ASTR421 // Winter2022

Stellar Observations and Theory

Lecture 01

Introductions & Review

Prof. James Davenport (UW)

2022-Jan-03

Introductions

- **Course Website: https://jradavenport.github.io/astr421/**
- Your instructor… me!
  - Prof. James Davenport
  - Associate Director of the DiRAC Institute @ UW Astro
  - I work on stars, SETI, big data, time domain astronomy, wacky ideas
  - I like coffee, gardening, the PNW,

Introductions

- Your TA: Andy Tzanidakis
  - 1st year grad student @ UW
  - Experience in stars, time domain astronomy, statistics, ground & space-based data
  - Skilled science communicator!

Textbook(s)

- An Introduction to Stellar Astrophysics (LeBlanc)
- Caroll & Ostlie (aka BOB)

- I'll try to stick to these two textbooks, and will provide links to papers where possible.

  However, there are *so many* good textbooks you can refer to, and I might send chunks of reading (as a PDF) from those as needed.

The plan…

- Going to *try* and do the “flipped classroom” model that other faculty have used during the pandemic.
- All lectures (except today) will be recorded in advance
- I will aim to post the lecture videos ~1 week ahead
- You submit Q’s regarding the reading/lecture/HW **by 9AM** day-of lecture via Google Form
- Class time is spent in active discussion, or occasionally tutorials
- Any unused class time is “returned” to you

Evaluation

- Weekly Q/A Submission (10%)
  - Due by 9AM every "lecture day"
- Assignments (70%)
  - Turned in via Dropbox links
- Final Project (20%)
- Notes about GROUP WORK
- No extra credit

Most (all?) assignments will be coding-focused. We expect most people will use Python/Jupyter, but any language/tool that you want to use is OK!

If this is a stressor, reach out! We'll try to provide some tutorials as needed.

COVID protocols…

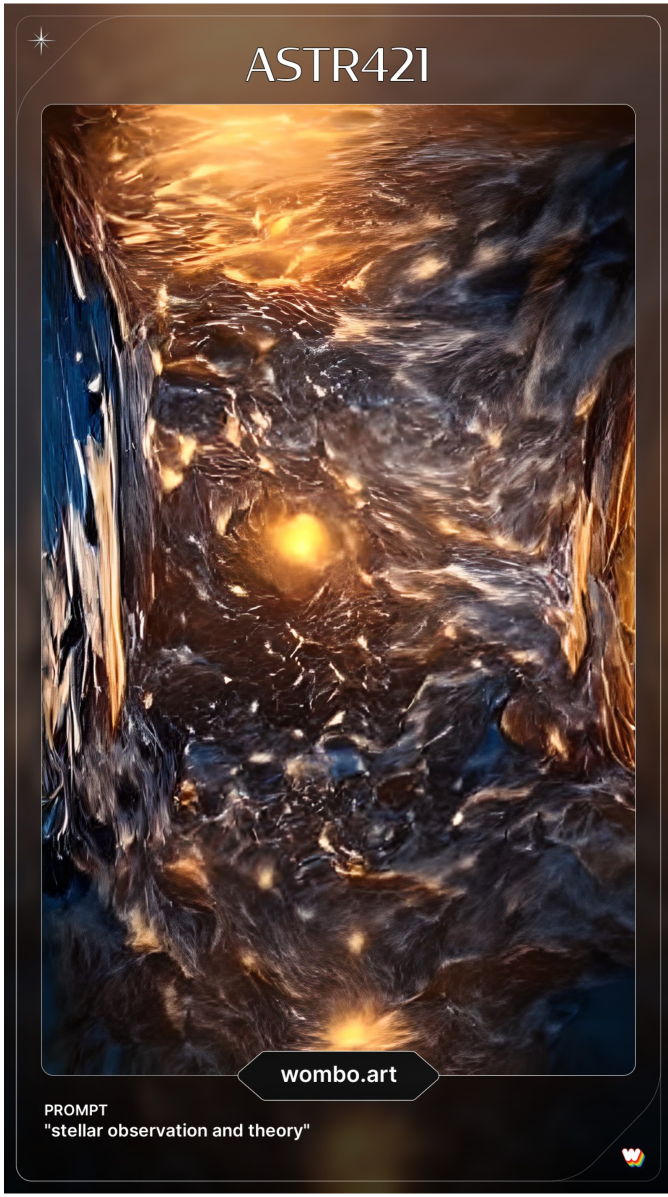
- We will strive to be 1) safe, 2) empathetic, and 3) practical
- If you get sick or might have been exposed, please let us know!
- If you need to miss a class activity because of a COVID-related disruption, let us know!
    - I will strive to do the same…

Code of Conduct

- Absolutely no bullying, harassing, disruptive, rude, or exclusive behavior will be tolerated – both in-person & virtually.
- Work together, be kind
- No tool shaming
- https://www.washington.edu/cssc/for-students/student-code-of-conduct/
- https://www.washington.edu/cssc/for-students/academic-misconduct/

Read the syllabus

- All these details and more are in the syllabus.
- **Any questions? Let's take a moment…**



Introduce yourselves!

I'll call on folks, can you please share:

- Preferred Name & Pronouns
- Year/major @ UW
- Would you rather we had 2 Suns or 2 Moons?

Now, on to Lecture 01!

Course Goals

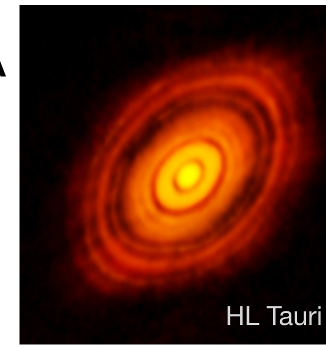
- Let's start by acknowledging the comically broad course description: Stellar Observations and Theory

> **ASTR 421 Stellar Observations and Theory (3) NW**
> Observations and theory of the atmospheres, chemical composition, internal structure, energy sources, and evolutionary history of stars.
> View course details in MyPlan: ASTR 421

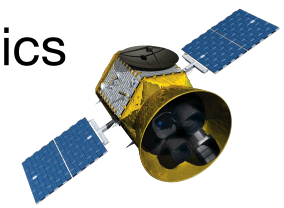
- My #1 hope is for you to **gain intuition** about how we observe stars, general theory of their atmospheres and structures, and how to engage with relevant astronomical data/tools.

Course Goals

- **Now is a particularly good time to work on stellar observations** (IMO)
- Can SEE (i.e. resolve) stars & stellar systems, w/ interferometry, ALMA

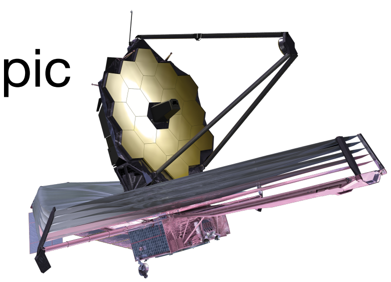


- Huge catalogs of spectra (SDSS, LAMOST, APOGEE…)
- Kepler, Gaia, TESS… a major revolution for stellar physics



- Time domain & big data studies, incl. archives
- Rubin and other surveys coming, the era of statistics for all things

- JWST ensures stars will continue to be critical topic



Course Goals

- Theory also very powerful now, backed by huge computational power
- MESA has become ubiquitous MESA
- Asteroseismology
- Star & planet formation simulations
- Lots of stars-specific, detailed modeling going on, e.g.
  - Dynamo models
  - SNe models

What is a star?

1.1 Introduction

First, a definition must be given for what constitutes a star. *A star can be defined as a self-gravitating celestial object in which there is, or there once was (in the case of dead stars), sustained thermonuclear fusion of hydrogen in their core*. For example, in the Sun, hydrogen, which is the most abundant element in the Universe, is fused into helium via the nuclear reaction $4\,^{1}H \rightarrow {}^{4}He$ + energy. Fusion is only present in the central regions of stars, because there exists a minimum threshold temperature at which this exothermic reaction can be ignited (which is of the order of ten million degrees for this particular reaction). For hydrogen nuclei (protons) to be fused, they must have a close approach on the order of distance at which the strong nuclear force comes into play.[1] The strong nuclear force is responsible for binding the nucleons (protons and neutrons) in the nucleus and contrary to gravity, for instance, its field of action is limited to a distance on the order of 10^{-15} m. At the high temperatures found in the centres of stars, the kinetic energy of the protons is sufficient to vanquish the repulsive Coulomb force between them and bring the protons within the distance where the attractive strong nuclear force becomes dominant. Protons can then fuse together while emitting energy.

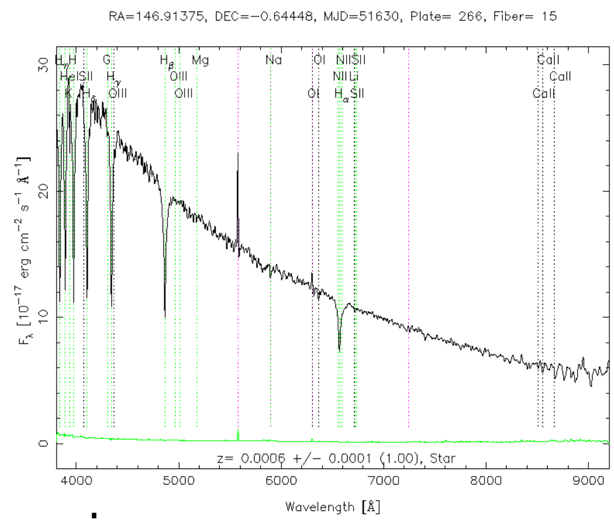
From LeBlanc, page 1

What is a star?

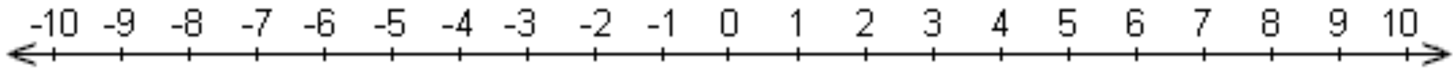
- Fusion of H -> He + energy is critical
  - Brown dwarfs (and planets) are not stars
  - Reasonable limits on their size
  - No dark stars
- They are formed out of collapsing gas cloud
  - Planets form *around* stars
- This all gets blurry for brown dwarfs & giant planets (~50 Jup mass)

Why study stars?

- They're *awesome.* Just go outside some time, day or night!
- To understand the Sun
- Nucleosynthesis ("star stuff", aka YOU)
- Host of exoplanets
- Primary component/tracer in galaxies
- Anchor the cosmic distance ladder
- Source of SNe, WD, NS, BH, lots of (re)ionization in the universe



Astro Jargon Review



- Magnitudes (apparent vs absolute) & flux
- Colors

$$m_i = -2.5 \log_{10}\left(\frac{F_i}{F_0}\right)$$

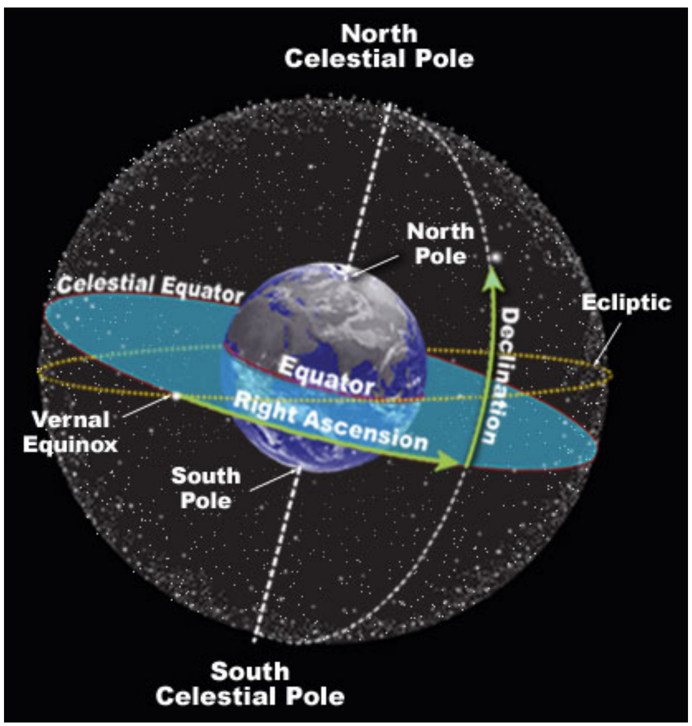
$$m - M = 5 \log_{10} d[pc] - 5$$

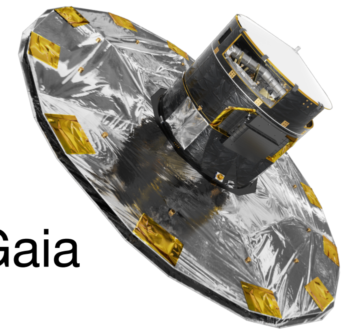
$$B - V \equiv m_B - m_V \equiv M_B - M_V$$

Bold statement: magnitudes are a good unit!

Astro Jargon Review

- Parallax & distance modulus
- 3D positions (ra,dec,distance)



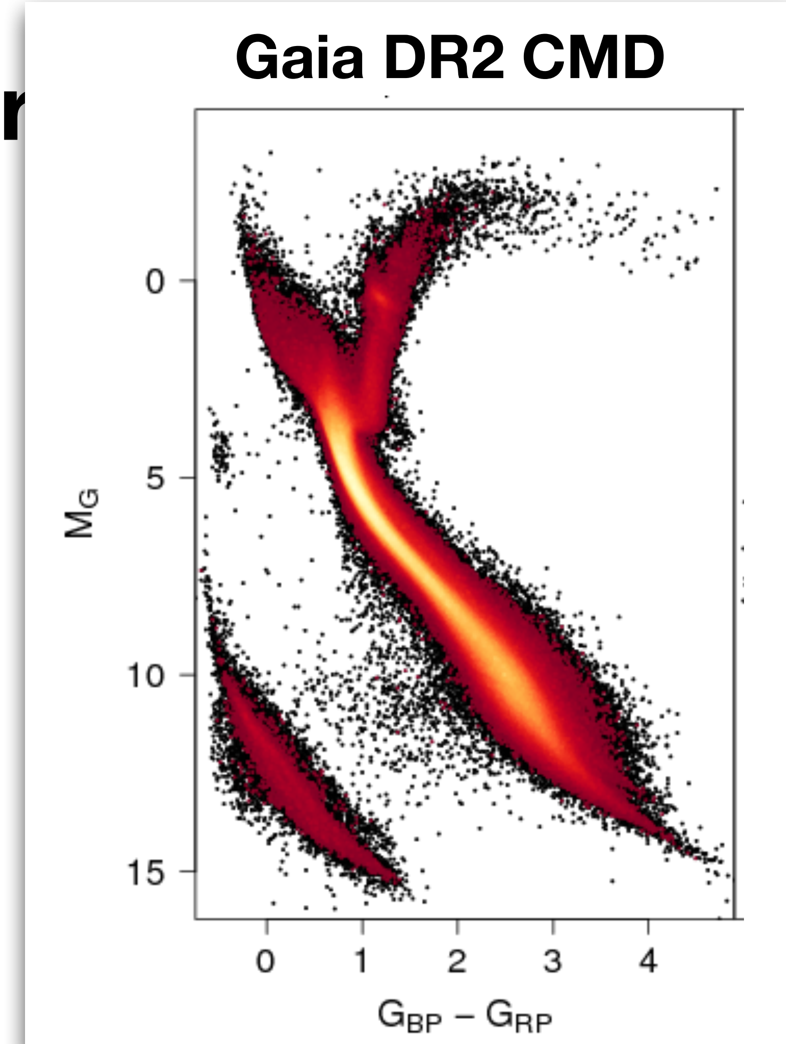


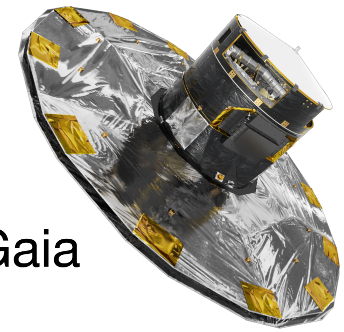
Gaia

$$m - M = 5\log_{10} d[pc] - 5$$

$$m - M = 5\log_{10}(1/\pi) - 5$$

Astro Jar



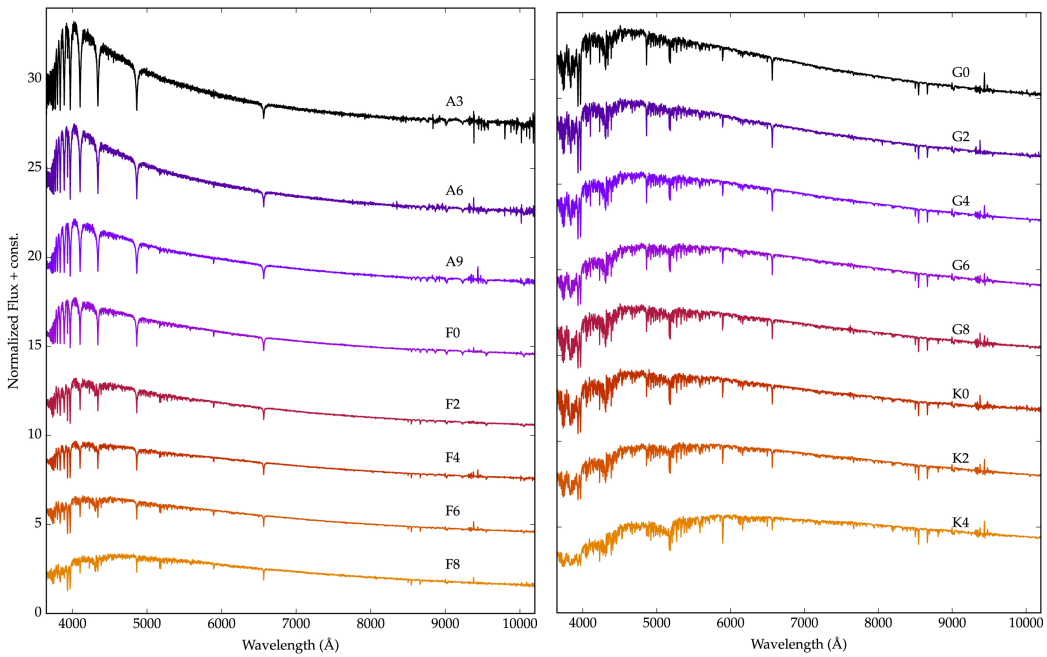


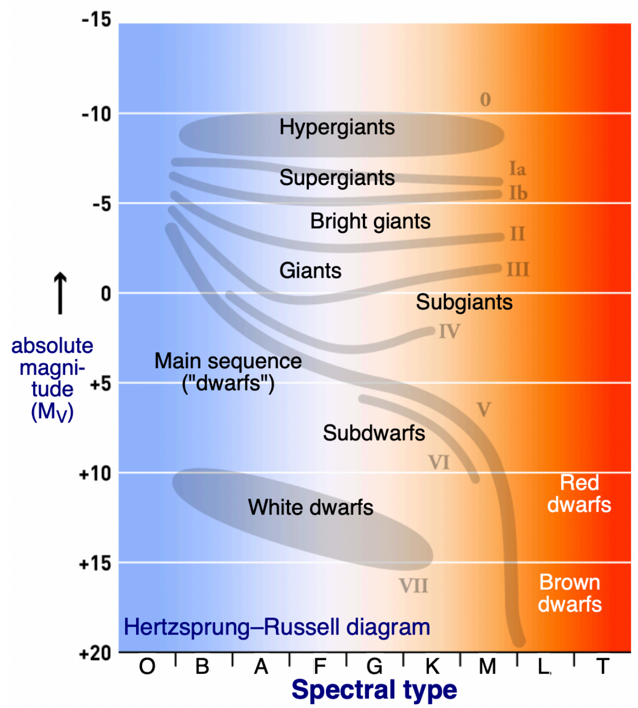
https://www.cosmos.esa.int/web/gaia/gaiadr2_hrd

Astro Jargon Review

- Spectral types
- Luminosity classes

OBAFGKMLTY





Kesseli+2017
https://arxiv.org/abs/1702.06957

Next time:

- **“Measuring the fundamental properties of stars”**
  - Watch the Lecture 02 video (up now!)
  - Send Q’s by 9AM on Wednesday (Jan 5)
- Reading this week: LeBlanc, Ch 1
- HW 1 is posted, if you want to get started…
  - Due in 1 week (Jan 10)