's email: skundu@syr.edu

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Slack

We will be using Slack as a communication tool in our course. It's commonly used for professional collaboration in many business settings.

It combines the good features of email and group messaging; it's basically Discord for professionals.

Take a few minutes to join now, say hi, and send memes...

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I will have my laptop running Slack on the podium each day, and will respond to comments and questions that you ask there. (You can of course raise your hand or just shout out questions, too!)

Clickers

You all should have gotten a clicker with your textbook from the bookstore.

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We're using an extremely high-tech, state-of-the-art clicker system in this class. Make sure you get one, and bring it to class every day.

Clickers

If you ever forget your card, click on the “Forgot your response cards?” link on the website.

You can then find the image that you want and hold up your cellphone/tablet/laptop in class.

Who are you?

What academic year are you?

A: Freshman
B: Sophomore
C: Junior
D: Senior
E: Graduate student / non-degree

Who are you?

What's your primary field of study?

A: Science / engineering

B: Social sciences / Maxwell / international relations

C: Management / business / marketing / accounting

D: SUNY ESF

E: None of these

Who are you?

What's your primary field of study?

A: Visual / performing arts
B: Liberal arts / humanities
C: Communication / Newhouse
D: The iSchool
E: Something else

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Someone threw a gauntlet at you...

"With more knowledge comes deeper, more wonderful mystery... with pleasure and confidence we turn over each new stone to find unimagined strangeness leading on to more wonderful questions and mysteries–certainly a grand adventure!

Our poets do not write about [this]; our artists do not try to portray [it]. I don't know why. **Is nobody inspired by our present picture of the universe?** [Science] remains unsung by singers, so you are reduced to hearing not a song or poem, but an evening lecture about it. Is no one inspired by our present picture of the universe? **This is not yet a scientific age.**"

–Richard Feynman, from *The Value of Science* (1955)

Do you agree with Feynman?

... are we not yet living in a "scientific age"? Were we in 1955?

A: No, we don't live in a scientific age
B: We didn't then, but we do now
C: We did then, and we still do!
D: What a silly question!

Do you agree with Feynman?

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D: What a silly question!
My answer comes in three parts...

Our poets and writers have (always) been busy...

The source of all wisdom: tumblr.

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This is the saddest little thing I have ever read.

> *Send me to Mars with party supplies before next august 5th*

No guys you don't understand.

The soil testing equipment on Curiosity makes a buzzing noise and the pitch of the noise changes depending on what part of an experiment Curiosity is performing, this is the way Curiosity sings to itself.

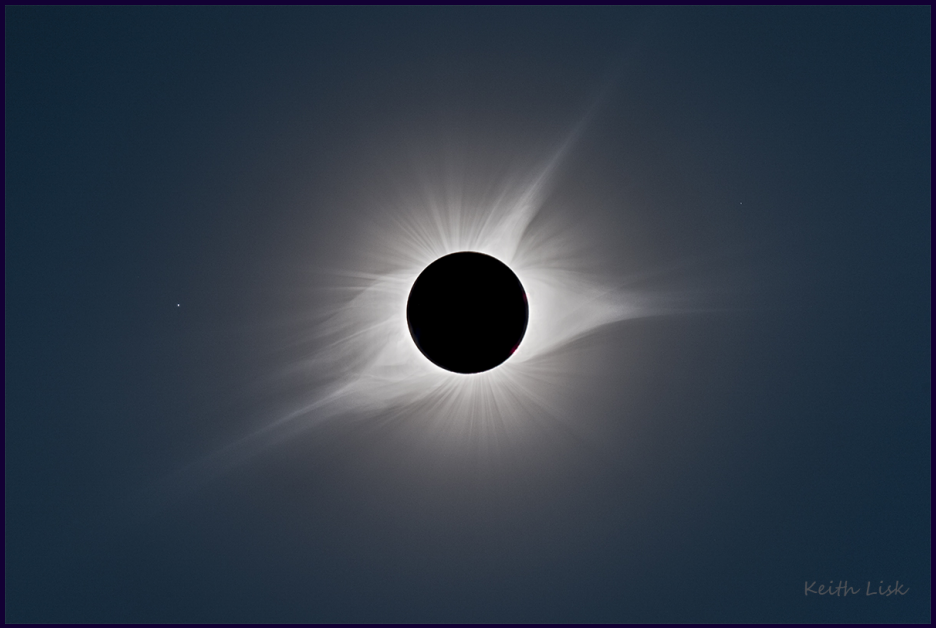
So some of the finest minds currently alive decided to take incredibly expensive important scientific equipment and mess with it until they worked out how to move in just the right way to sing Happy Birthday, then someone made a cake on Curiosity's birthday and took it into Mission control so that a room full of brilliant scientists and engineers could throw a birthday party for a non-autonomous robot 225 million kilometres away and listen to it sing the first ever song sung on Mars*, which was Happy Birthday.

This isn't a sad story, this a happy story about the ridiculousness of humans and the way we love things. We built a little robot and called it Curiosity and flung it into the star to go and explore places we can't get to because it's name is in our nature and then just because we could, we taught it how to sing.

That's not sad, that's awesome.

(source: thebaconsandwichofregret.tumblr.com)

The eclipse of 2017



(by Keith Lisk, shot in Paducah, KY: https://www.dpreview.com/forums/post/60016117)

The eclipse of 2017

(photographers Andrew Studer and Ted Hesser; climbers Tommy Smith and Martina Tibell; Smith Rock State Park, OR)

https://www.dpreview.com/articles/5501288570/how-the-viral-climber-eclipse-photo-and-video-were-shot
https://youtu.be/H6rxml7TRf0

Astronomy's broader impact on human thought

Astronomy has been inspiring art, philosophy, music, and literature since those things have existed.

Why is the fourth planet named Mars?

We're going to spend much of our class looking up ... but we'll spend a bit of time looking back down, too, to see how astronomy has influenced so many fields of human endeavor.

Course organization: four units

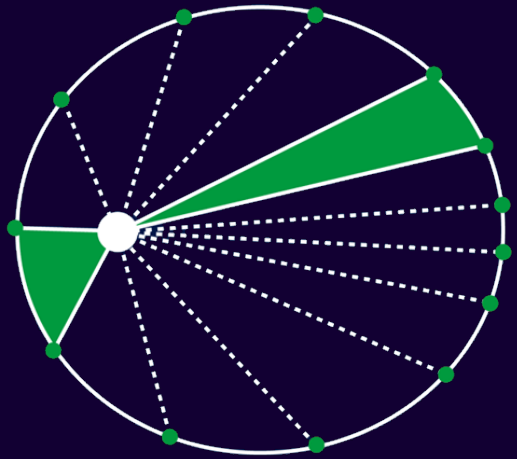
- Naked-eye astronomy
- Astromechanics
- The science of light
- Humanity and the cosmos

Naked-eye astronomy

- What can we see from Earth?
- What changes do we see in the sky?
- How are they explained by Earth's motion?

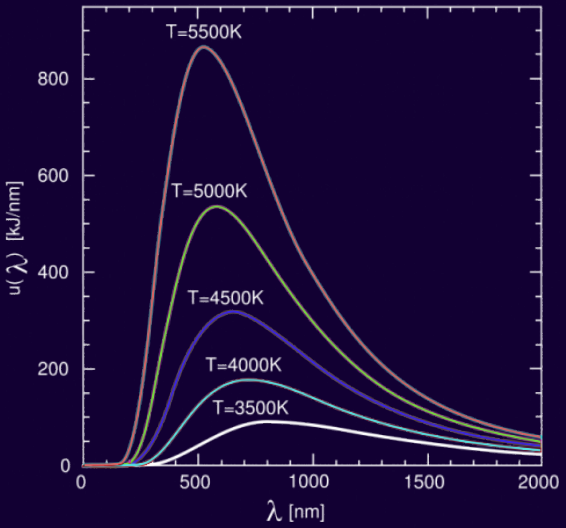
Astromechanics

- How does scientific thought work?
- How do we know the planets orbit the Sun?
- What do the motions of the planets really look like?
- How do the laws of physics cause them to move this way?



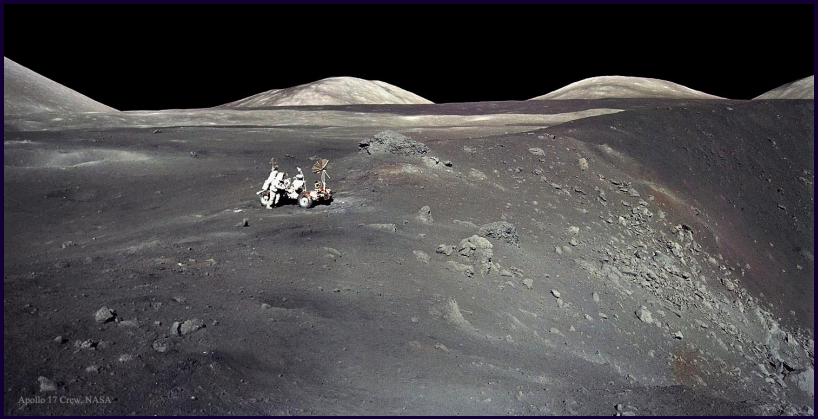
Light and the electromagnetic spectrum

- What is light?
- How does a telescope work?
- Where does light come from, and what does it do?
- How do we use light to study the sky?
- What has this taught us about the Sun?



Humanity and the cosmos

- What are the past and present of spaceflight?
- ... what might its future be in our lifetimes and beyond...
- ... and where else in the Universe might we find life, and what might it look like?



Course components: the labs

- Labs start on the **second week of class**.
- **Prelabs:** Every lab has a prelab. You *must* complete the prelab and bring it with you to lab, or you won't be able to do that lab.
- The prelab for the first lab will be available Thursday.
- Take-home labs assigned next week, due later
- Labs meet in Holden Observatory, led by TA's

Course components: homework

What kind of homework/classwork do you have in your philosophy class?

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Your other homework:

- Read the textbook
- Make sure you understand the thought process behind the *Lecture Tutorials* questions

Course components: other things

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- Lots of details in the syllabus

I'm here to help you!

My full-time job is to help you all (and my other students). This is your class, not mine.

This means:

- Interrupt me any time in class if you have a question
- Yell at me if you have a question and I don't see your hand
- Email me and ask for help: wafreema@syr.edu
- Send a message to the Slack channel, or private message me on Slack
- Come to office hours: Wednesdays, 2-4 PM, and Fridays, 10-12 AM (maybe not this Friday, though)
- Come bang on my office door (room 215) – I'll often be around
- If you have questions you'd like addressed ("ask the physicist!"), or course suggestions, please send them to me (and get extra credit, if they're good!)

"Baltimore is about five hours away."

Does this statement make sense as a way to describe the distance to Baltimore?

A: Yes
B: No
C: Yes, if I give you some other information...

The cosmic perspective: measuring distance

"China is about 1/15 of a second away."

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(This is something anyone who's tried to play a video game with someone across the ocean knows about!)

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→ We can measure long distances by *how long it takes light to get there!*

... if China is one-fifteenth of a light-second away, then a *light-year* has to be a pretty long way...

Three measures of distance...

Inside the Solar System, it's also useful to measure distances with a different yardstick: the distance to the Sun. This is called an astronomical unit, or AU.

We have:

- 1 kilometer
  - (good for measuring Earth-size things)
- 1 AU = 150 million km (1.5×10^8 km) = about 9 light-minutes
  - (good for measuring distances to the planets)
- 1 light-year = 60,000 AU = 9 trillion km (9×10^{12} km)

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- 1 universe = 14 billion light-years!

Takeaways: size and scale

- Inner planets like Earth are about 10,000 km across
- The Moon is around 400,000 km from Earth
- The inner planets are hundreds of millions of km – around an AU – away from the Sun
- Outer planets like Jupiter are about 100,000 km across and tens of AU from the Sun
- The nearest star is around 250,000 AU (4 ly) from us

The first chapter of your textbook goes into a lot more detail; you should read it.

We don't expect you to memorize exact numbers, but you should have a general idea of the scale of things near us in the Universe.

Another Freeman can explain it better than me!

https://www.youtube.com/watch?v=vRjGarICal4

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... where are we in all this?

Physics: Everything here is all the same!

It's no accident this class is in the physics building!

Everything in the Universe is made of the same sort of stuff.

- Those distant billions of galaxies, and their billons of stars each...
- ... the planets that we now know orbit many of those stars...
- ... the atoms that make up our own sun...
- ... the matter here on Earth...
- ... and even the atoms that make up you and I...

... are all made of the same sort of matter, doing the same dance they've been doing since the beginning.

By studying a few dancers, we learn about them all..

https://youtu.be/W-csPZKAQc8

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This is a computer simulation of a collision that will happen in a few billion years.

Using a few principles you'll learn about in this class, and a computer, you can make this!

We, on our little rock, can actually *understand* how this all works!

Next time: the night sky

Thursday: How does the night sky move each night?

Stuff to do:

- Go find the course website and read the syllabus
- Join the course Slack team
- Bring your colored cards *and Lecture Tutorials* on Thursday

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- Get to know the folks around you!

Summary

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