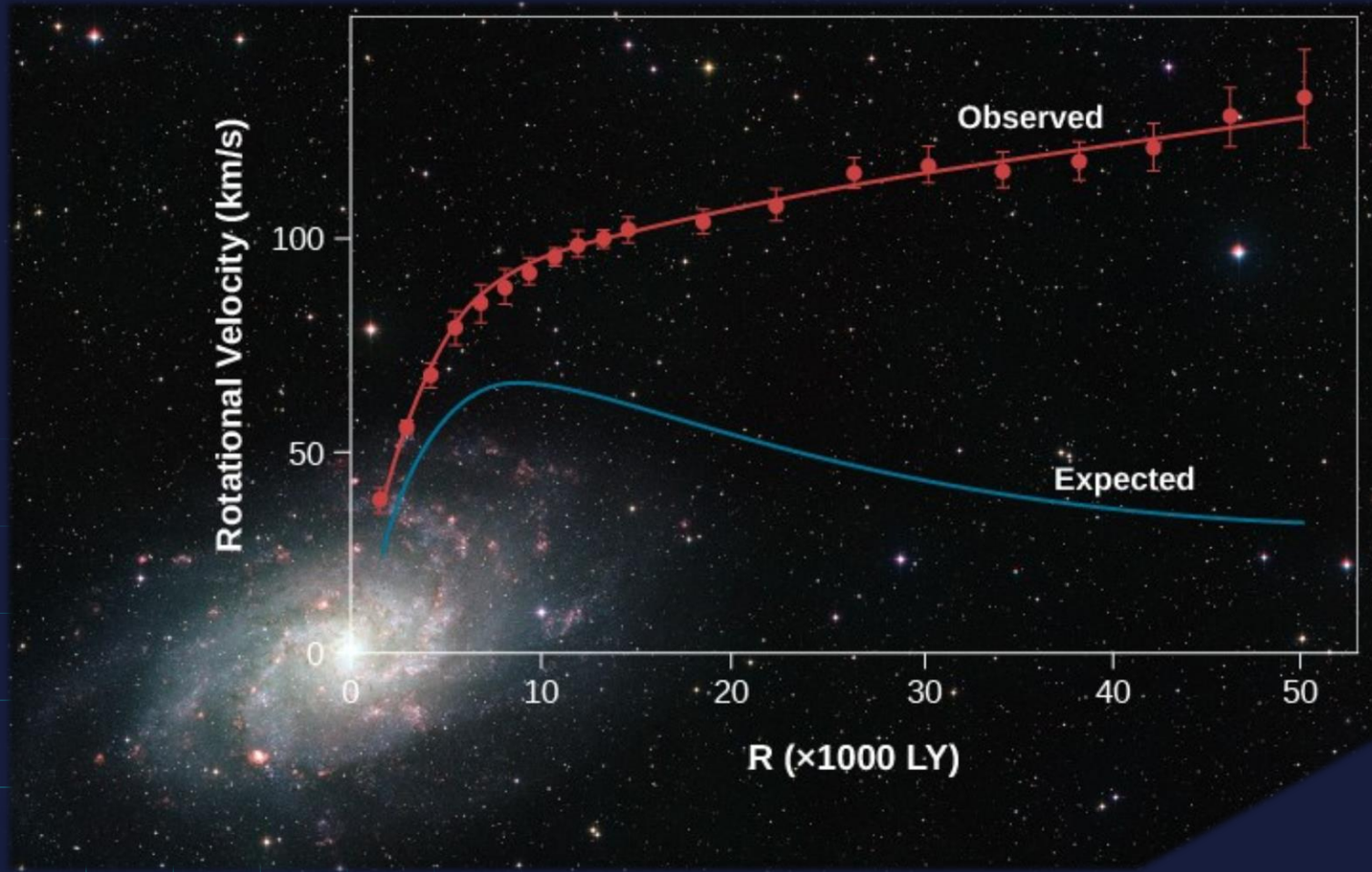




# Stellar Evolution as a Probe for Light Dark Matter Particles

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# Why is dark matter necessary?



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## Virial Theorem

- Friz Zwicky - 1933

## Rotation Curves

- Horace Babcock - 1939
- Vera Rubin – 1970s

$$\langle T \rangle = -\frac{1}{2} \langle U \rangle$$

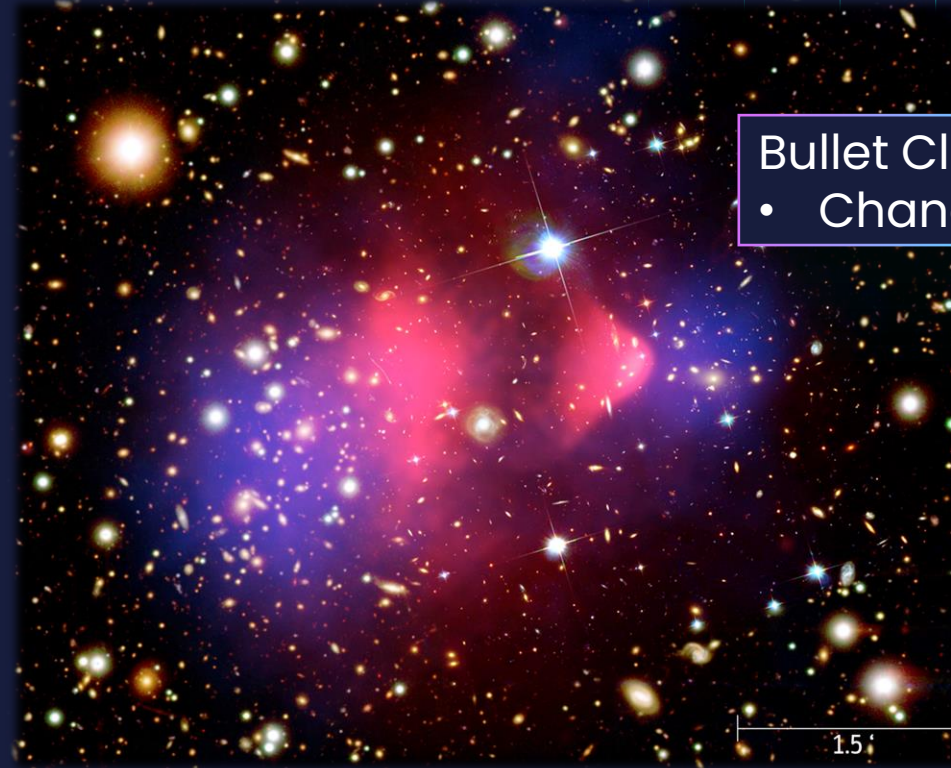
# Why is dark matter necessary?



## Gravitational Lensing

- 1980s - Now

Gravitational lensing. (n.d.). HubbleSite.



## Bullet Cluster Merger

- Chandra (2006)

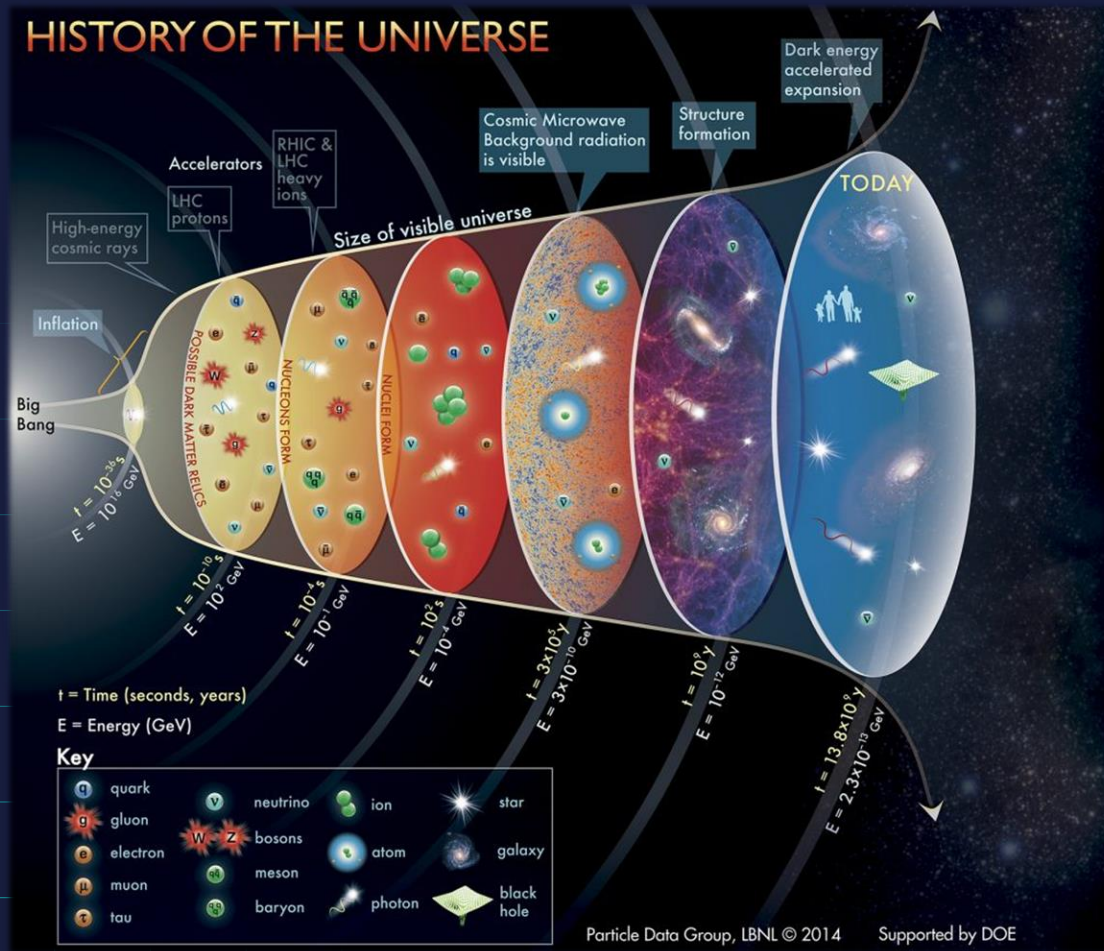
X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al

## Early Structure Formation

- Radiation pressure prevents early structure formation

# Neutrinos

→ Are neutrinos **dark** matter?



## Neutrinos

- Weakly Interacting
- Neutral
- Stable (ignoring oscillations)

$$m_{tot} = \sum_{\nu} m_{\nu}$$

Cosmological Limits:  $m_{tot} < 0.12 \text{ eV}$

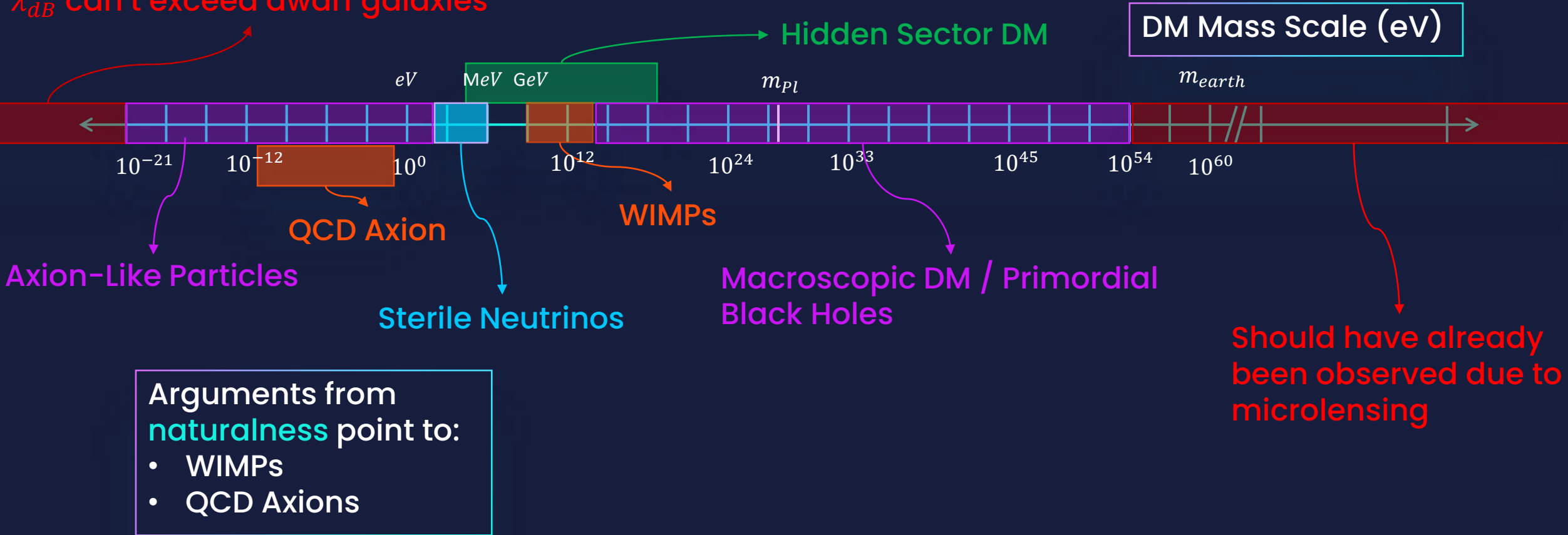
S. Navaset al.(Particle Data Group), Phys. Rev. D110, 030001 (2024)

## Neutrinos are **hot** DM!

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# Dark Matter Candidates?

$\lambda_{dB}$  can't exceed dwarf galaxies



## Is it time for a different approach?

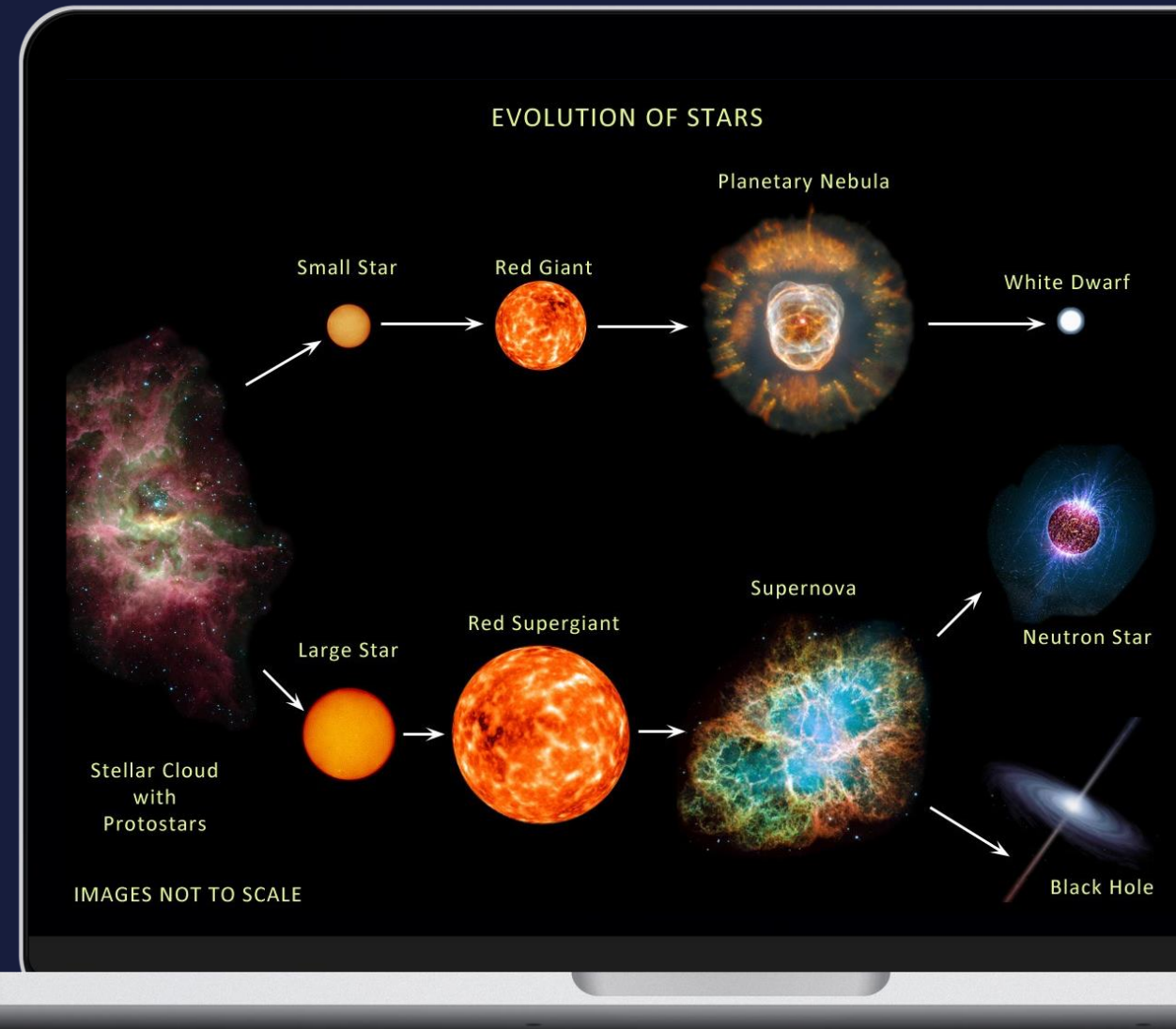
# How can we use Stellar Evolution to Probe Dark Matter?

## Indirect Detection at Population Level:

- White Dwarf Cooling
- Helium Ignition
- Supernova

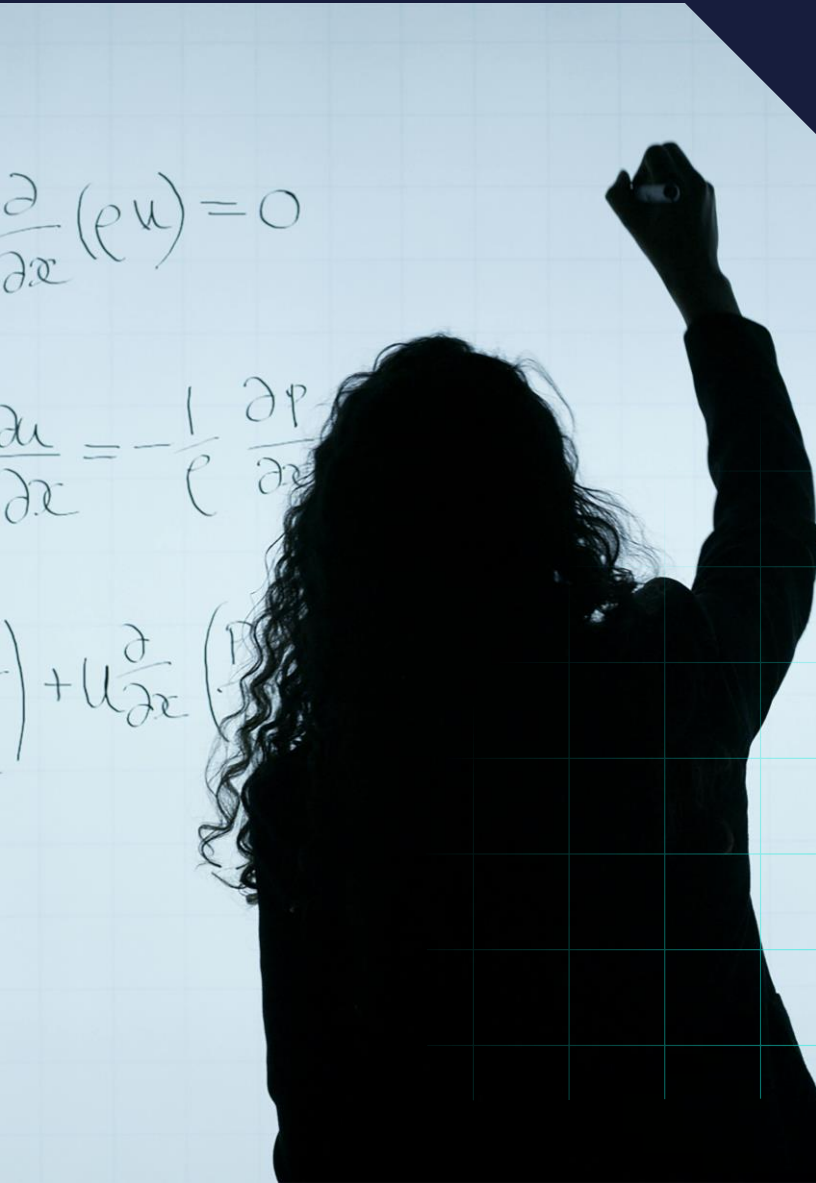
Raffelt, Georg G. Stars as laboratories for fundamental physics: The astrophysics of neutrinos, axions, and other weakly interacting particles. University of Chicago press, 1996.

## Ground Up Approach



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# What is **my** role? ———•



Learn to Write Down a Model for Light  
DM Interactions

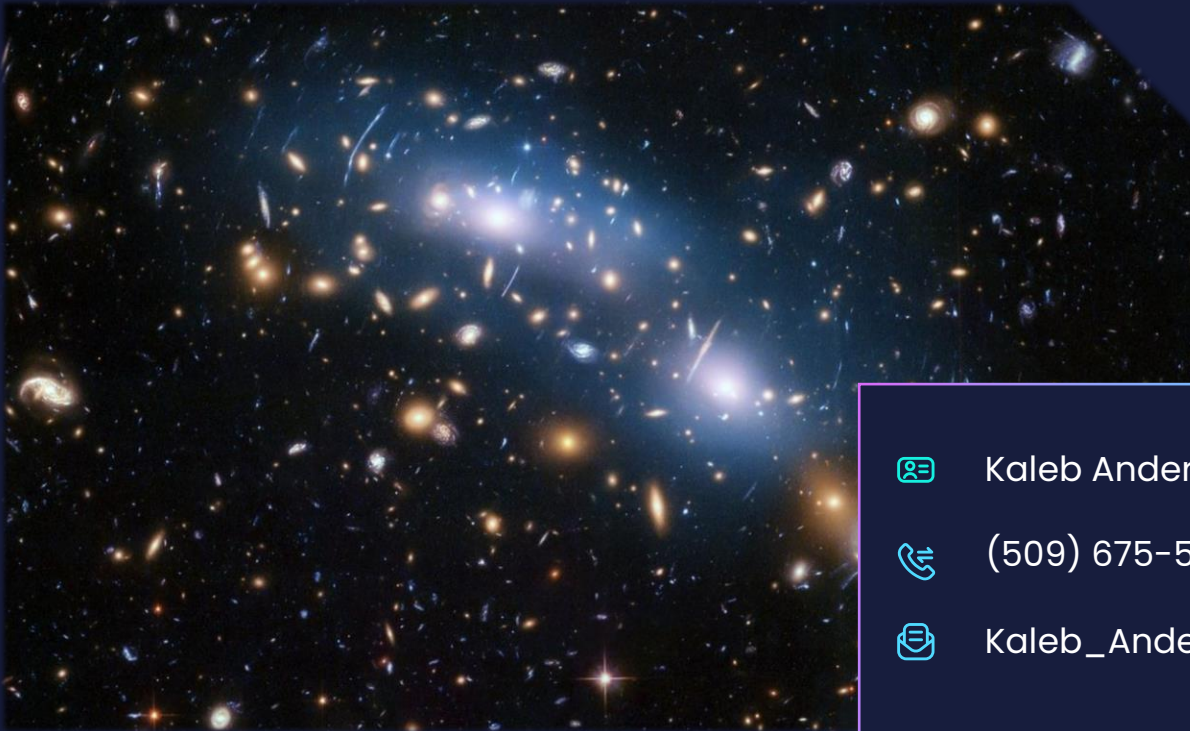
Run Stellar Evolution Simulations




Check Model Predictions Against Data

Interpret Constraints on Possible  
Axion-like DM Properties

# Thank You for Listening

Please let me know if you  
have any questions.



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