Probing the Early History of the Milky Way though PHOENIX/MESA Models of Ultracool Dwarfs

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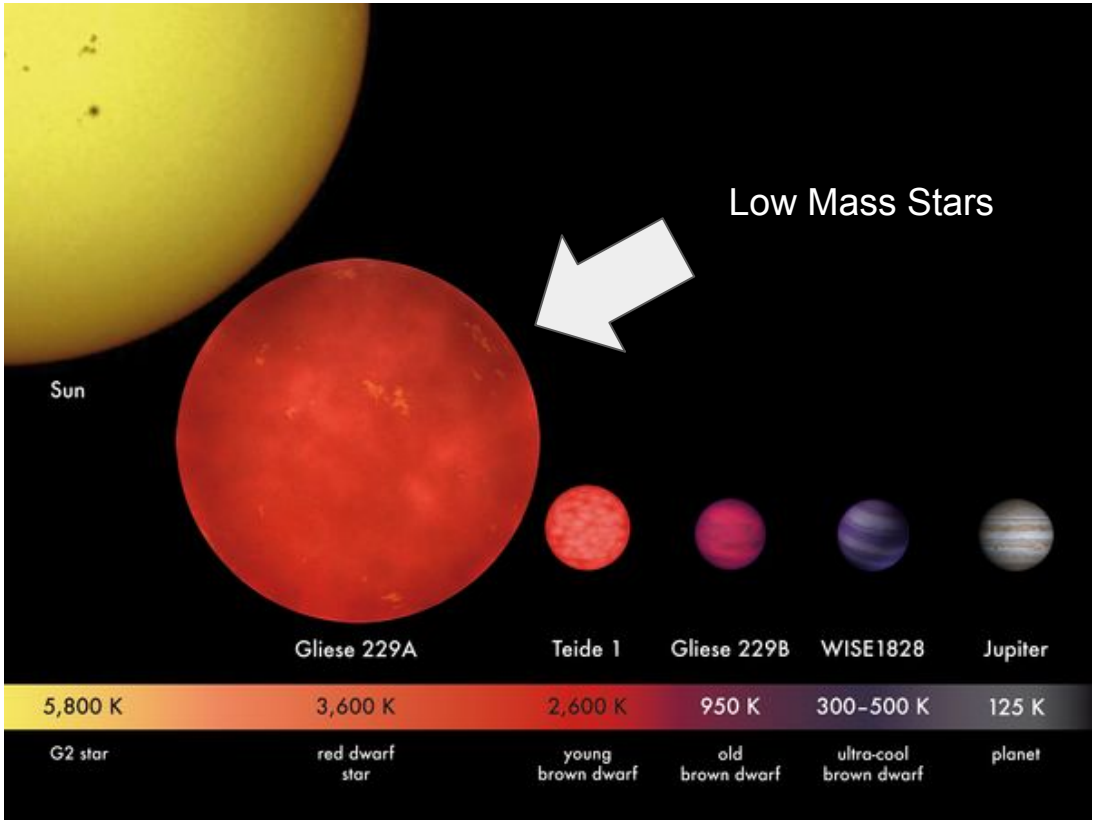
Mentors: Prof. Adam Burgasser, Roman Gerasimov Ph.D.

Background

Ultracool Subdwarfs:
metal-poor, low-mass stars and brown dwarfs with surface temperatures (Teff) $\lesssim$ 3000 K and masses $\lesssim$ 0.1 solar mass.



Credit: MPIA/V. Joergens.

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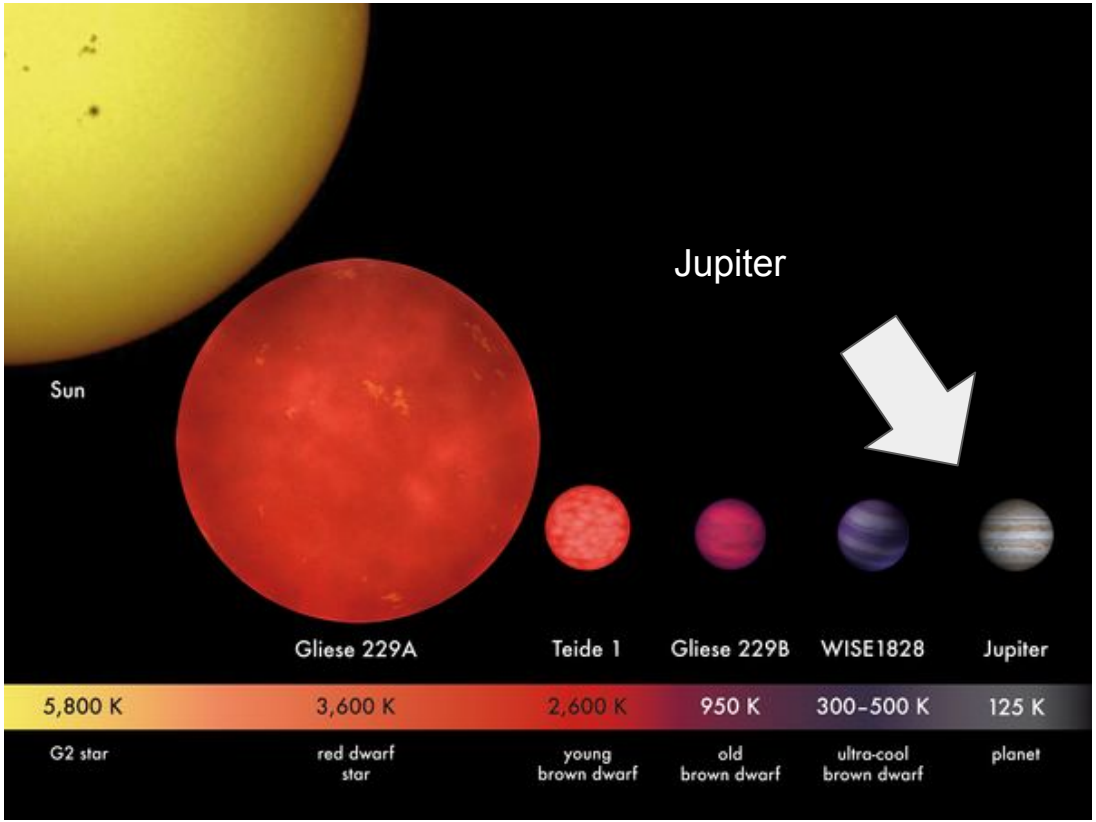

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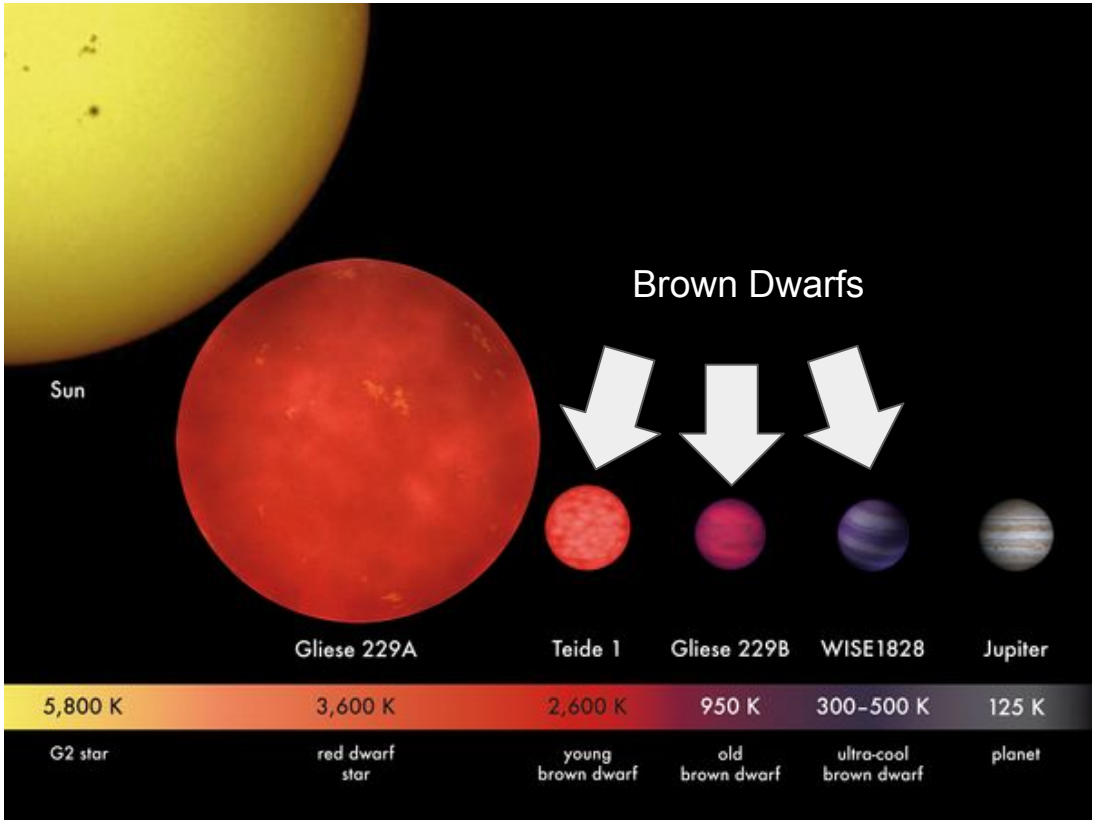
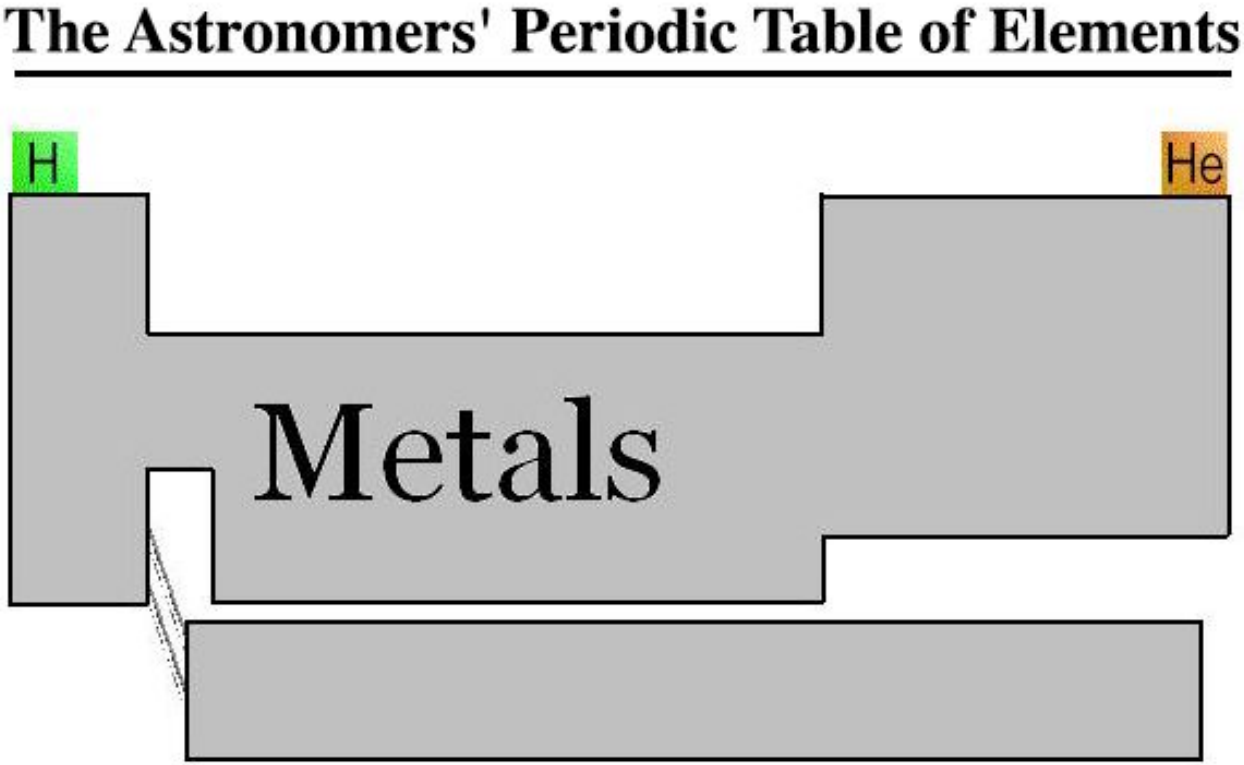


Credit: MPIA/V. Joergens.

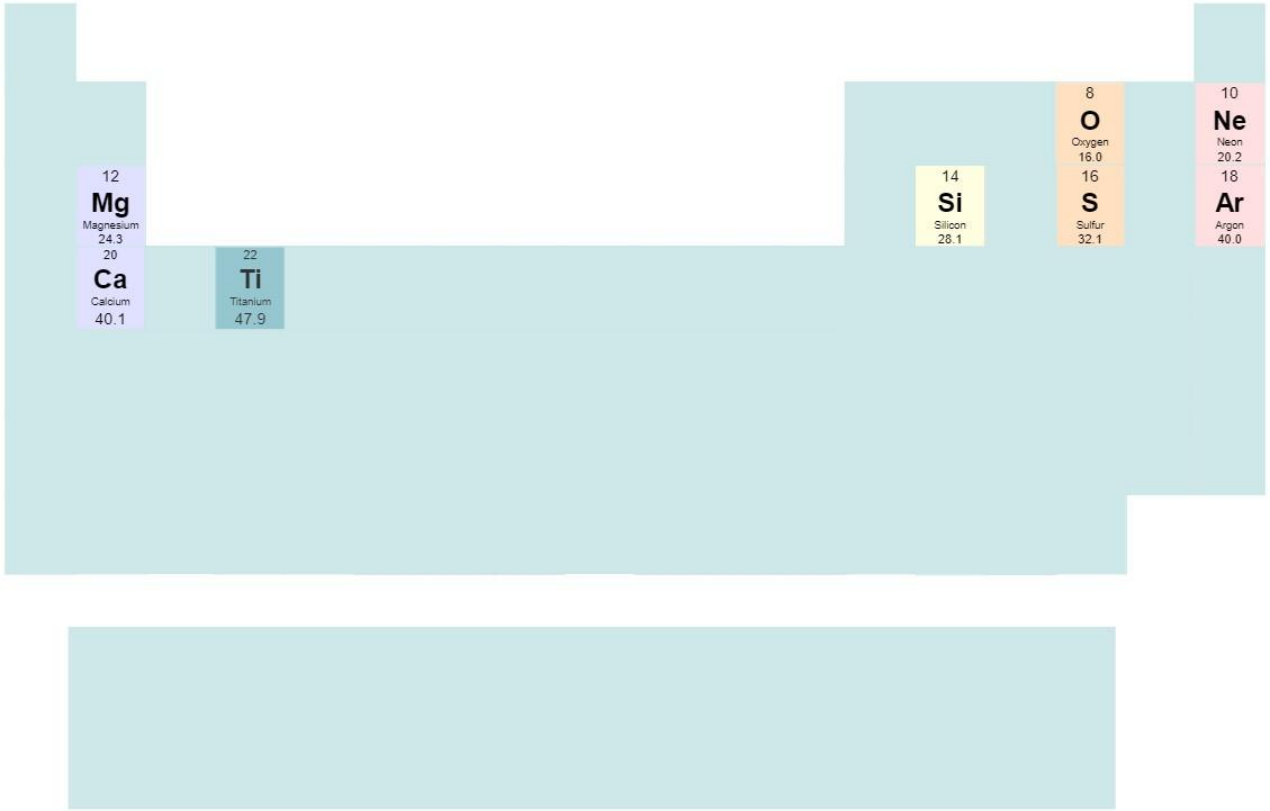
Background

Metalicity [M/H]:
Abundance of elements heavier than hydrogen and helium

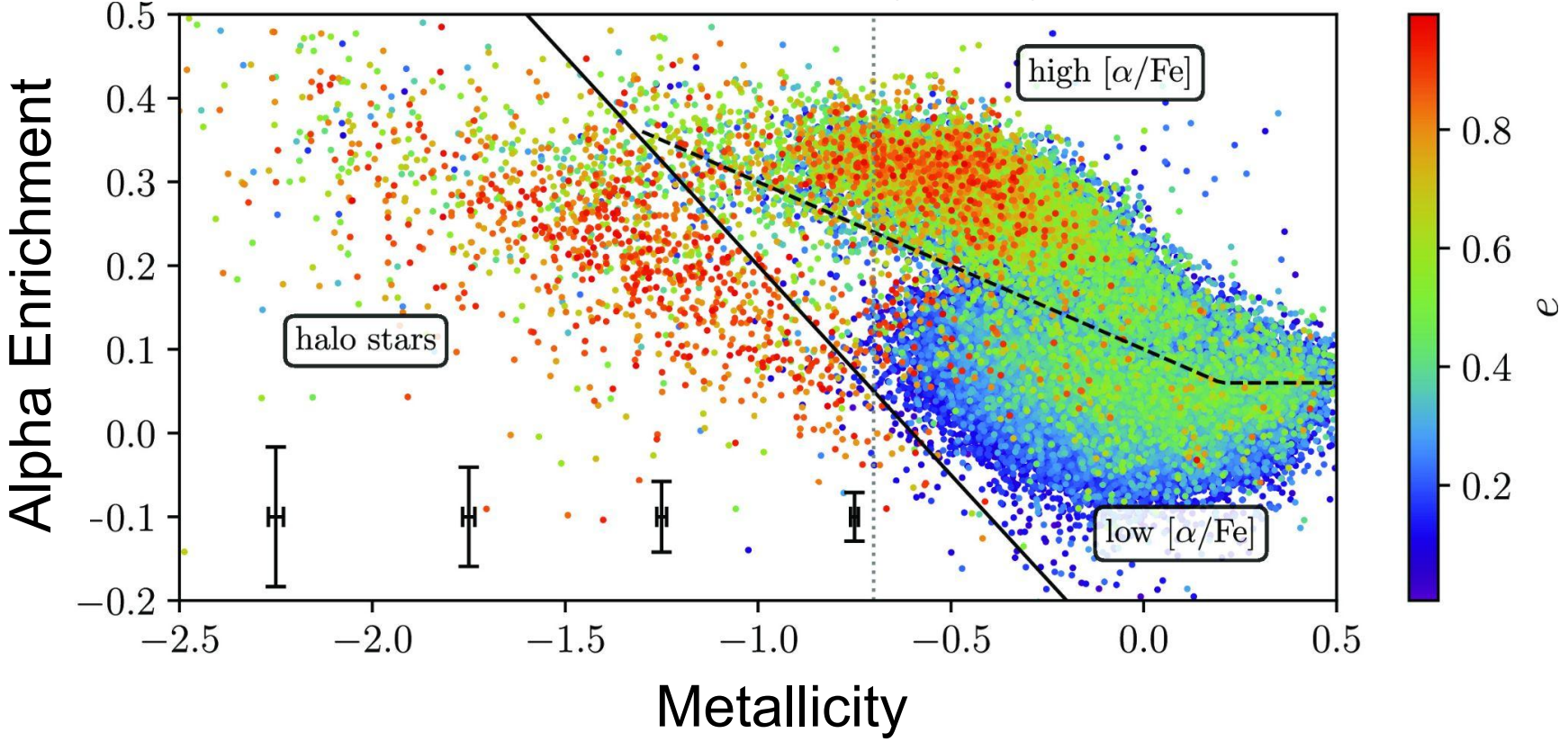


Background

Alpha Enrichment [α/Fe]: Abundance of elements of O, Ne, Mg, Si, S, Ar, Ca and Ti



Another Visualization of the Milky Way



(Adapted from Mackereth 2019)

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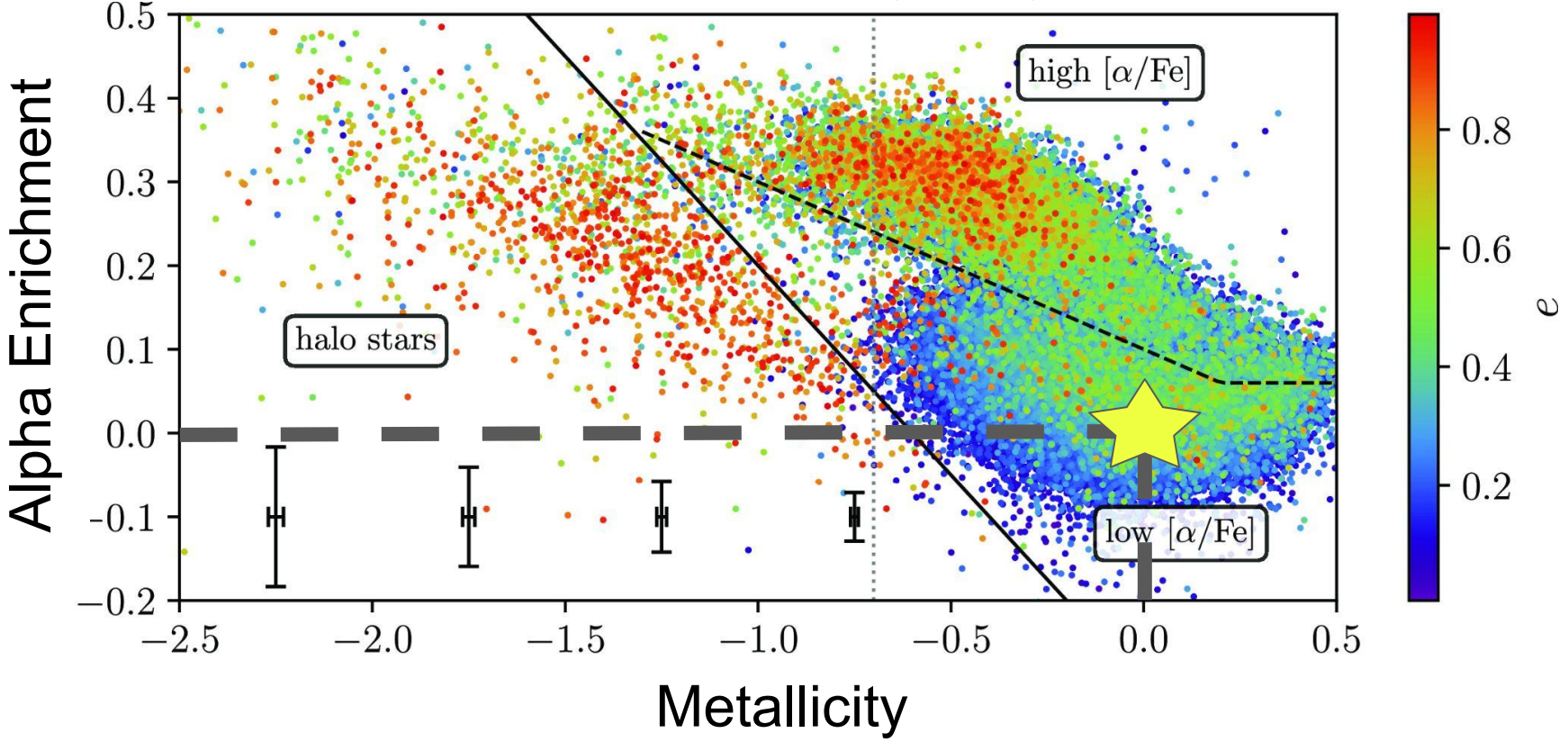

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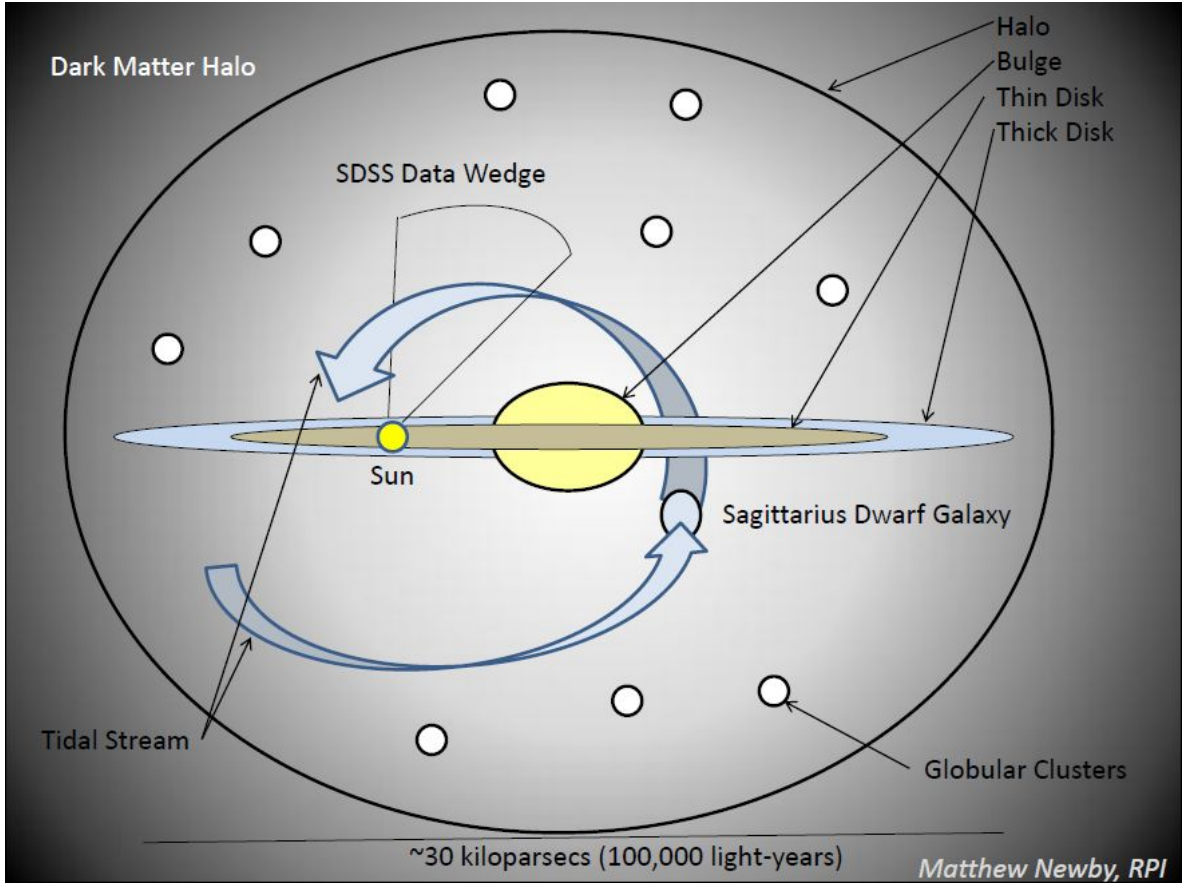
Context

There four main populations in the Milky Way:

- Halo
- Bulge
- Thin Disk
- Thick Disk



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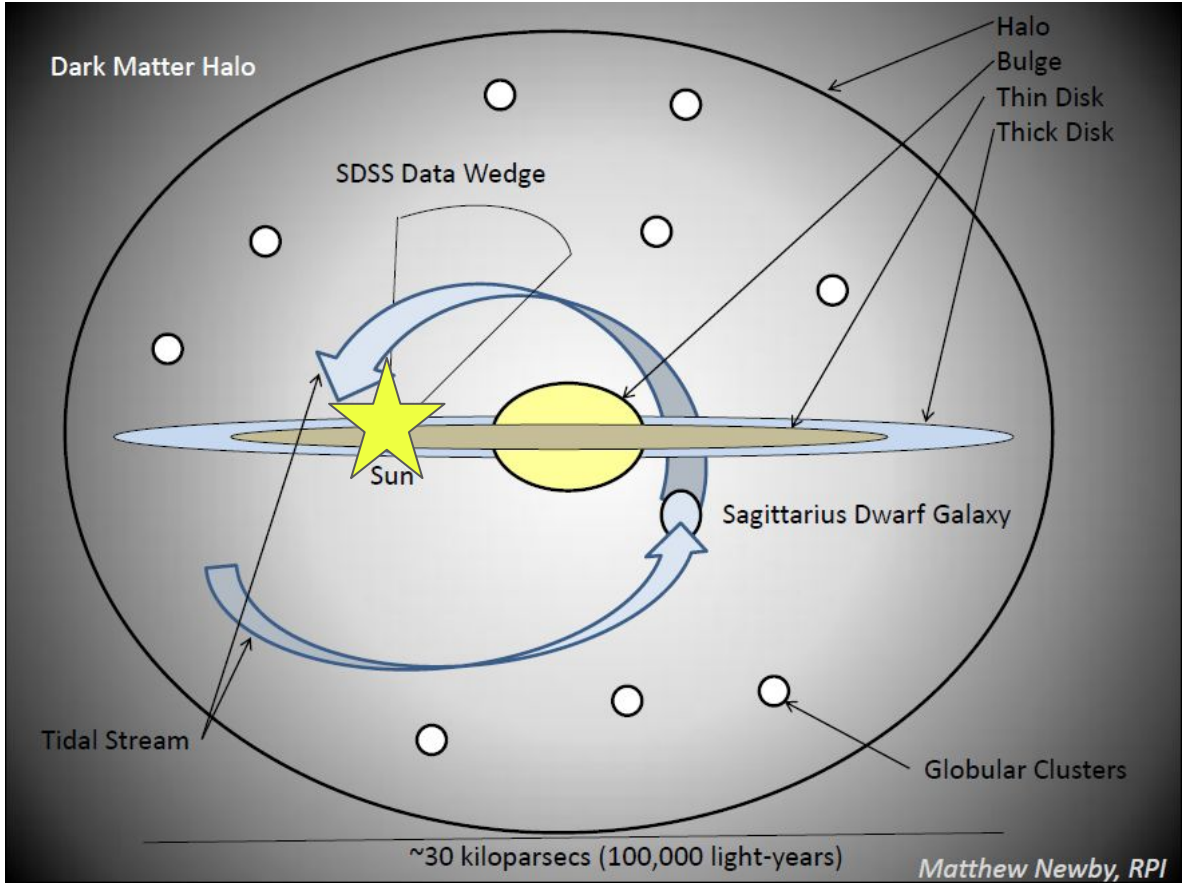
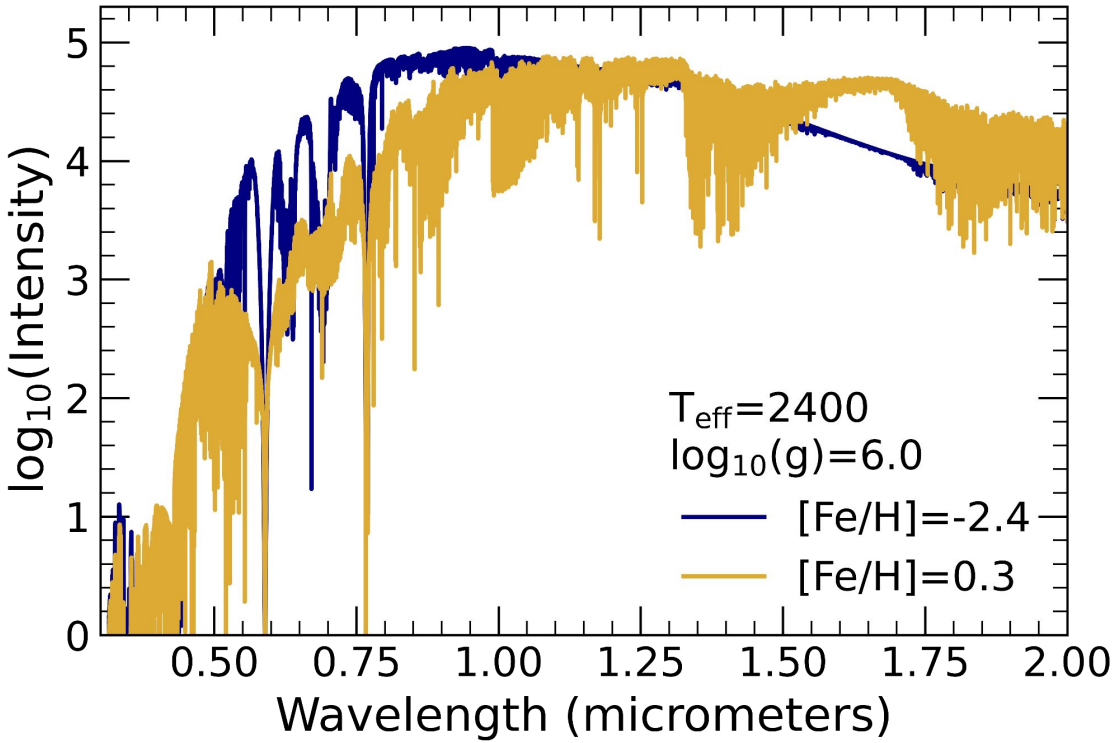
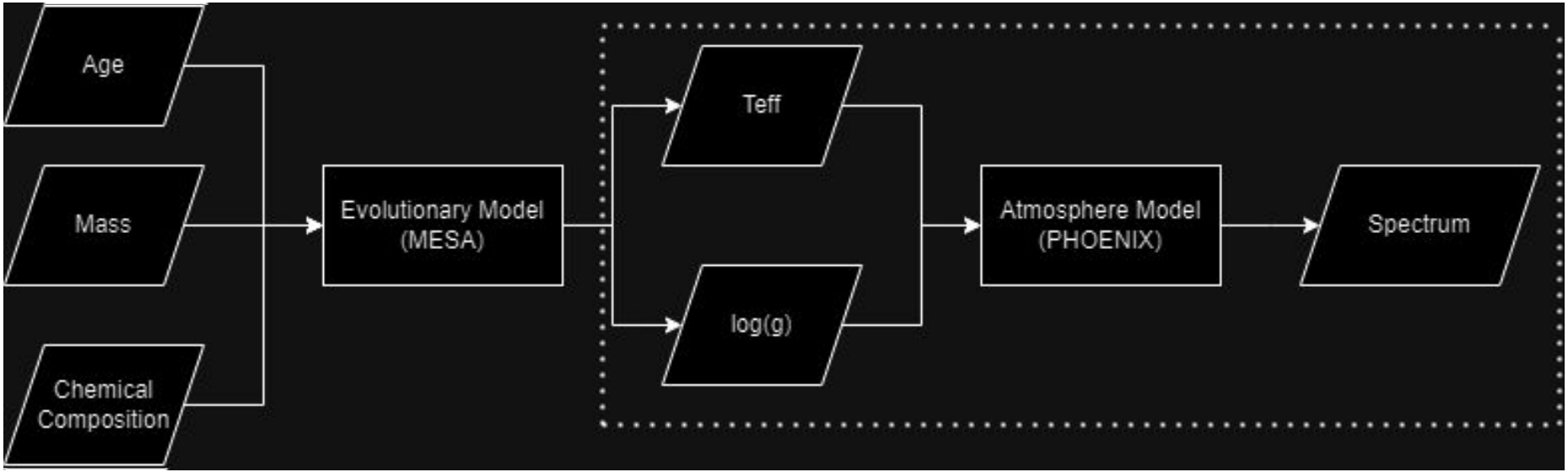


Why should you care?

- Galactic archeology
- How do we use ultracool dwarfs to study the Milky Way?
- Problem: We few models of UCDs with low metallicities
- Project Goal: Create these models!



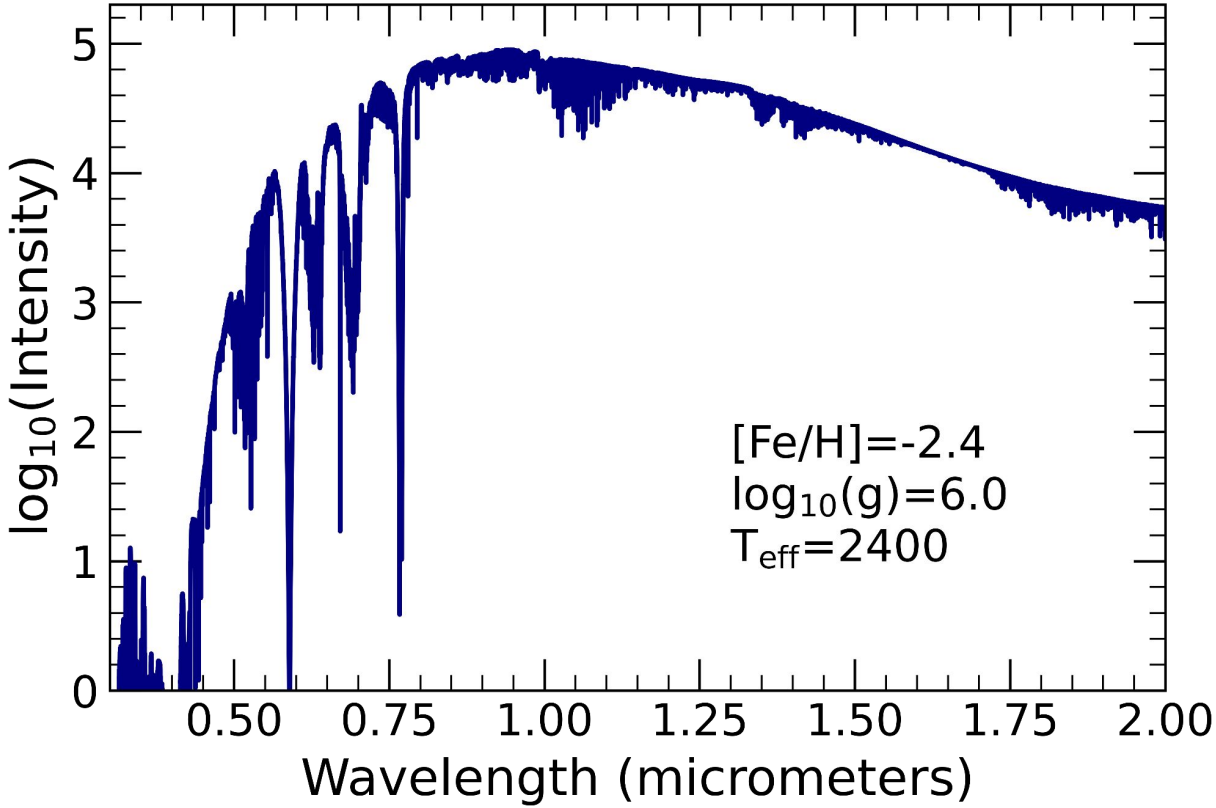
Methodology



Atmospheric Modeling

PHOENIX: generates stellar spectrum.

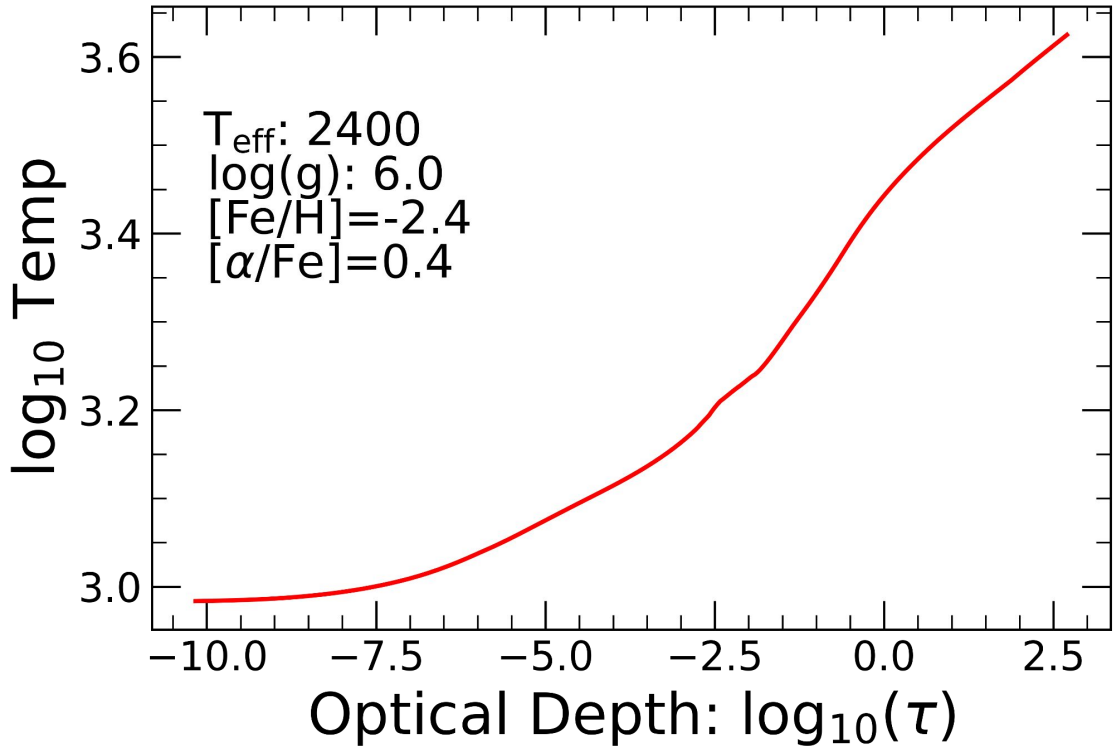
Spectrum is what astronomers use to gather information about a star.



Atmospheric Modeling

Temperature Profile:

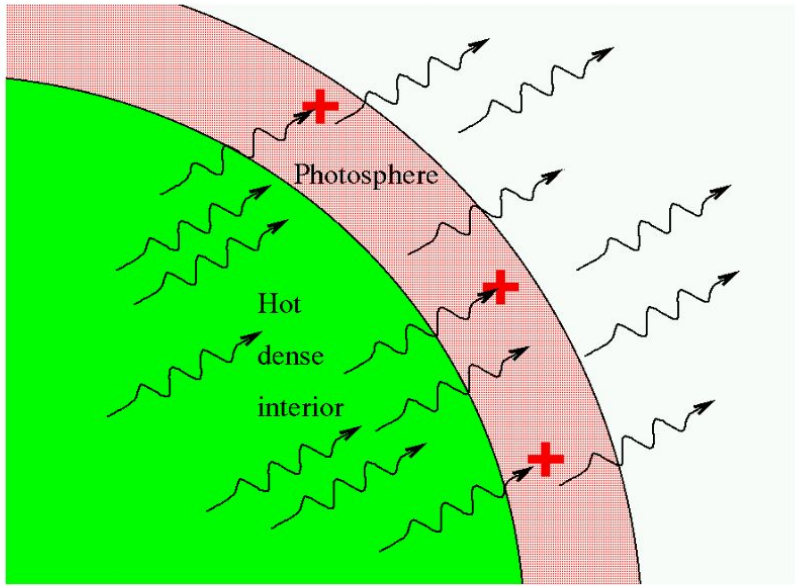
Describes how temperature changes with depth. Starts with the out layer going toward the core.



Atmospheric Modeling

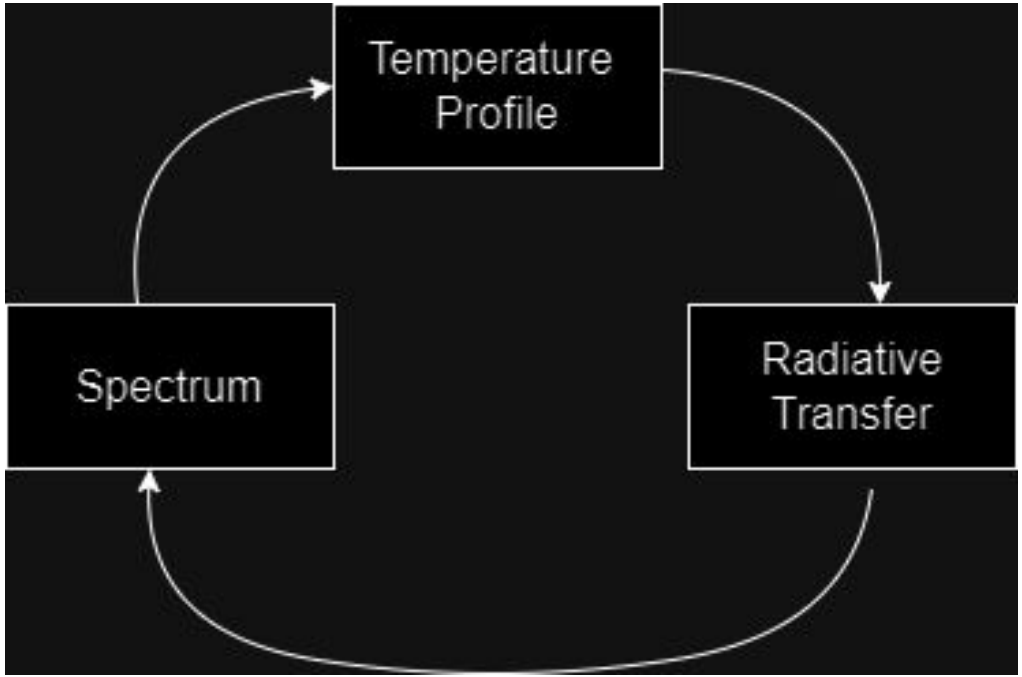
Radiative Transfer:

How light, heat, and energy moves throughout the star.



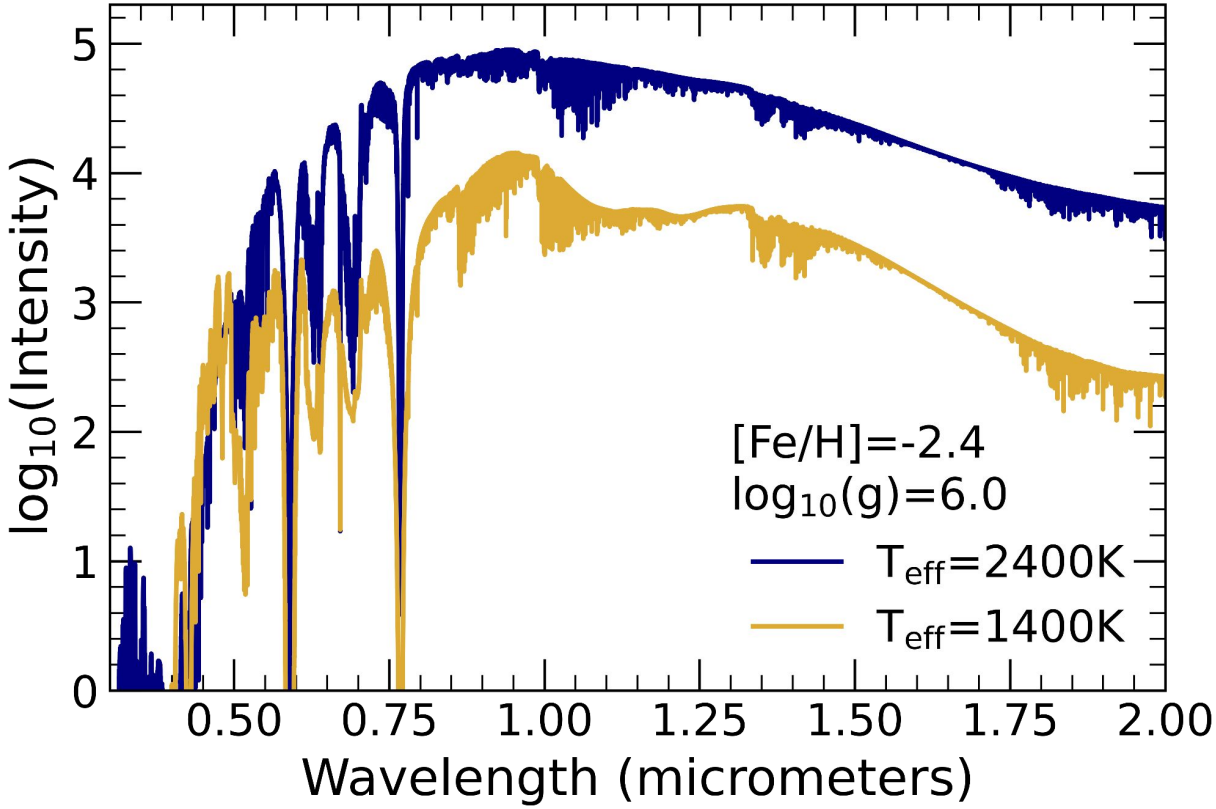
Atmospheric Modeling

Energy equilibrium is reconsidered to check which parts of the temperature profile are wrong.



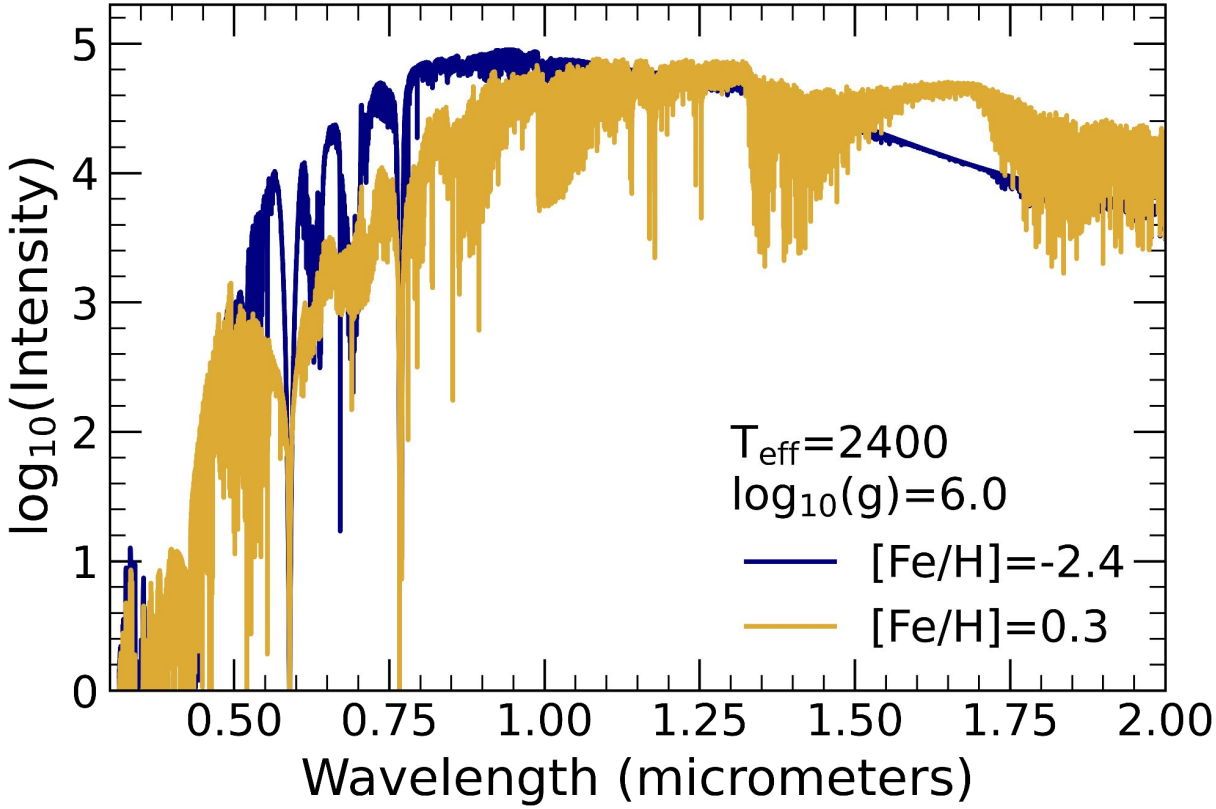
Spectral Analysis

Here is how the spectrum changes with varying temperatures.

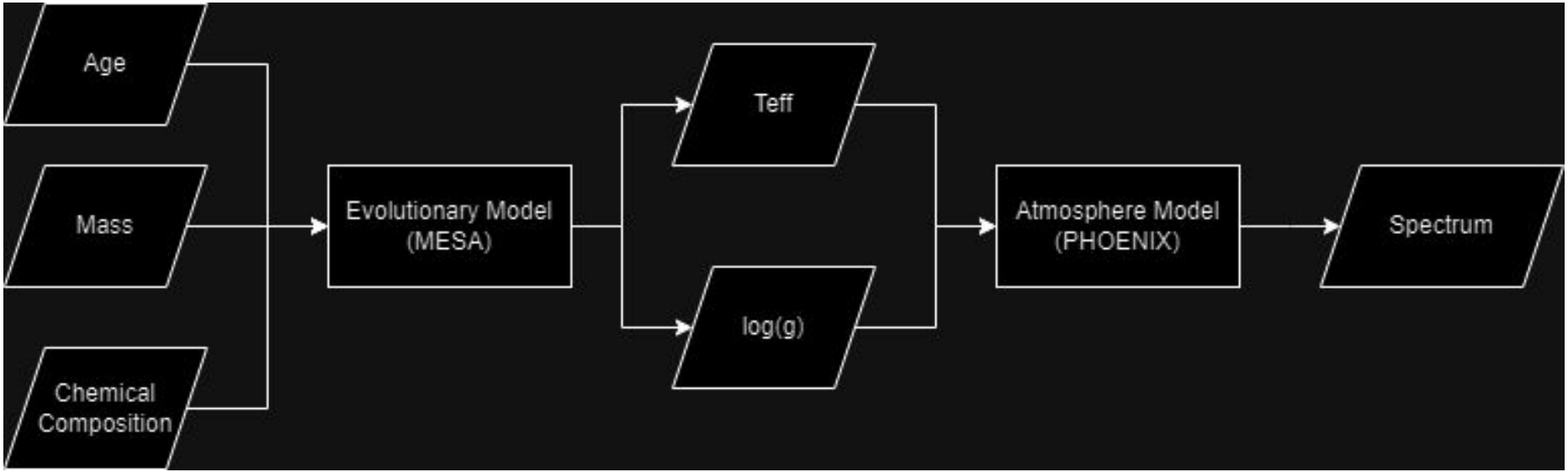


Spectral Analysis

Here is how the spectrum changes with varying metallicities.

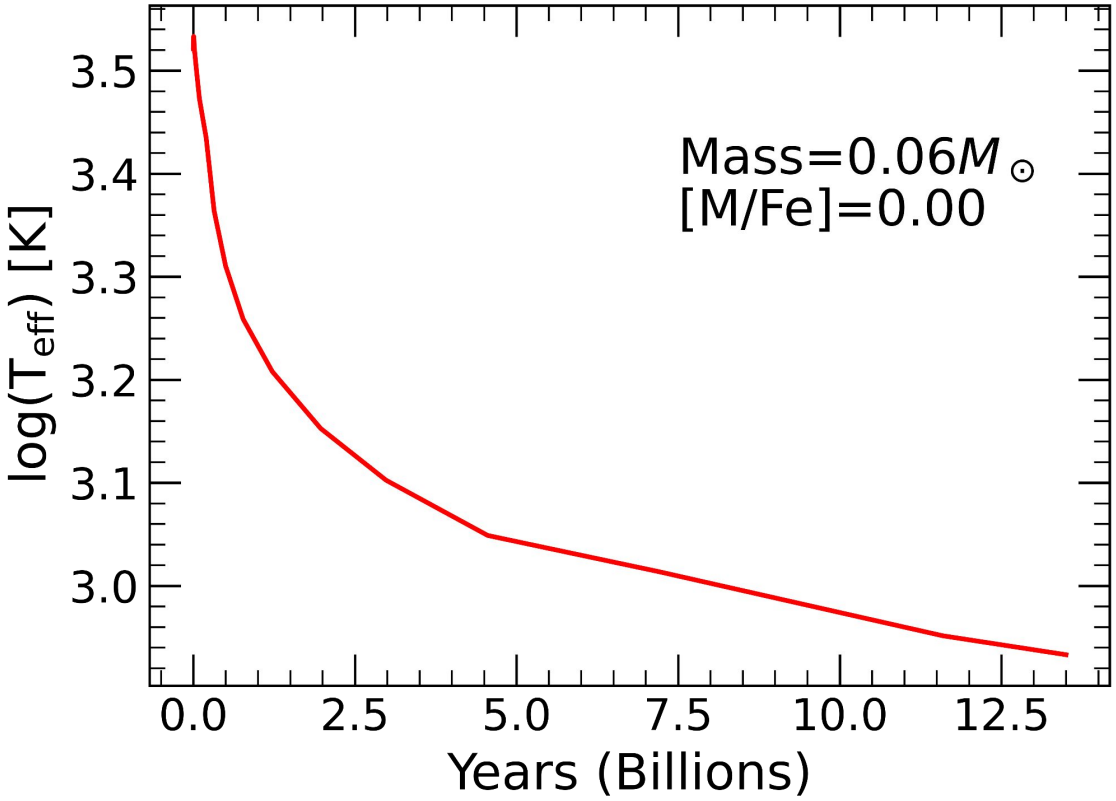


Next Steps


Age
Mass
Chemical Composition
Evolutionary Model (MESA)
Teff
log(g)
Atmosphere Model (PHOENIX)
Spectrum

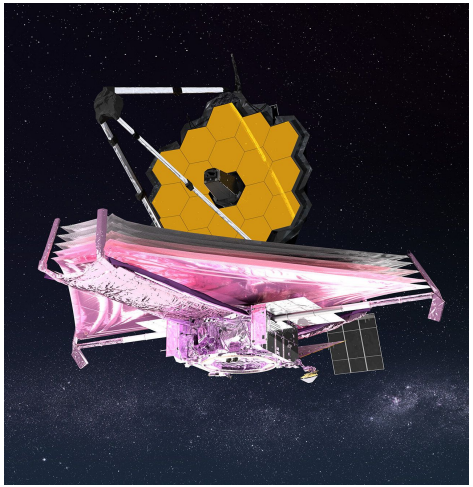
Next Steps

MESA: generates changes the star's lifetime from birth to death (or until desired age).

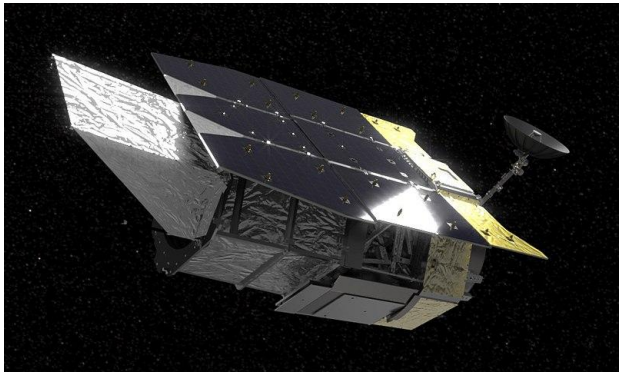


Implications

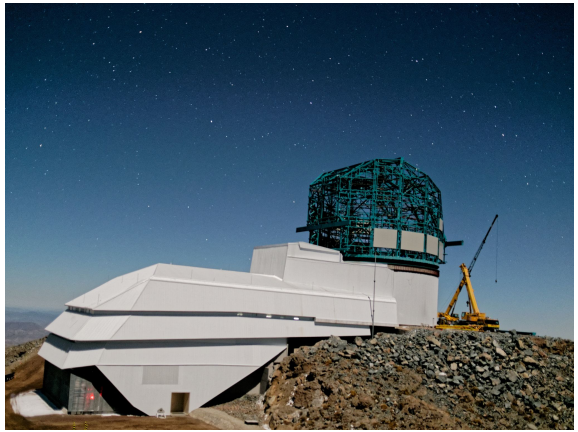
Will support deep surveys with the James Webb Telescope, Nancy Grace Roman Space Telescope, and the Vera Rubin Observatory.



NASA
GSFC/CIL/Adriana Manrique Gutierrez



NASA (WFIRST Project and Dominic Benford)



Picture taken by Wil O'Mullane

Acknowledgement

I would like to thank Professor Burgasser for warmly welcoming me into the Cool Star Lab. I would also like to thank Dr. Gerasimov for the incredible mentorship through this project. I am grateful for everyone in the Cool Star Lab for the support and encouragement.

I would like to thank Diana Lizarraga, the CalNERDS, and UCLEADS for funding this research project.

This acknowledgement is to hold respect for the land and the original people of the area where the campus is located. The university and the research is conducted on the land of the Kumeyaay people.

References

- Gerasimov et al (2022, ApJ 930, 24) https://ui.adsabs.harvard.edu/abs/2022ApJ...930...24G/abstract
- Mackereth et al. (2019, MNRAS 482, 3426) https://ui.adsabs.harvard.edu/abs/2019MNRAS.482.3426M/abstract
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