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

Astronomy 101
Syracuse University, Fall 2022
Walter Freeman

August 30, 2022

Course website:

https://walterfreeman.github.io/ast101/

We will post materials for this class here rather than Blackboard. Blackboard will only be used to post grades.

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, American astronomer, from *Cosmos* (1980)

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)

Chiricahua National Monument, Arizona, before sunrise: 15 seconds, f/2.5, 14mm, ISO 3200

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)

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

Professor: Walter Freeman (he/him)

Graduate student instructors:

- Nada Nabil Elsayed Elmeigy
- Keisi Kacanja
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- Chad Skerbec
- Byron Sleight
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- Juanitta "AJ" Bekoe
- Kiersten Edwards
- Sydney Jud
- Dominic Naggar
- Chloe Britton Naime
- Mykaylo Rafalskyy

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.

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

Let's practice: 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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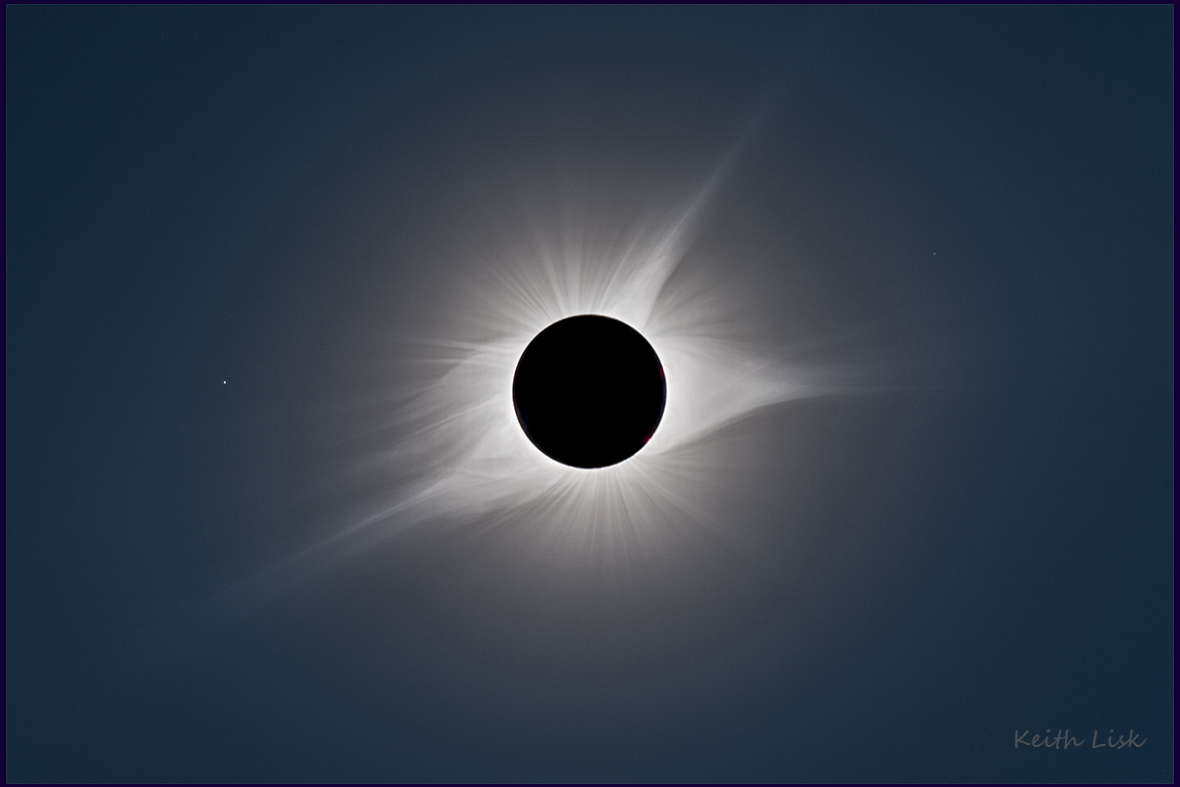
D: What a silly question!
My answer comes from a humble state park in Oregon...

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)

Optimism and humanism

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... and how, when that knowledge is humbling, we can take that humility to heart without fear or shame and use it, too, to further our cause.

This course is an attempt to tell that story. I hope you find it as glorious as I do.

Course organization: four units

- The motions of the sky
- Astromechanics
- The science of light
- Humanity and the cosmos

The first three of these will be split into two halves so you never have a quiz on too many things at a time.

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?
- What causes the phases of the Moon and the changing seasons?
- What about the planets?

Astromechanics

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- What do the motions of the planets really look like?
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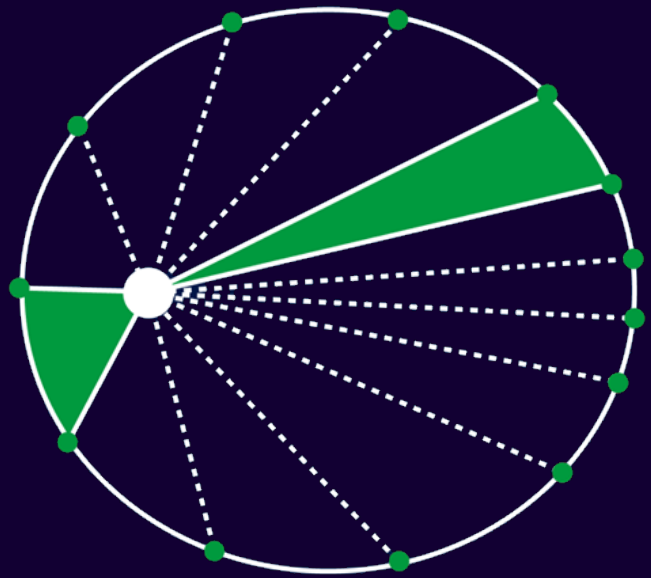
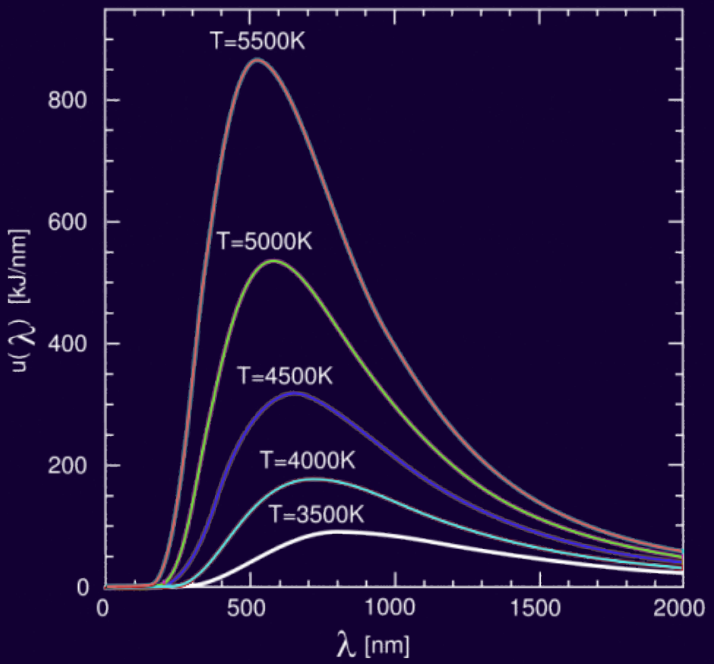
- What is science?
- What is pseudoscience?



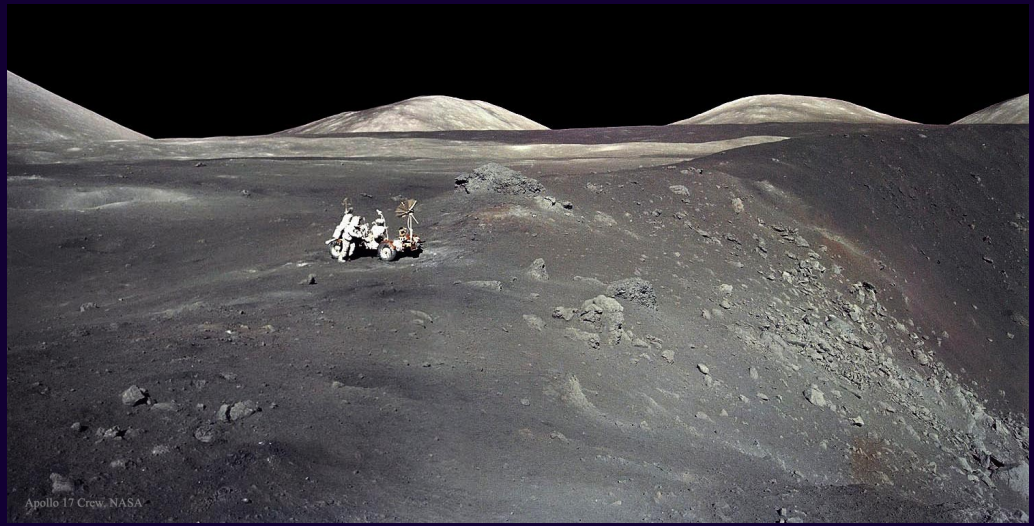
Light and the electromagnetic spectrum

- What is light?
- What kind of light do hot objects produce?
- How do different materials and chemicals interact with light?
- How do we use these properties to study things in the sky?
- What has this taught us about the Sun?



Humanity and the cosmos

- How and when did the Solar System form?
- Why are the different planets different?
- What determines Earth's climate, and how are we affecting it?
- 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 later in September
- Labs meet in Holden Observatory, led by TA's

How likely is it that you're going to get the exams for this class, look at them, and say "Oh! I know the answer to this question!" and write it down?

A: Not very likely
B: Only sometimes
C: Most of the time
D: All the time!

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Science isn't mostly about *knowing things*.

It's about:

- talking about things
- figuring out things
- doing things

All of these are skills you have to *practice*.
How do we do that?

Course components: in-class tutorials

To get good at figuring out stuff, you have to practice figuring out stuff.

We'll spend a lot of time in class working through exercises designed to get you this practice.

Take them seriously; they are the best preparation for the exams that you can have.

Some of the tutorials will relate to a short homework set. You won't turn these in, but quizzes/exams will have things very similar to the homework on them; if you have done the homework, these questions should be freebies.

Course components: writing and thinking and creating

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

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

... you're going to be writing a paper and doing a final creative project (which might be another paper), in this class, too. These papers and project will focus on connections between the science of astronomy and other disciplines in the humanities.

Course components: weekly “checkins”

Most weeks, I’ll send you a link to a Google form on Friday. (This week, it’ll be early – today!)

I’ll ask two kinds of questions:

- Things to see how you’re doing, in general
- Specific questions about your ideas about the following week’s material

I’ll also give you space to ask me things, which I’ll answer in a FAQ page or by personal email if you ask me something personal.

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
- Come to office hours: Wednesdays, 2-4 PM, and Mondays, 10 AM-noon, in the Physics Clinic (room 112)
- Come bang on my office door (room 215) – I'll often be around
- Email me and ask for help: wafreema@syr.edu
- 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

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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

We tend to usually use AU to measure things in this class, since we are mostly concerned with the Solar System.

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=44cv416bKP4

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... where are we in all this?

Sizes of things

Meters **AU** **Light travel time**

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	Meters	AU	Light travel time
A child	1 m		3 nanoseconds

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The Universe			14 billion years

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 billions 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

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

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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
- Answer the survey I'll send out tonight

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Thursday: How does the night sky move each night?

Stuff to do:

- Go find the course website and read the syllabus
- Answer the survey I'll send out tonight
- Get to know the folks around you!
- Read the first bits of your textbook (see the calendar)