The Winds of the Hot Massive Stars in I Zw 18

Dorottya Szécsi

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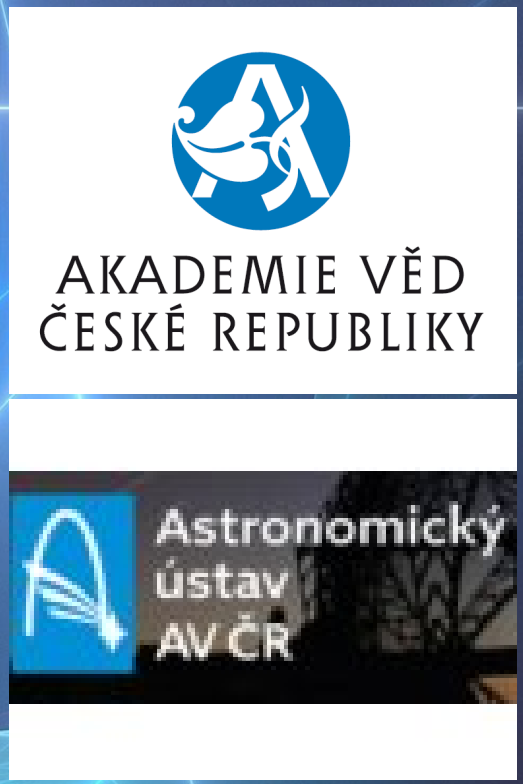
Carolina Kehrig (Granada, Spain),
Frank Tramper (Madrid, Spain),
Takashi Moriya (Tokyo, Japan)
Jíři Kubát (Ondrejov, Czech Rep.)



Grant: 13-10589S GA ČR

Quy Nhon, Vietnam, 11th August 2016

The night-sky and beyond

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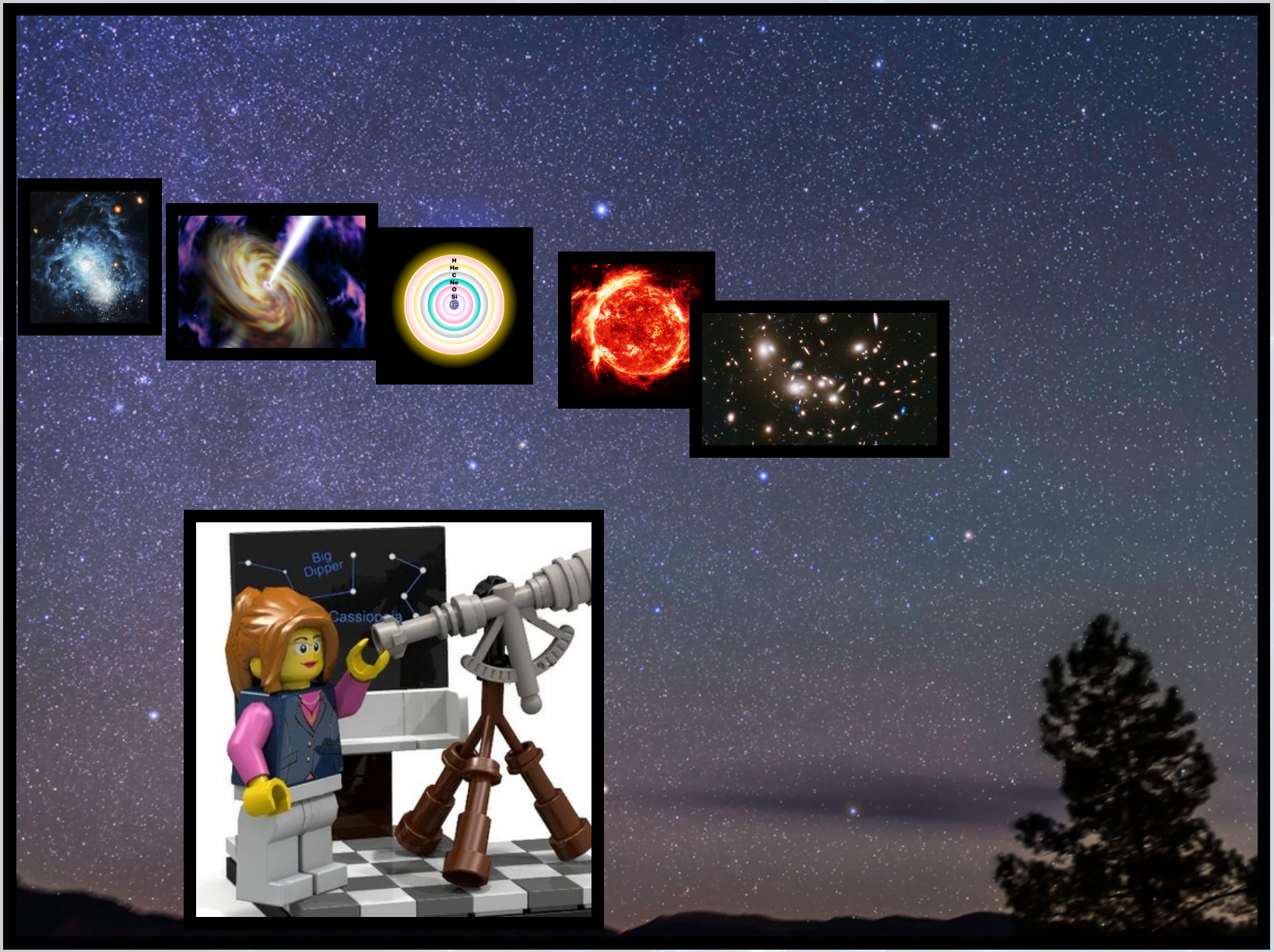

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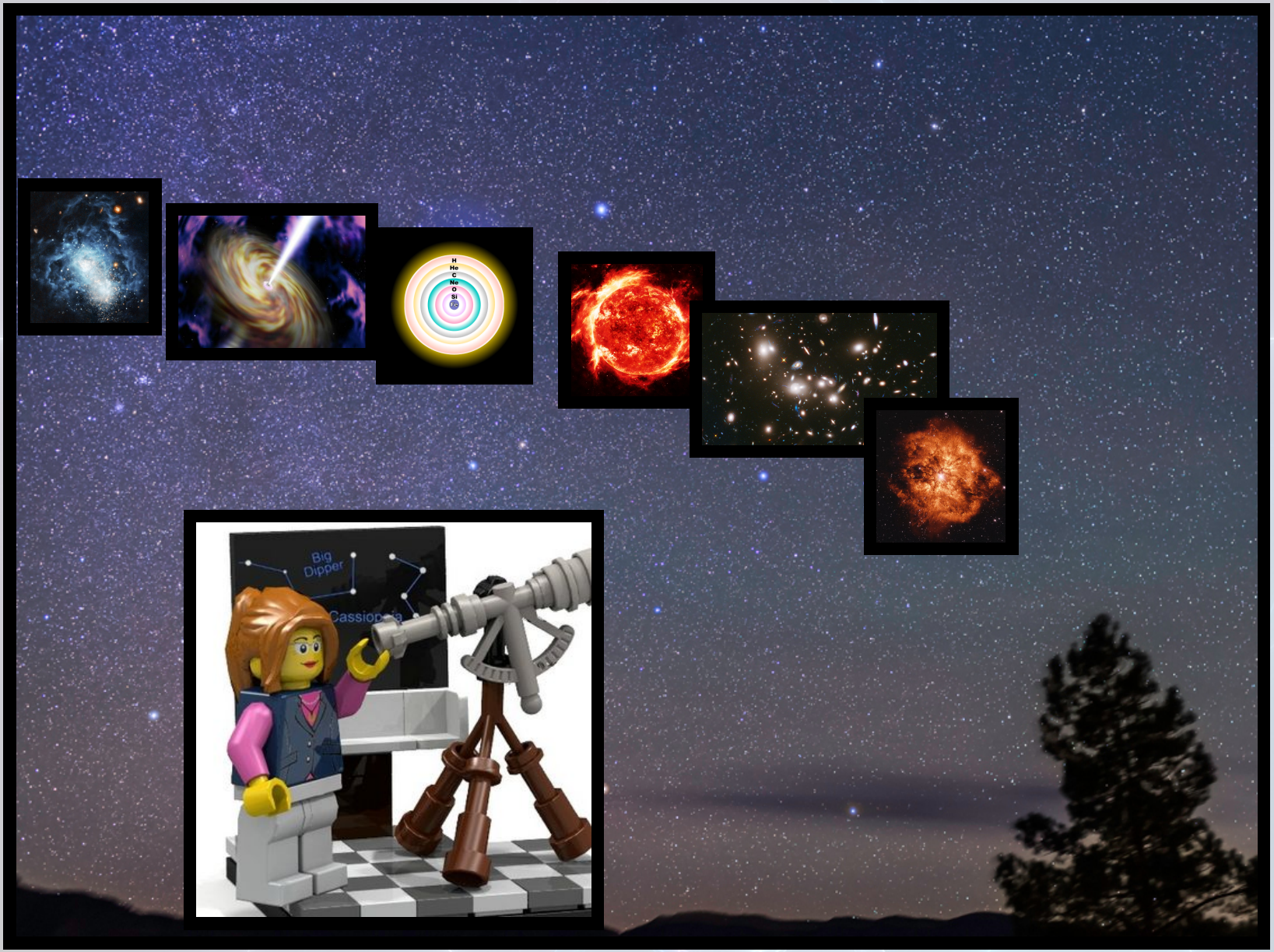

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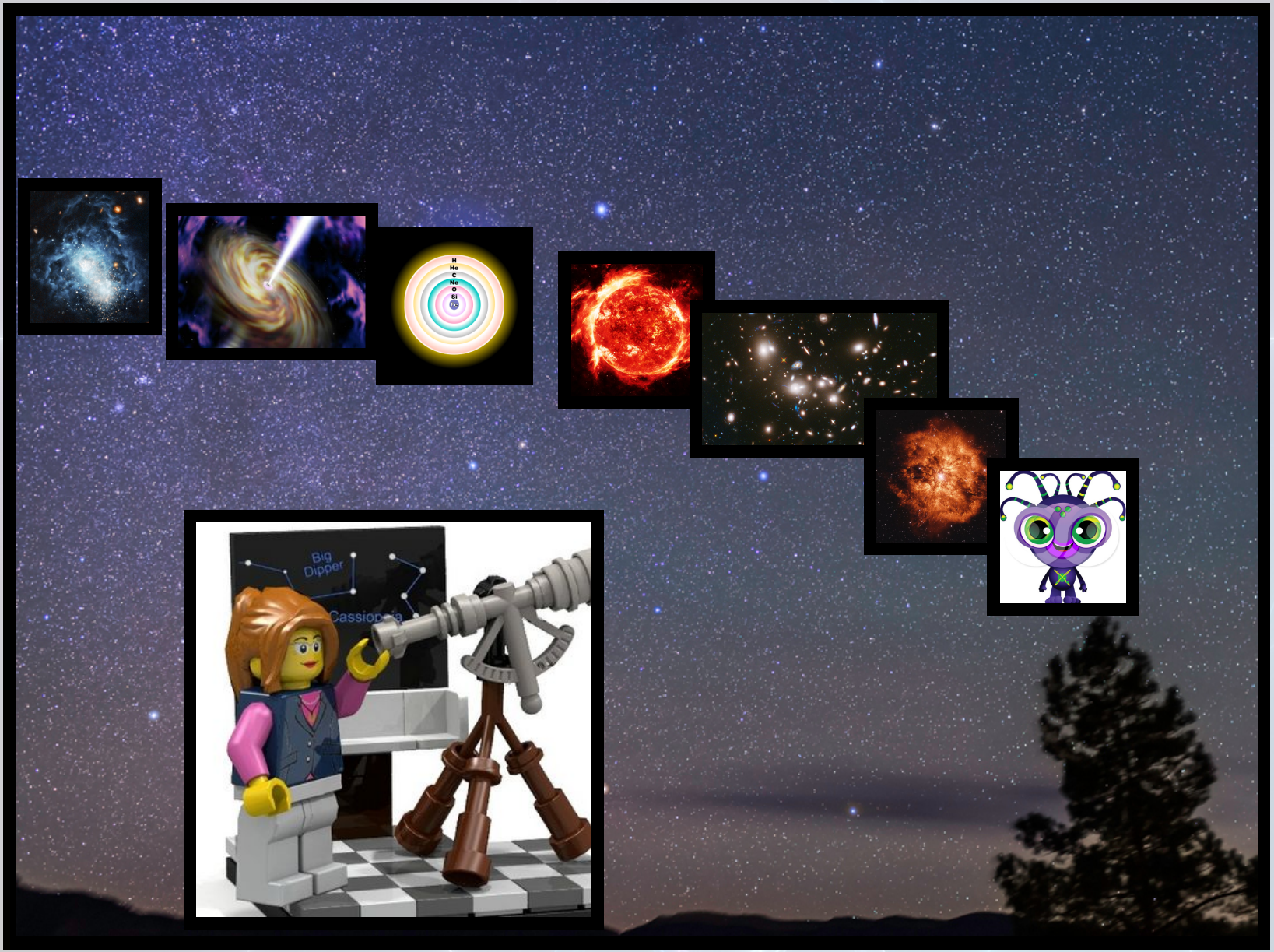

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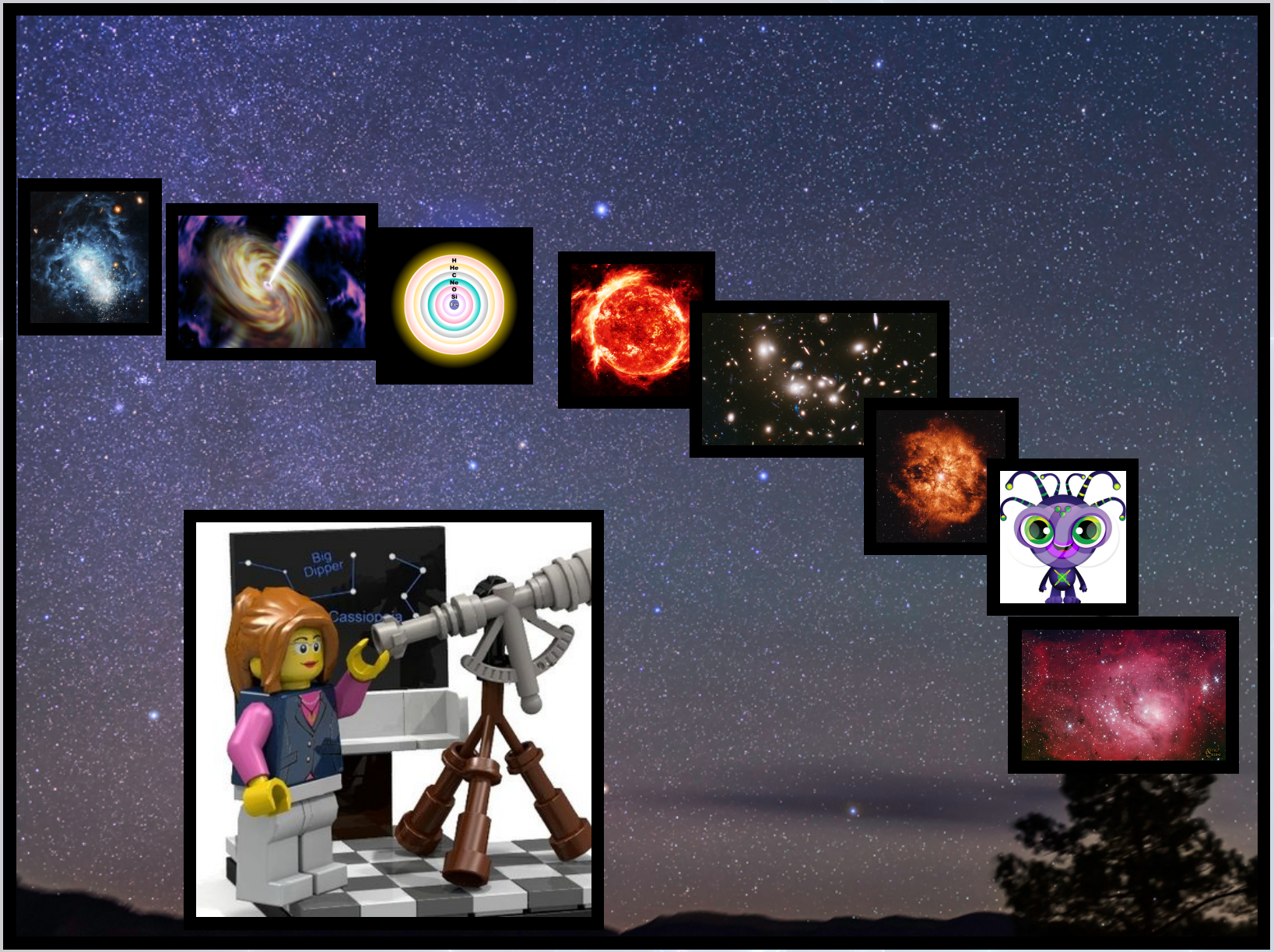

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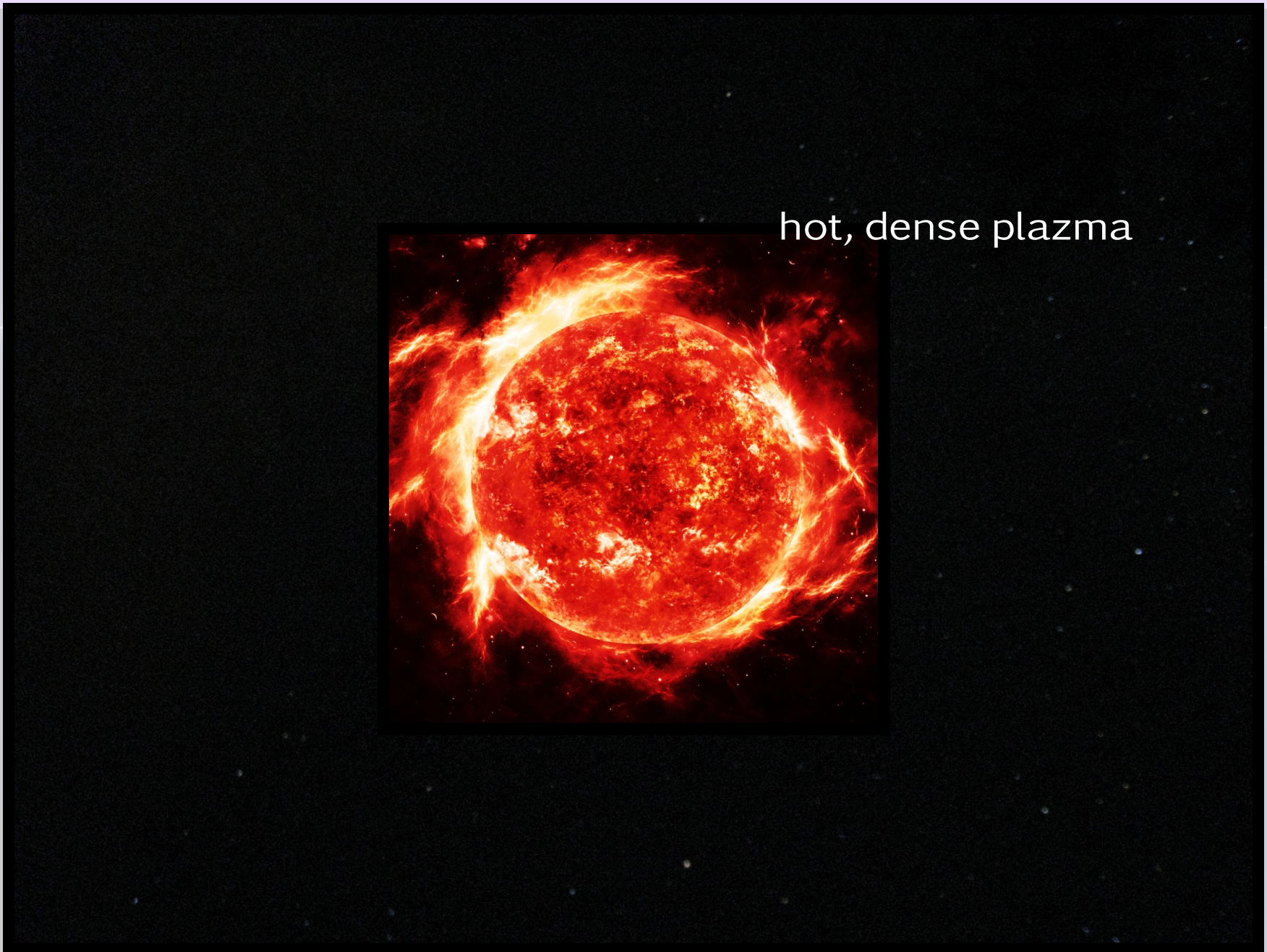
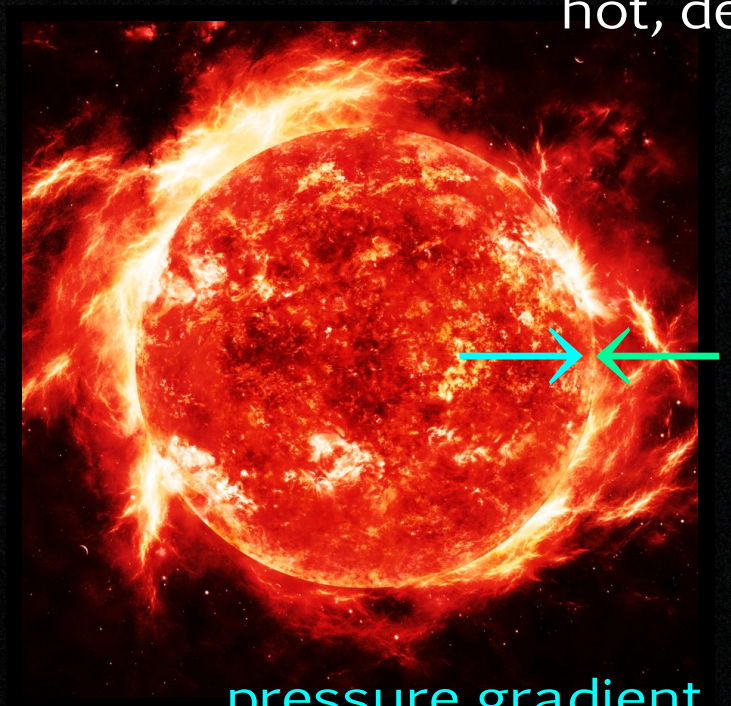


What is a star?

hot, dense plazma



equilibrium: pressure gradient gravity

What is a star?

surface?

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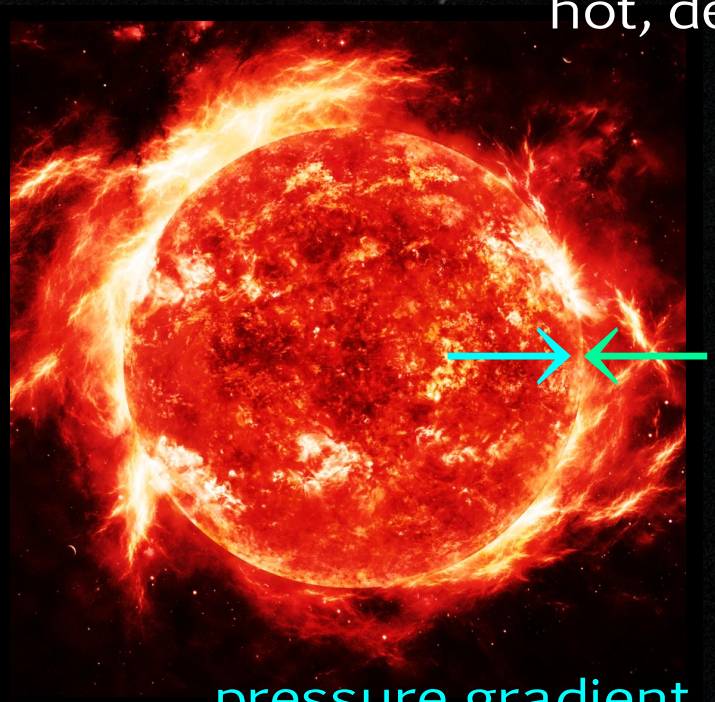

equilibrium: pressure gradient gravity

What is a star?

surface?
→ photons escape
"photosphere"

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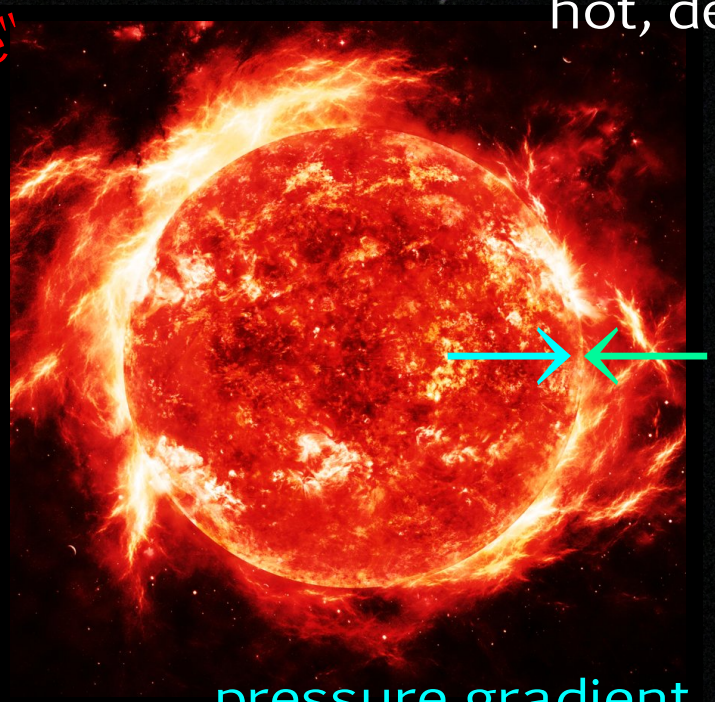

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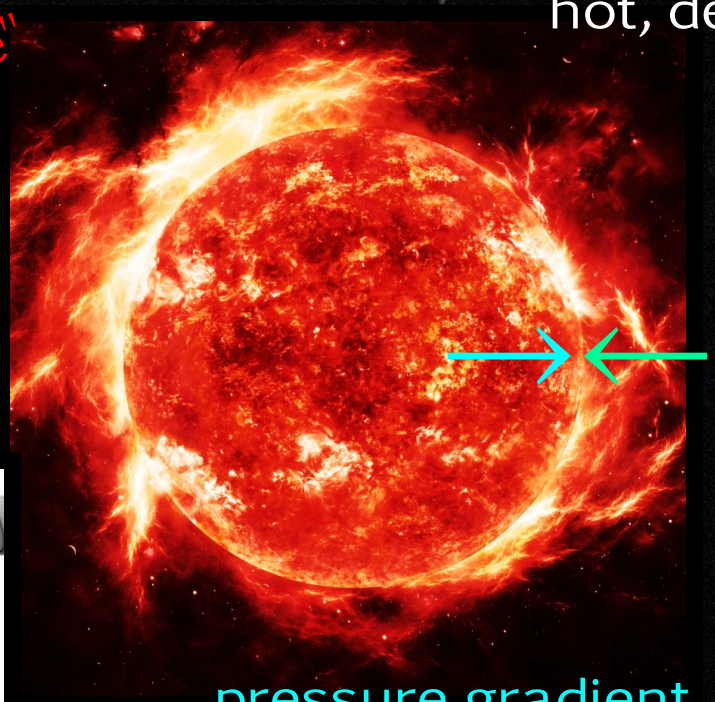

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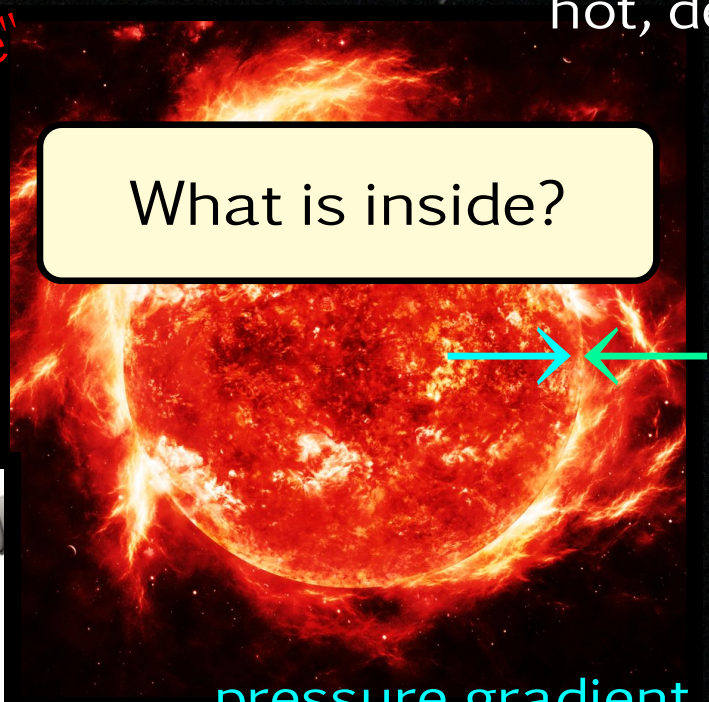
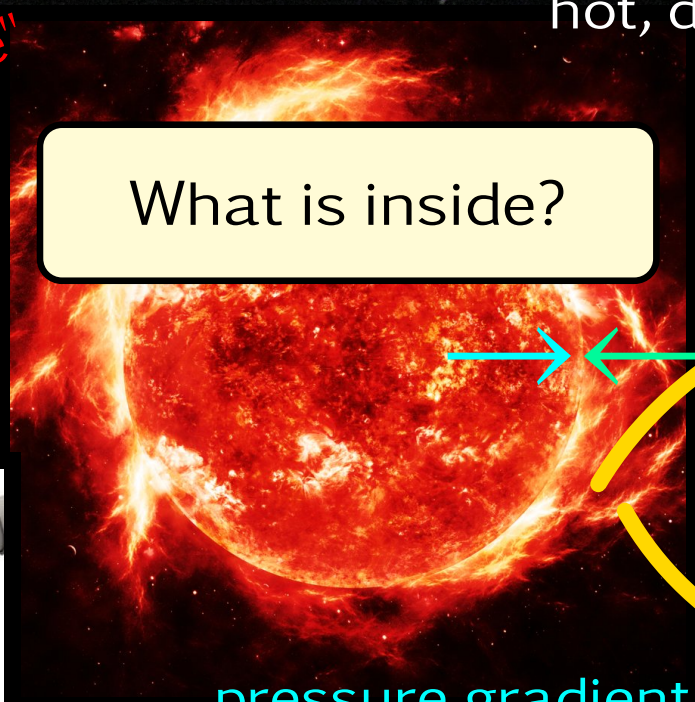


What is inside?

pressure gradient gravity

What is a star?

surface?
→ photons escape
"photosphere"



hot, dense plazma

What is inside?

theoretical modelling of the stellar structure

pressure gradient gravity

Theoretical modelling of the stellar structure

$$\frac{\partial r}{\partial m_r} = \frac{1}{4\pi r^2 \rho} \qquad \text{equation of definition of mass} \qquad (9)$$

$$\frac{\partial P}{\partial m_r} = -\frac{G m_r}{4\pi r^4} \qquad \text{equation of hydrostatic equilibrium} \qquad (10)$$

$$\frac{\partial L_r}{\partial m_r} = \epsilon_{\mathrm{pl}} - T\frac{\partial S}{\partial t} \qquad \text{equation of energetic balance} \qquad (11)$$

$$\frac{\partial T}{\partial m_r} = -\frac{G m_r T}{4\pi r^4 P}\nabla \qquad \text{equation of energy transport,} \qquad (12)$$

Guilera et al. 2011

Theoretical modelling of the stellar structure

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transport of energy

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composition change due to nuclear burning ?!

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$$\frac{\partial X_i}{\partial t} = \frac{A_i m_u}{\rho}(-\Sigma_{j,k} r_{i,j,k} + \Sigma_{k,l} r_{k,l,i}) \qquad \text{(13)}$$

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+ Rotation.

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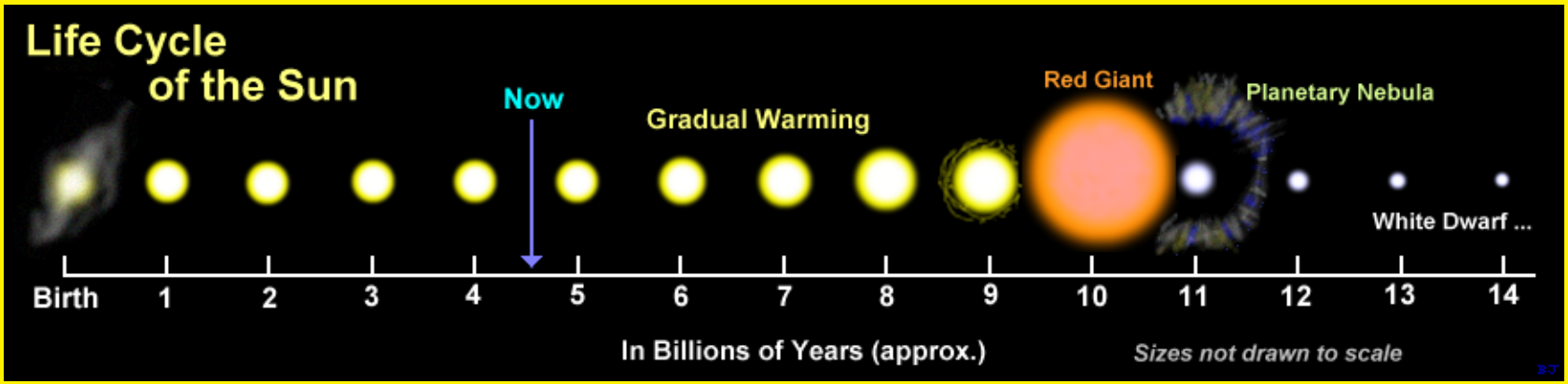
$$\frac{\partial L}{\partial} \qquad \frac{\partial S}{}$$



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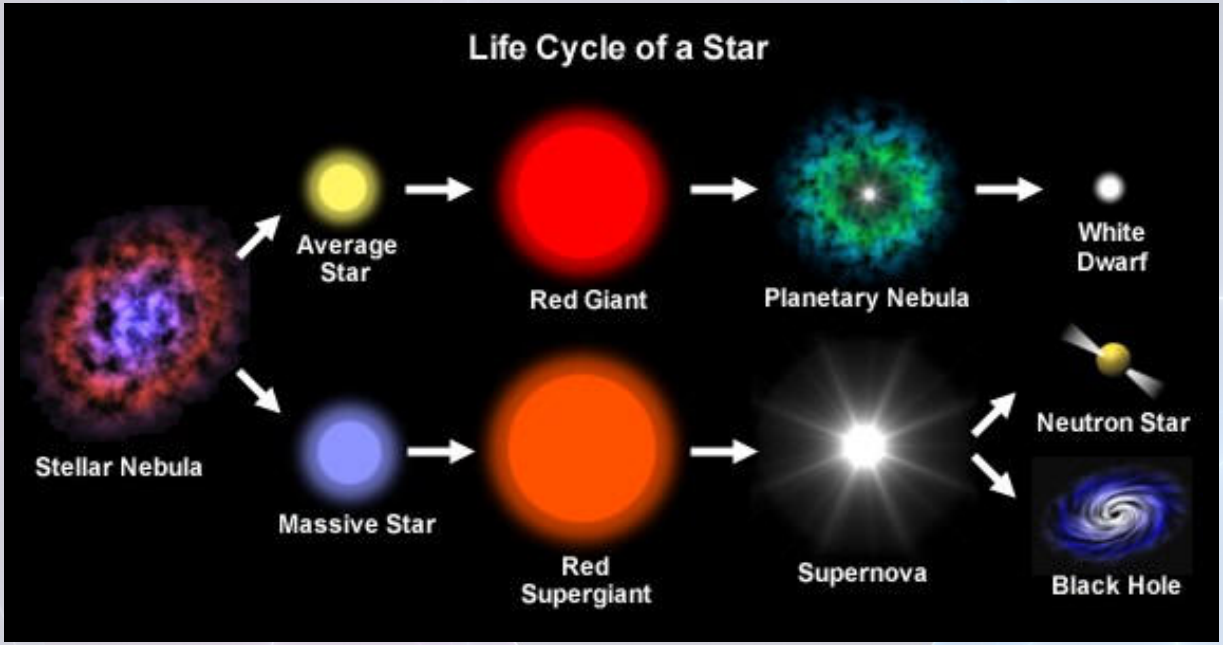
Massive vs. low-mass stars

Massive stars: $\gtrsim 9$ times the Sun ($\gtrsim 9\ M_\odot$)



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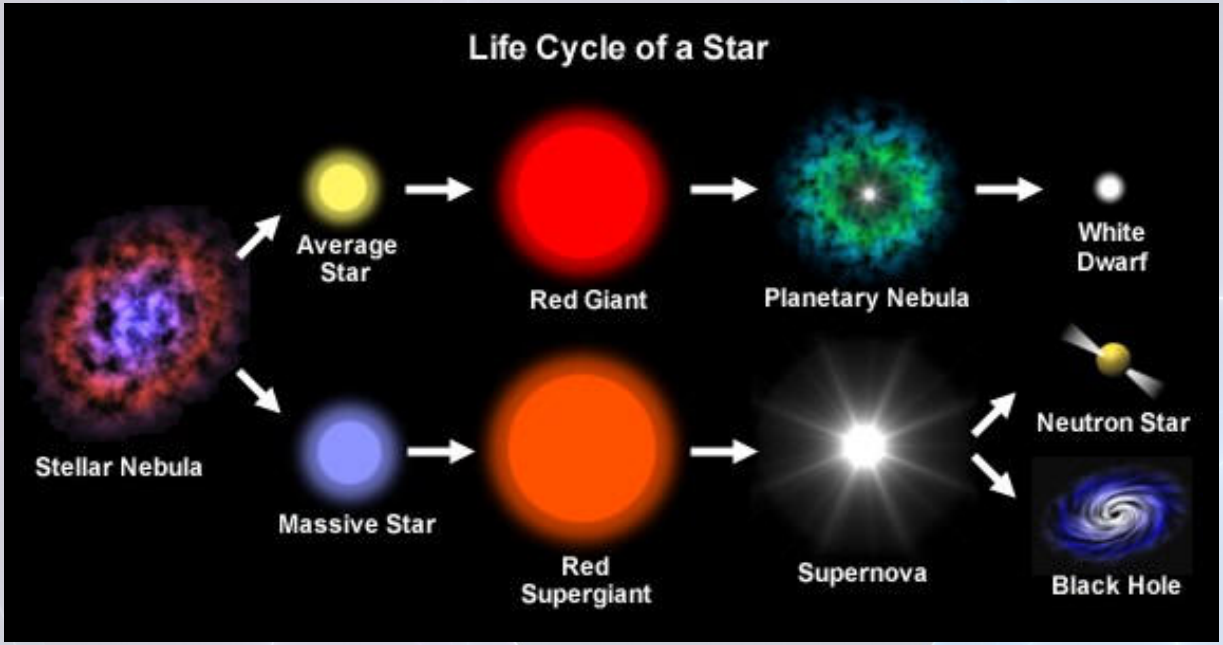

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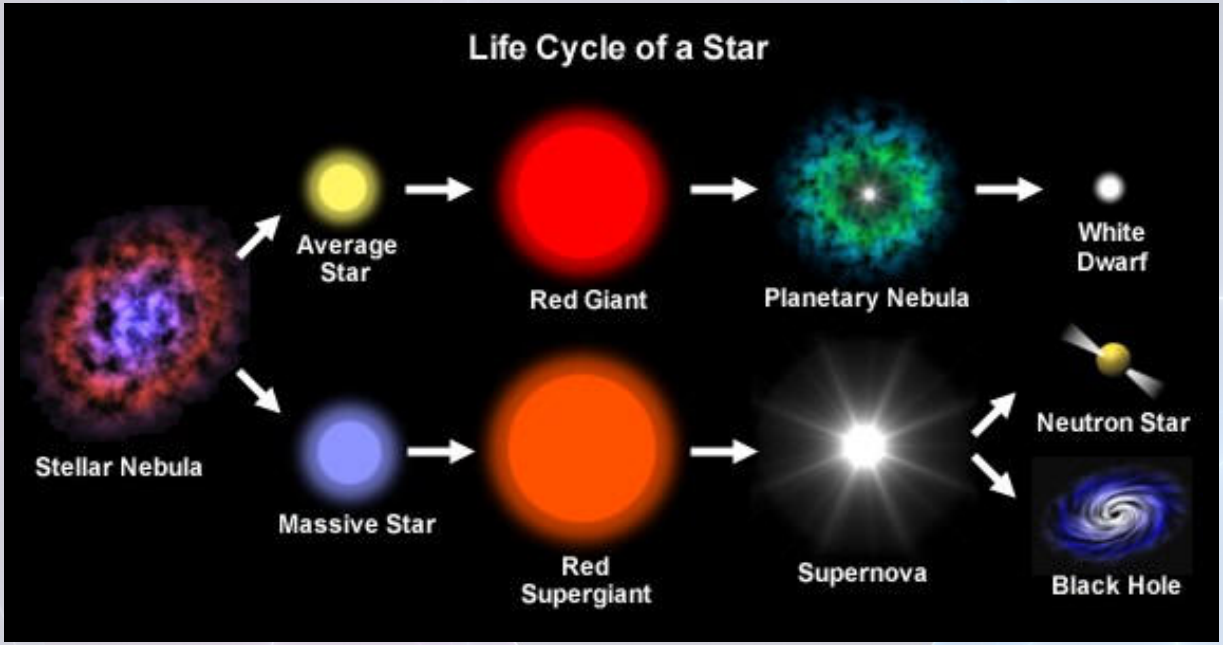

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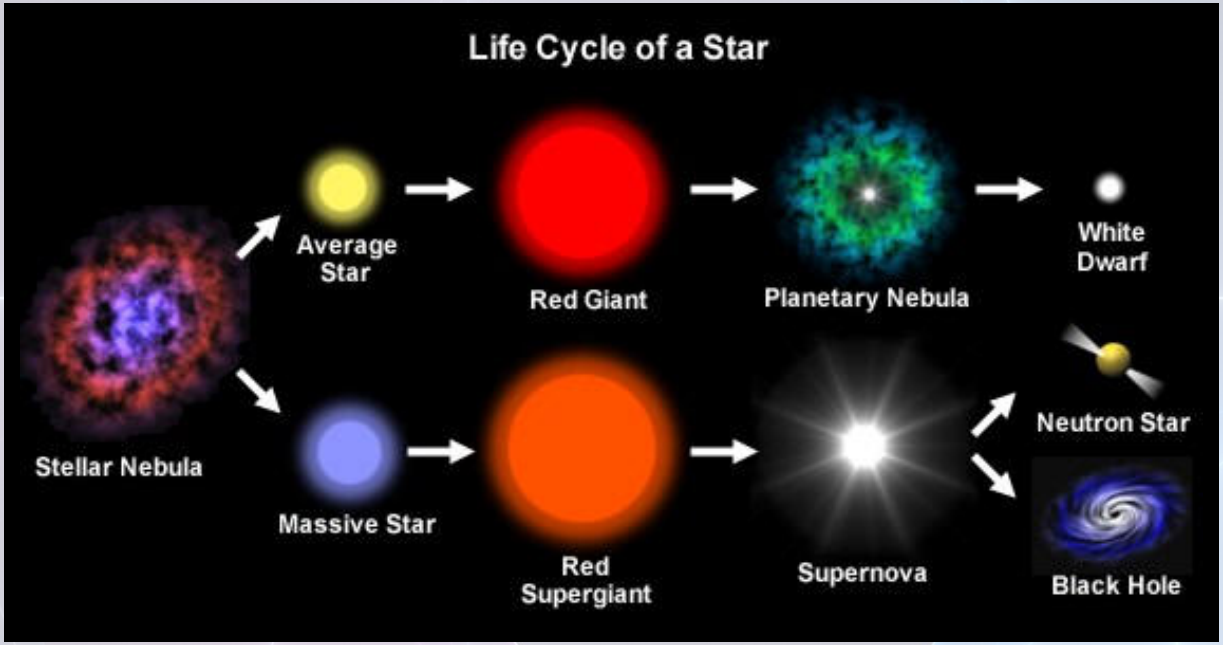

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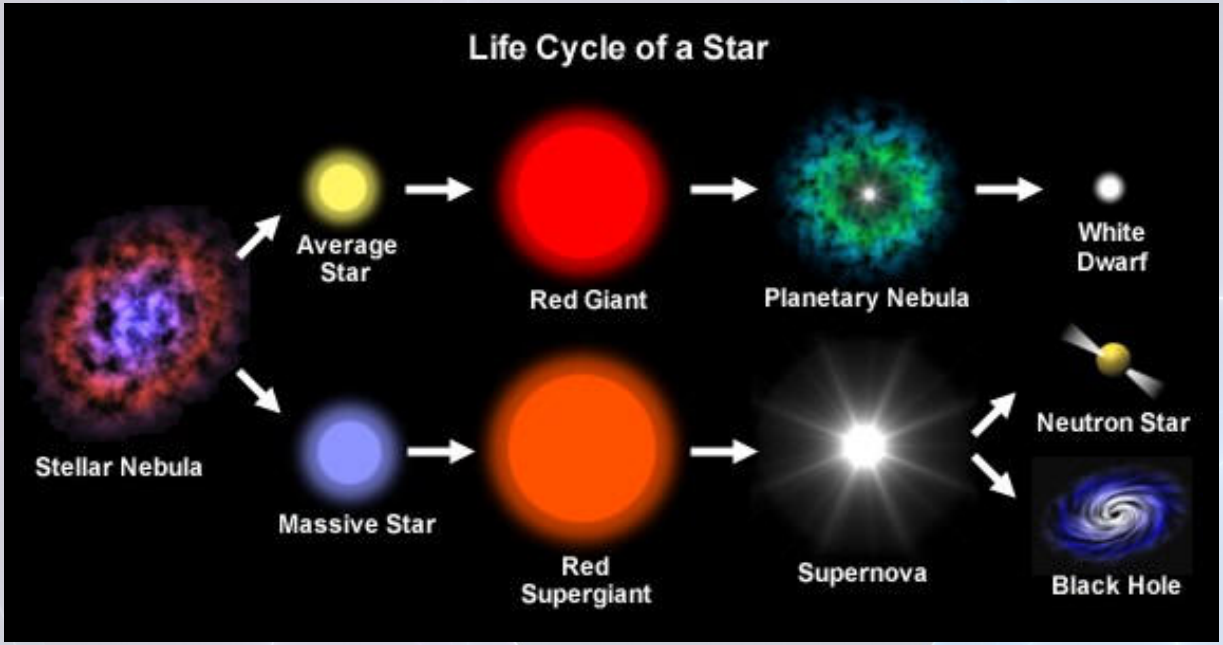

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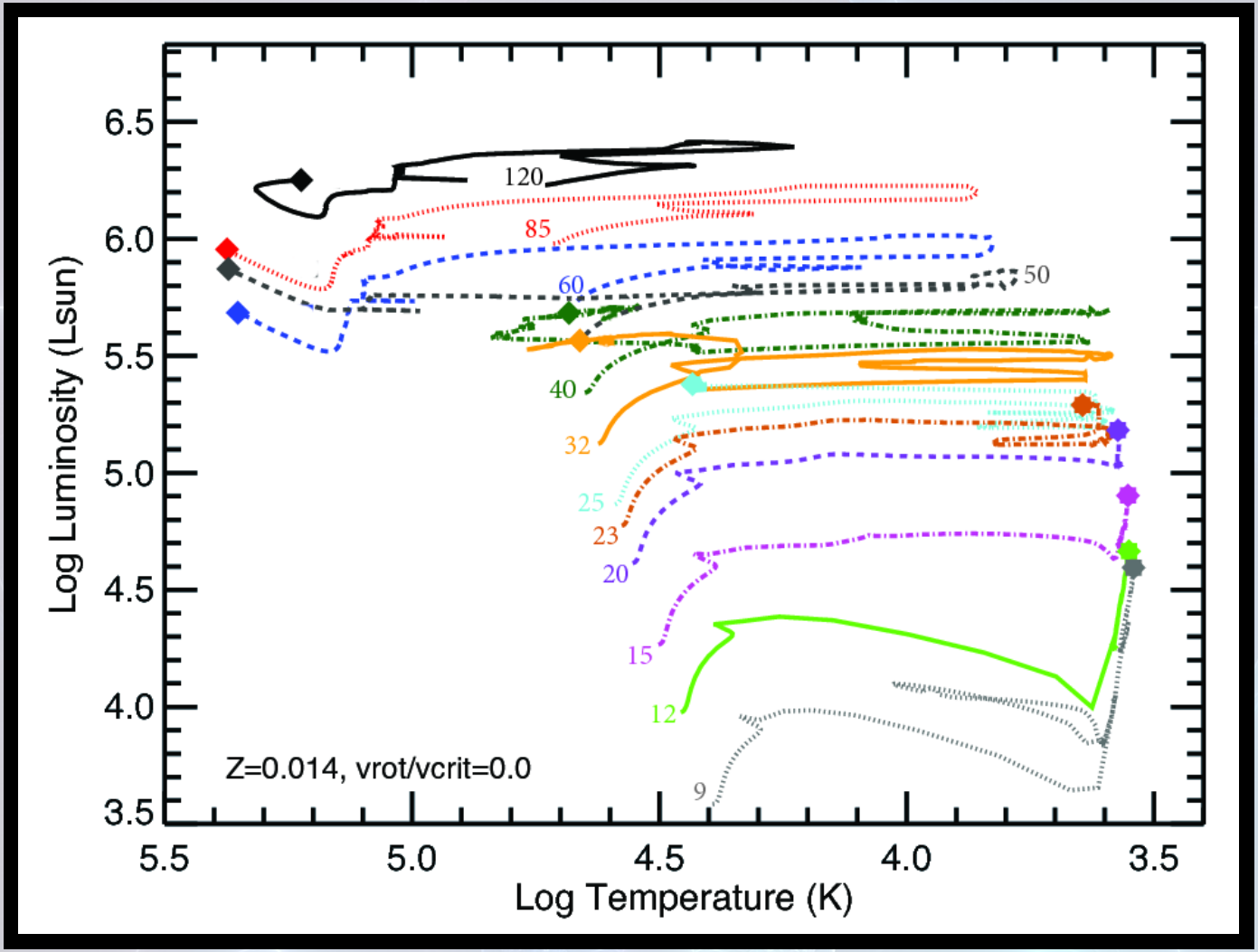
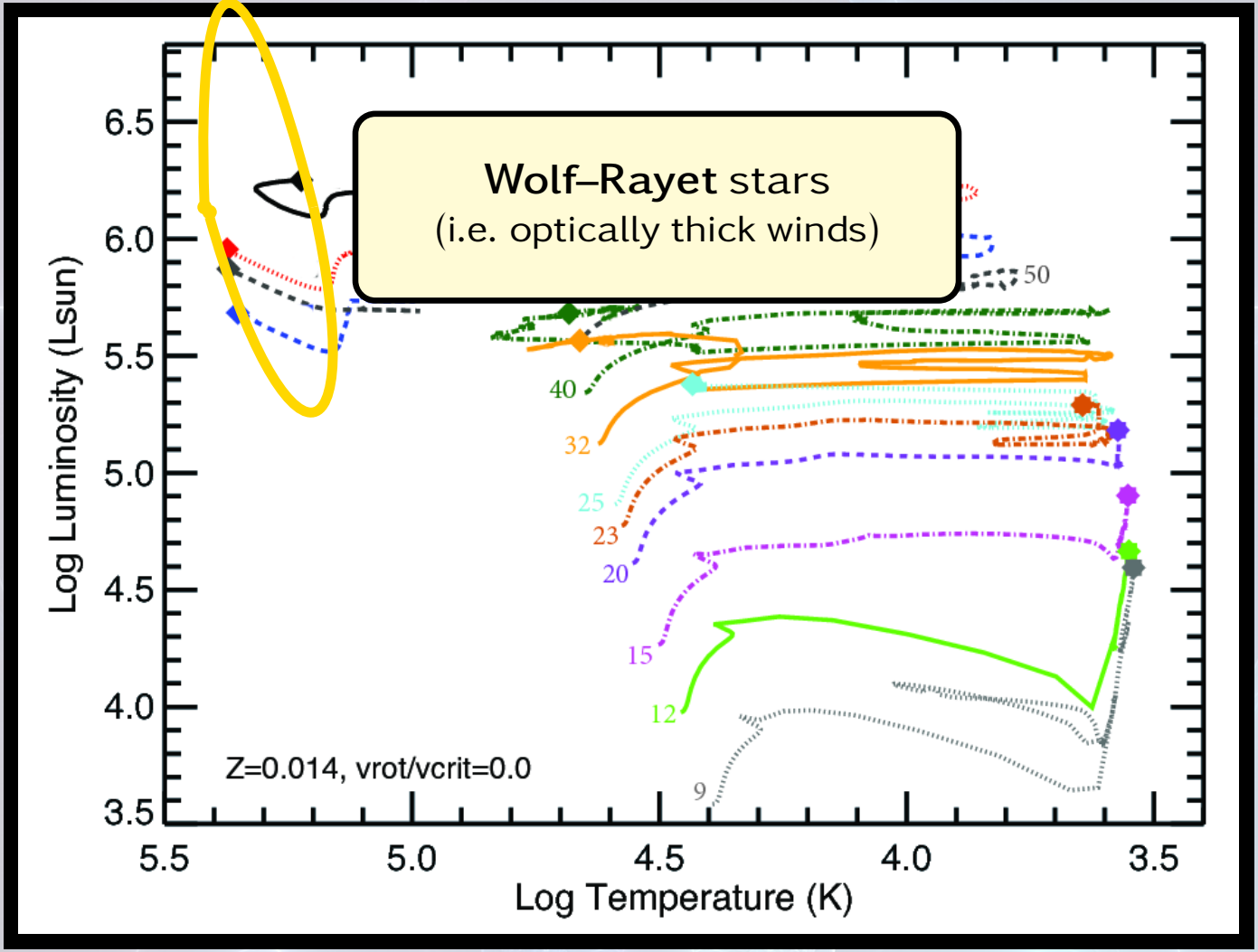
- final fate

Hertzsprung–Russell diagram



Groh et al. 2013

Hertzsprung–Russell diagram



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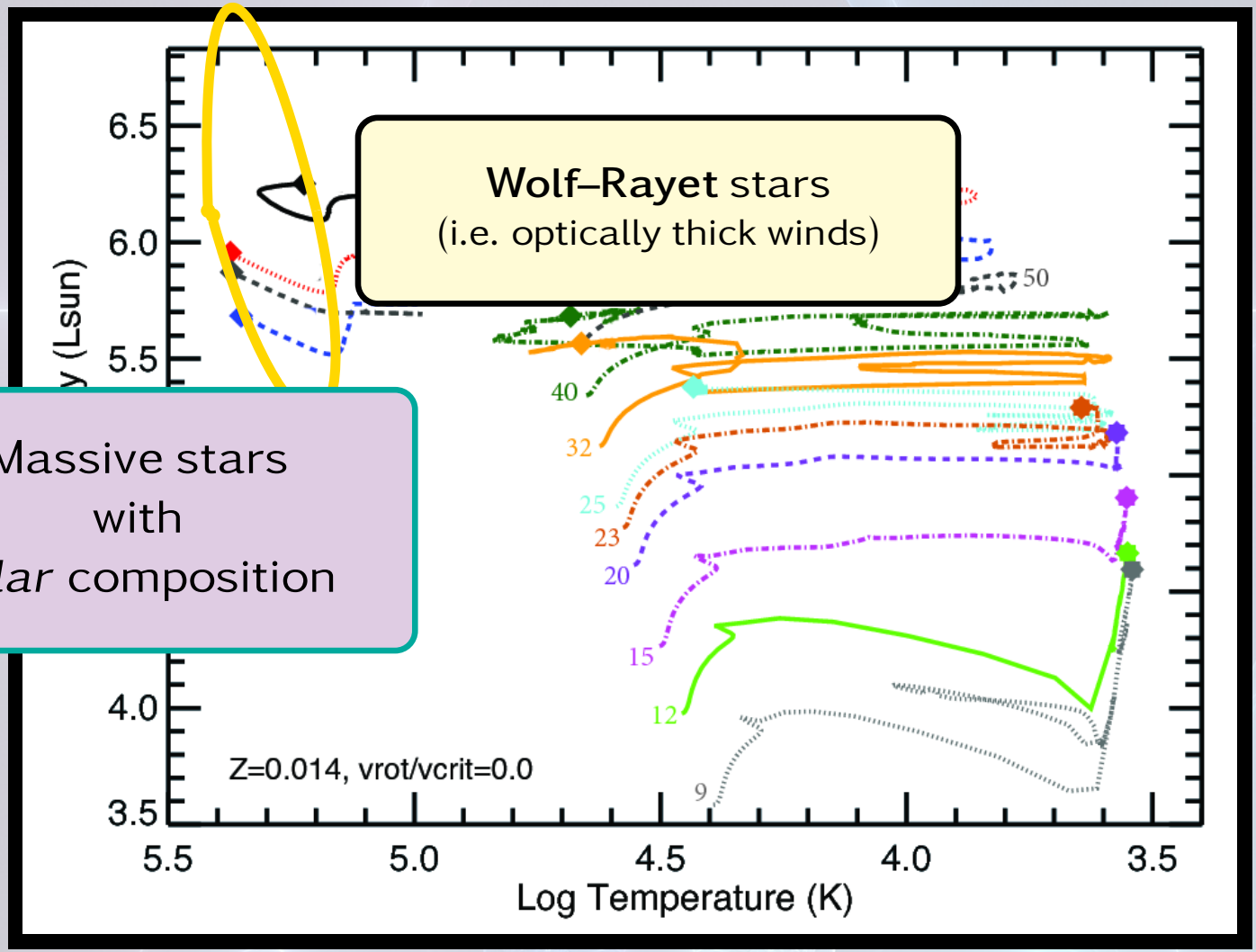

Groh et al. 2013

Low Metallicity Massive Stars

Low Metallicity Massive Stars

– my thesis ☺

Compact Dwarf Galaxies

Legrand+07, Aloisi+09, Annibali+13, Kehrig+13, Lebouteiller+13

Compact Dwarf Galaxies

I Zwicky 18

- Blue Compact Dwarf Galaxy
- 60 million lightyears $\rightarrow$ local
- star formation rate: 0.1 $M_{\odot}$/yr
- ionized gas
- low metallicity!

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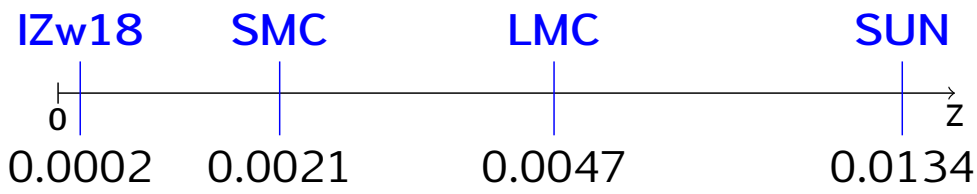

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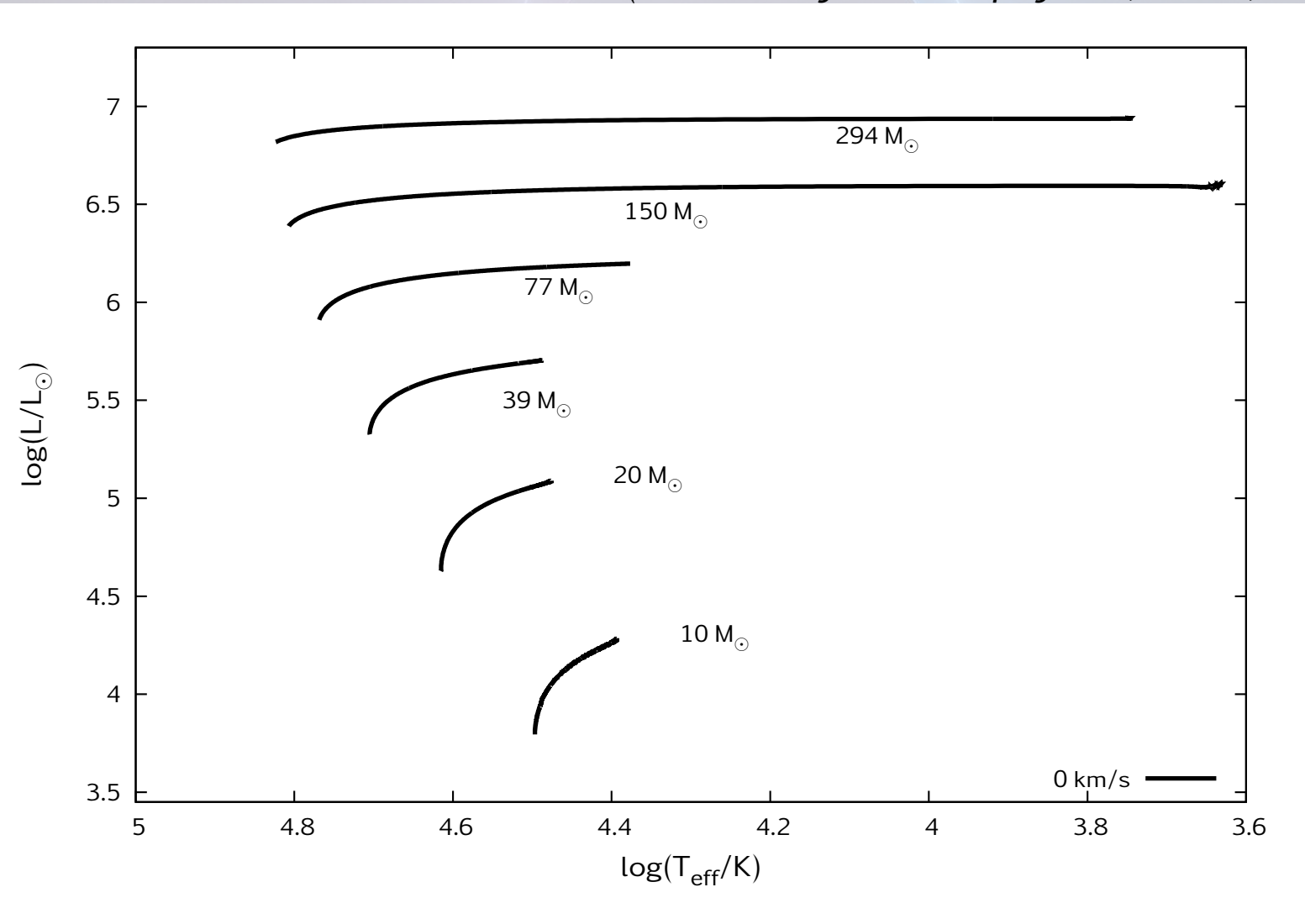
Szécsi et al. 2015 (Astronomy & Astrophysics, v.581, A15)



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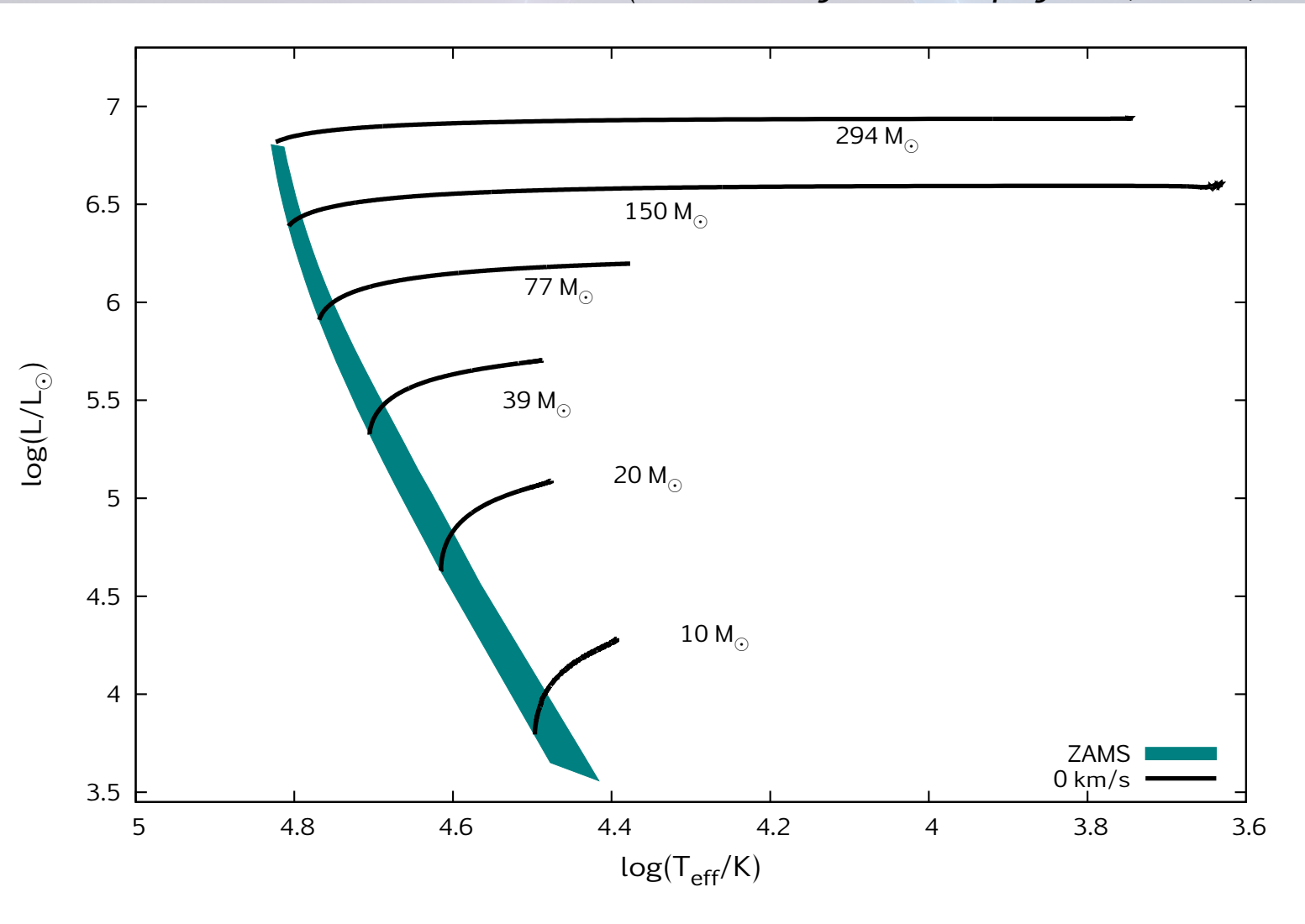

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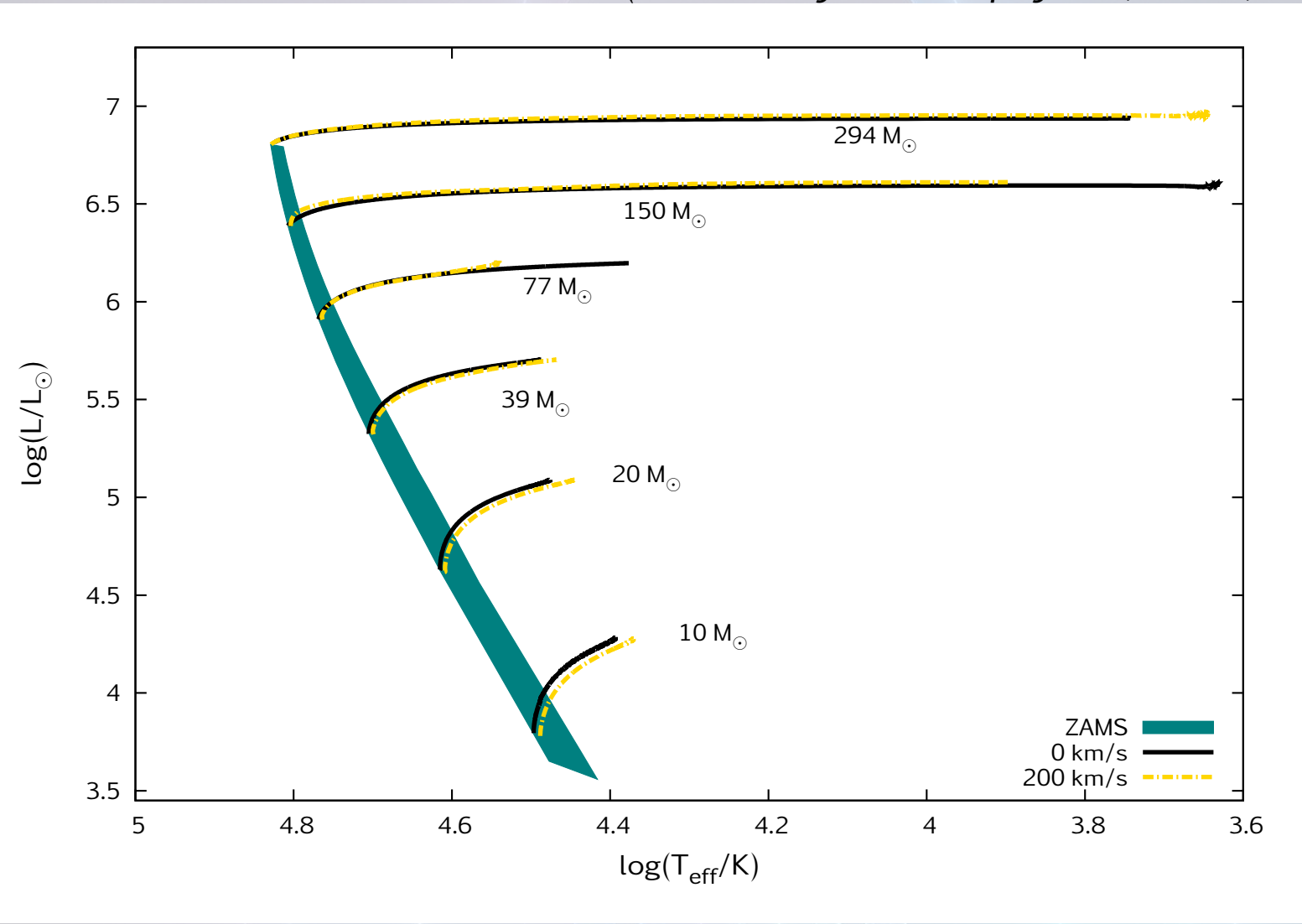

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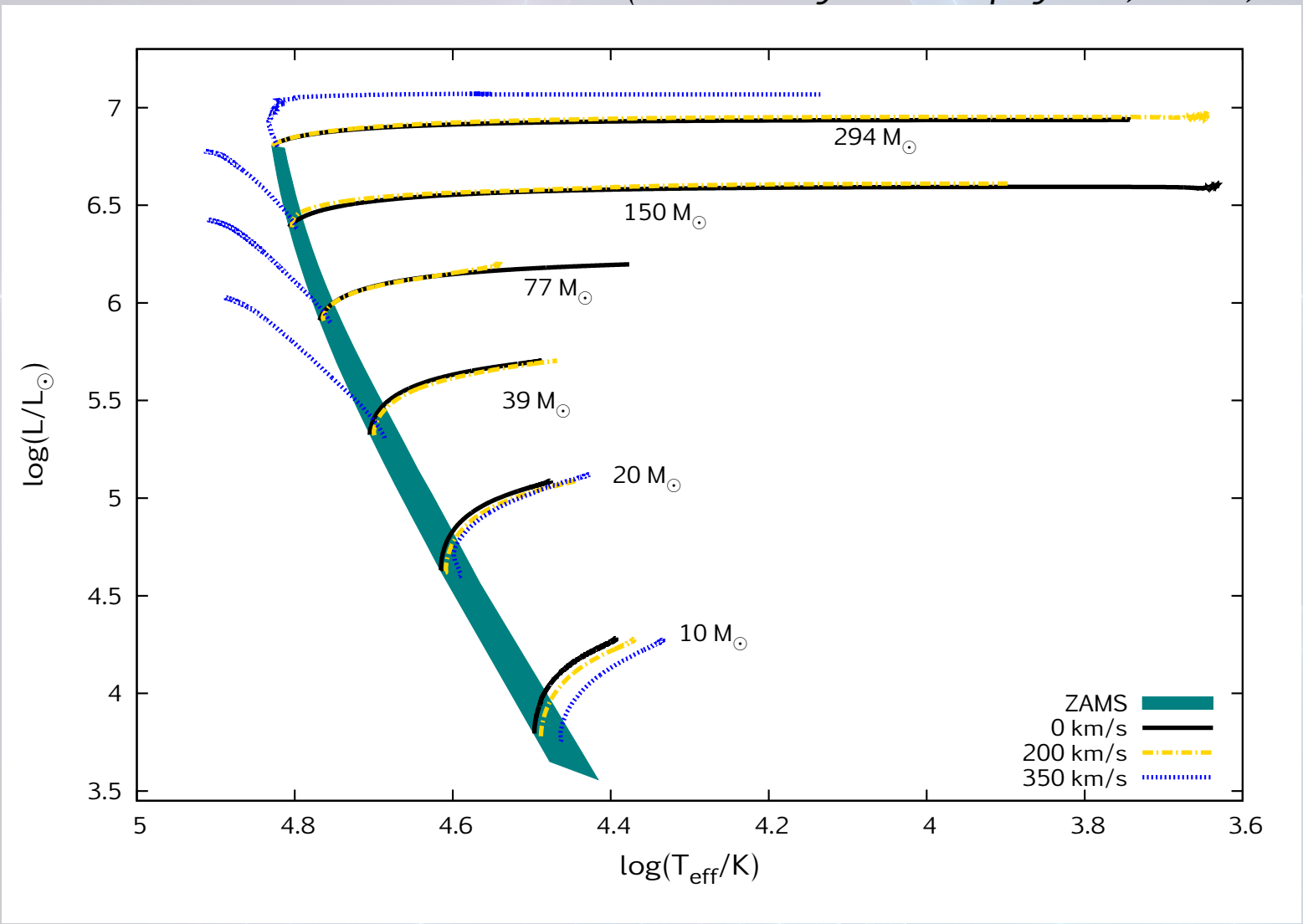

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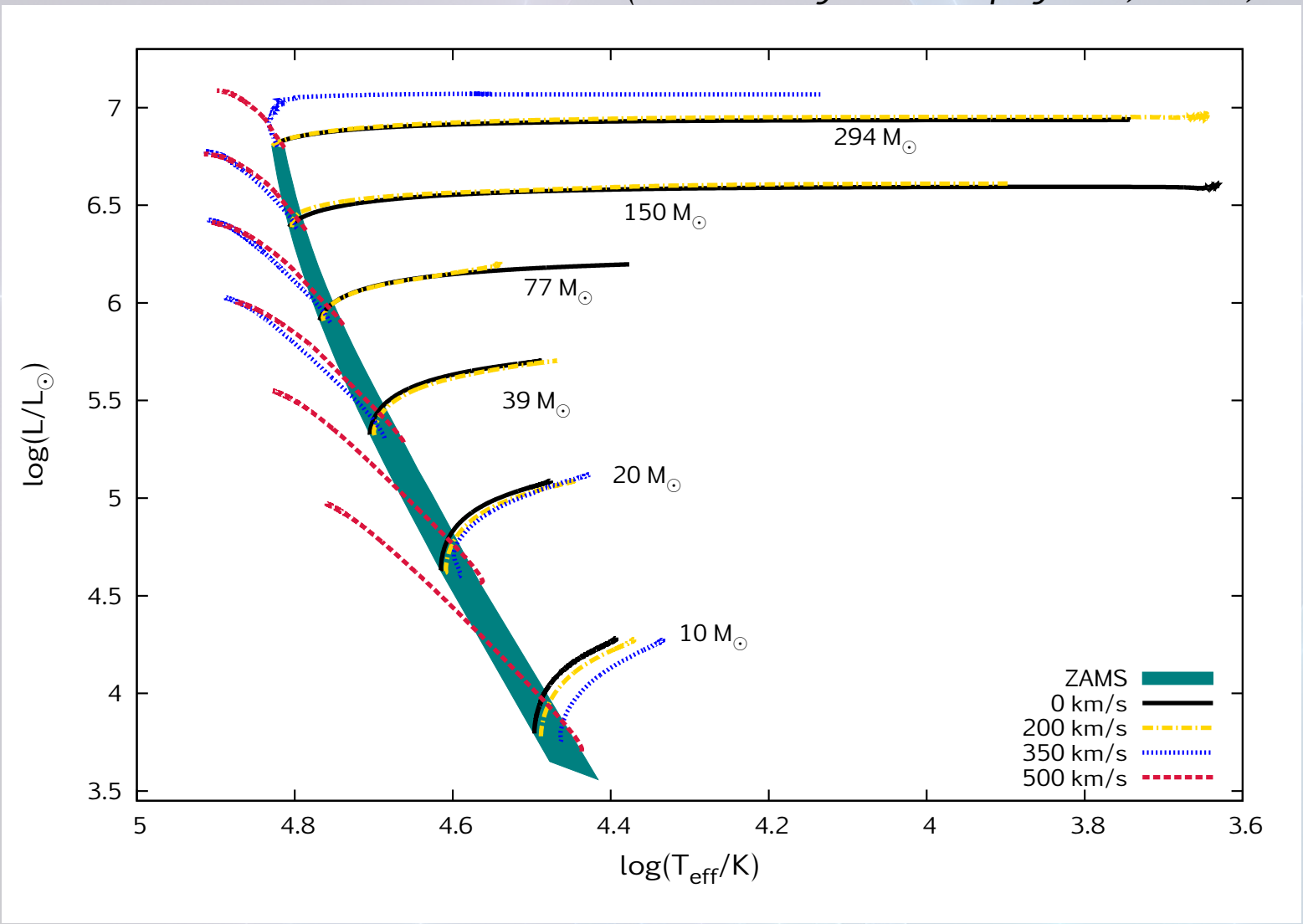

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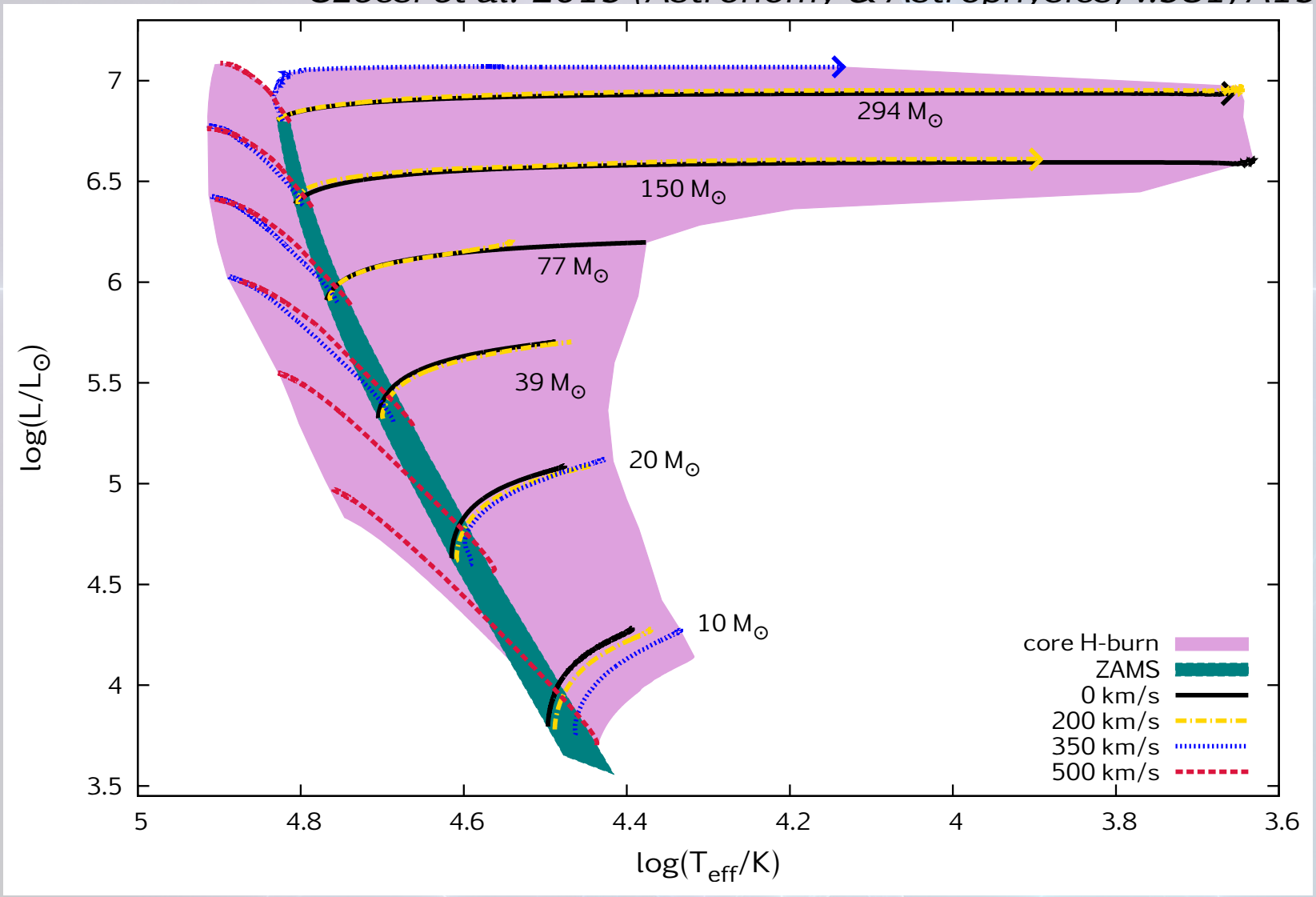

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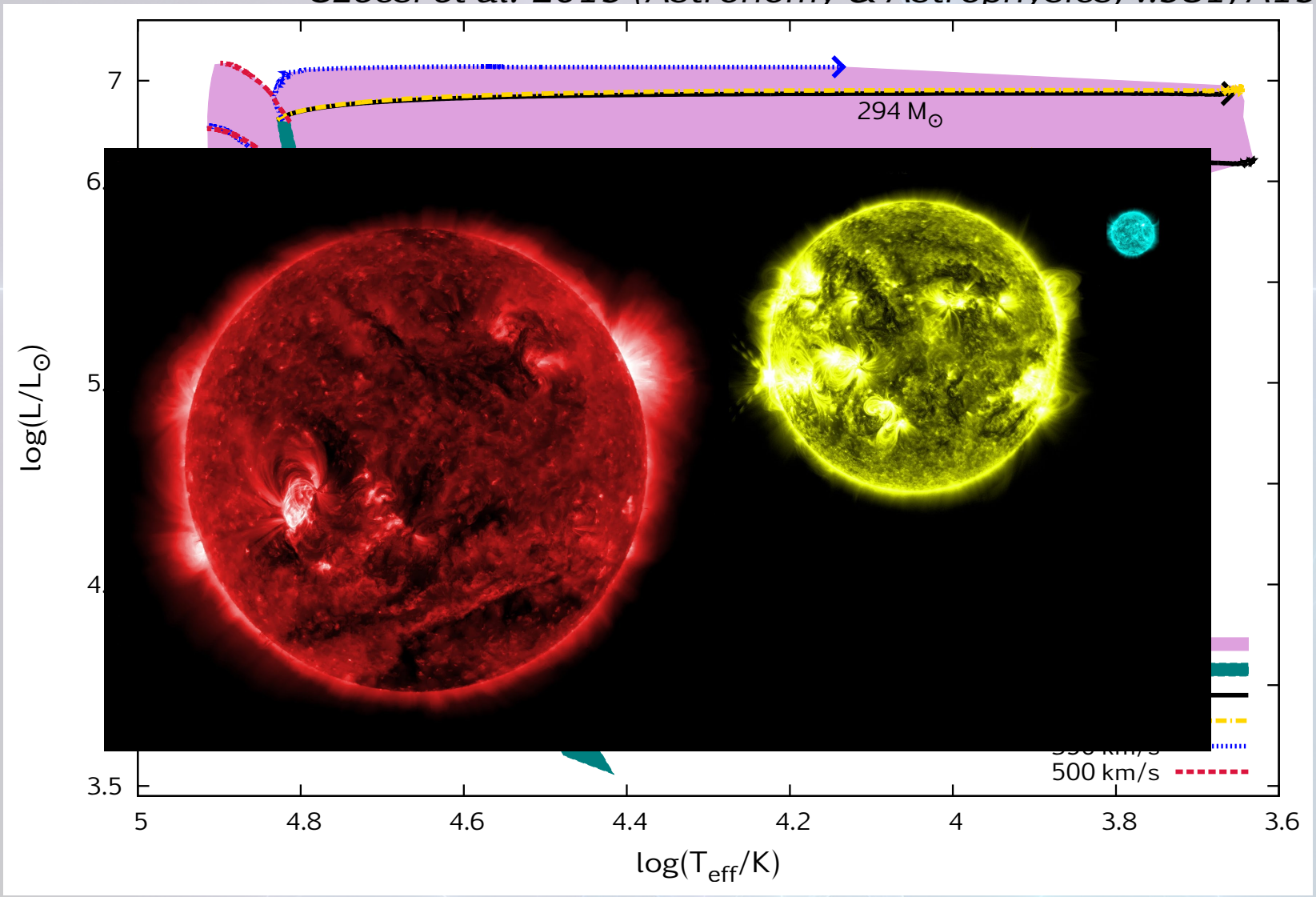

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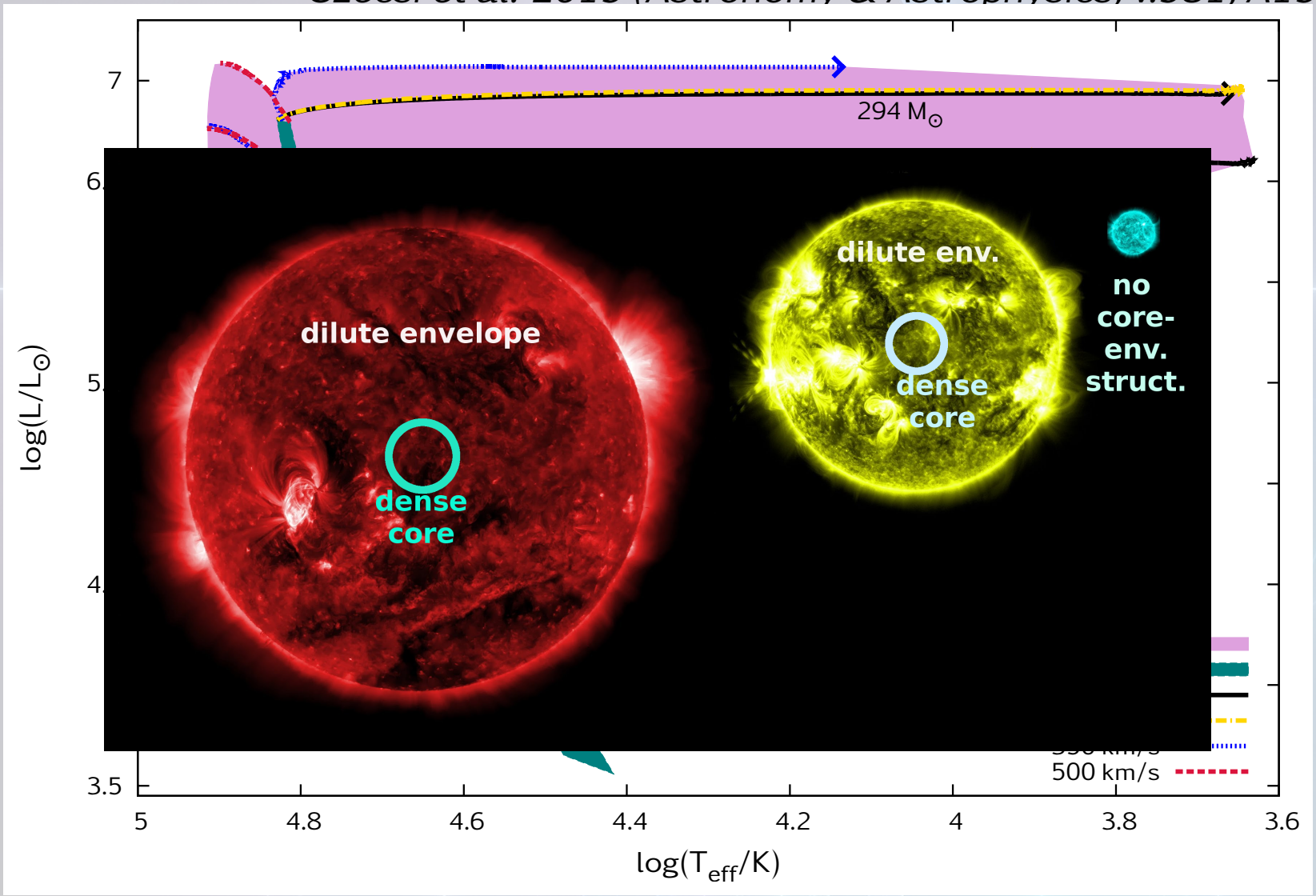
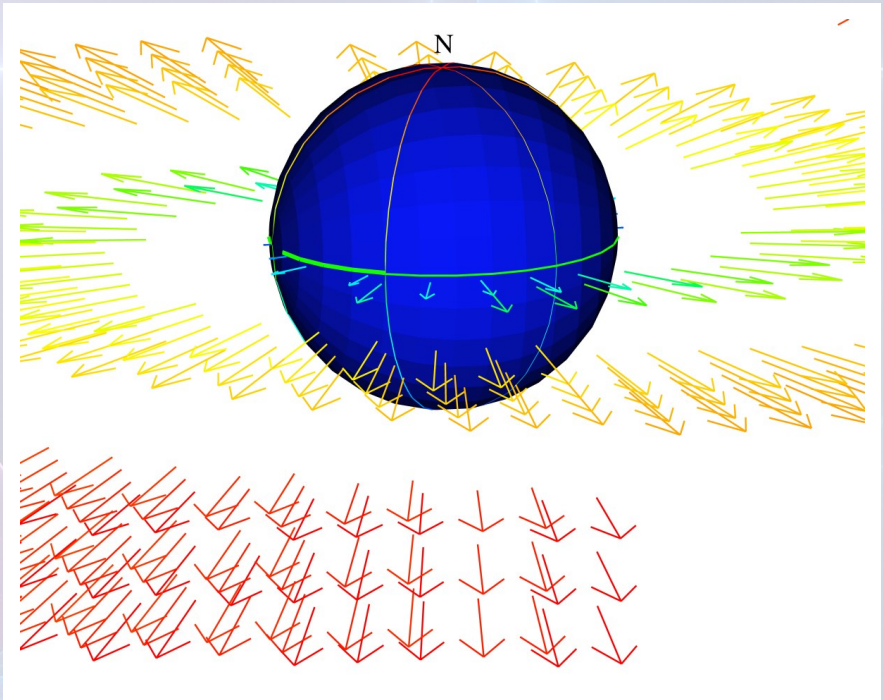


Stellar winds

- stellar ′wind′: accelerated particle flow
- hot stars at solar Z: **Wolf–Rayet** (WR) stars
  - opaque wind → strong emission lines
- hot stars at low Z?



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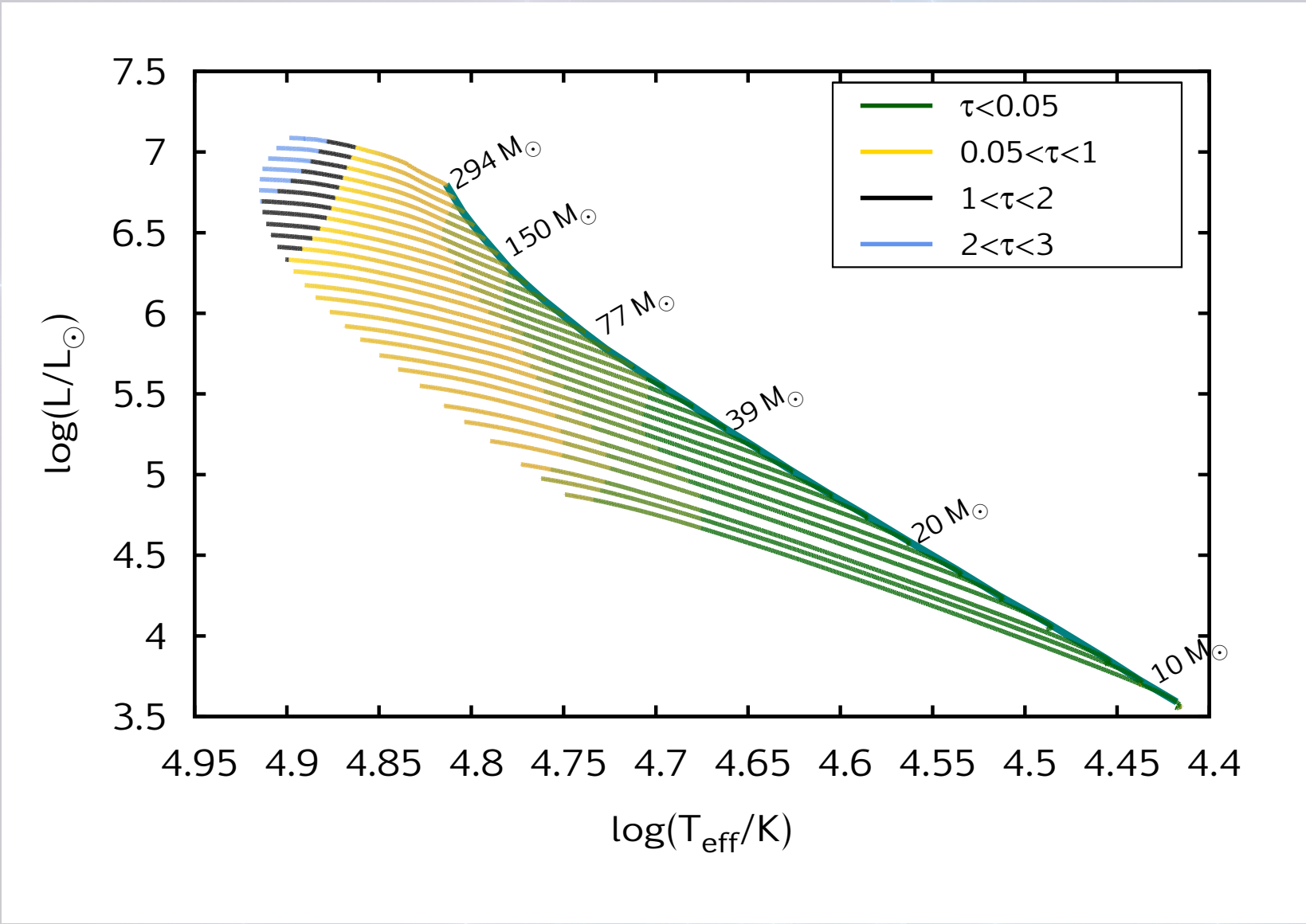
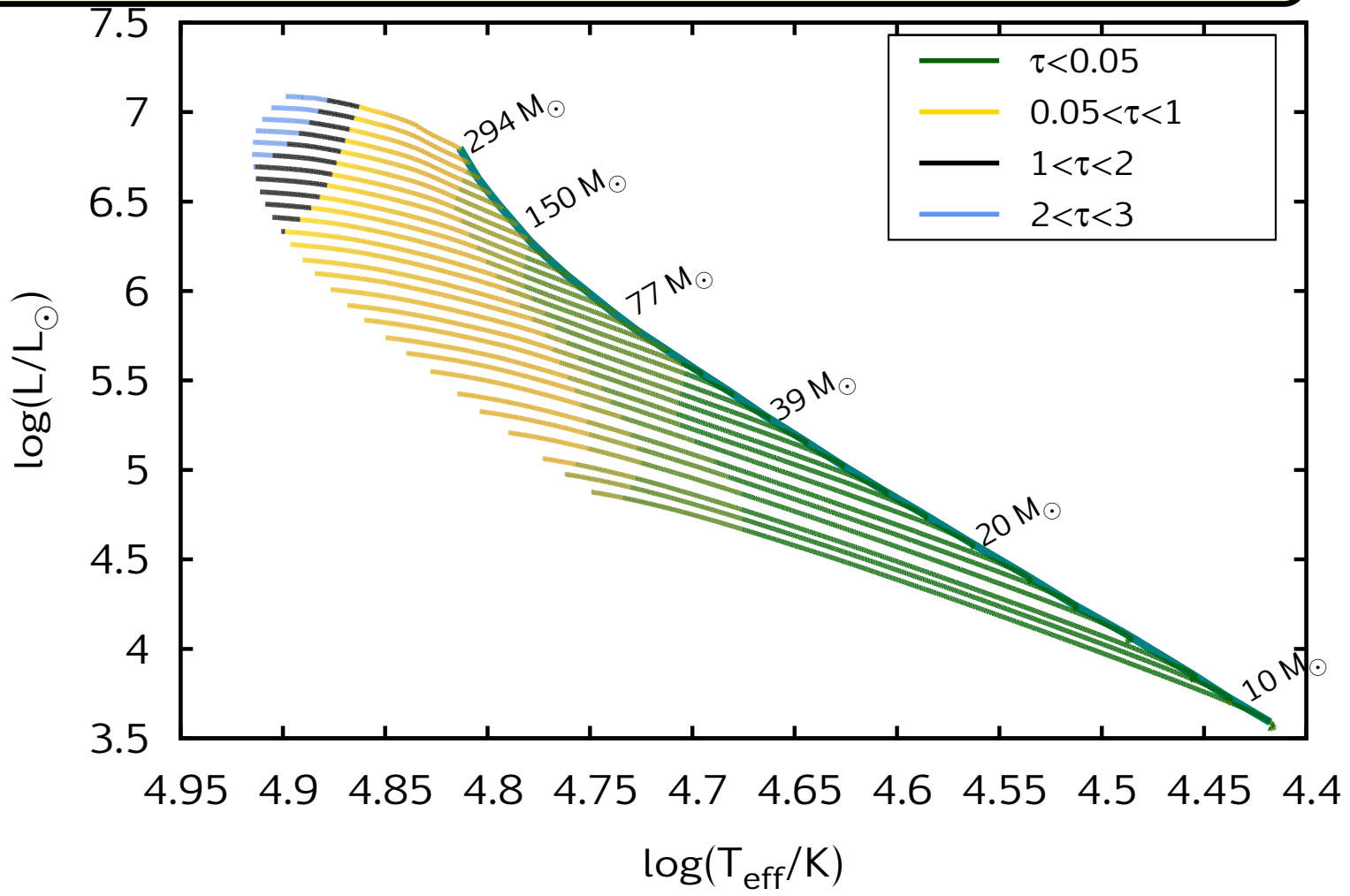


Hot stars at low Z: transparent wind!

Core-H-burning lifetime: wind optical depth is $\tau \lesssim 1$



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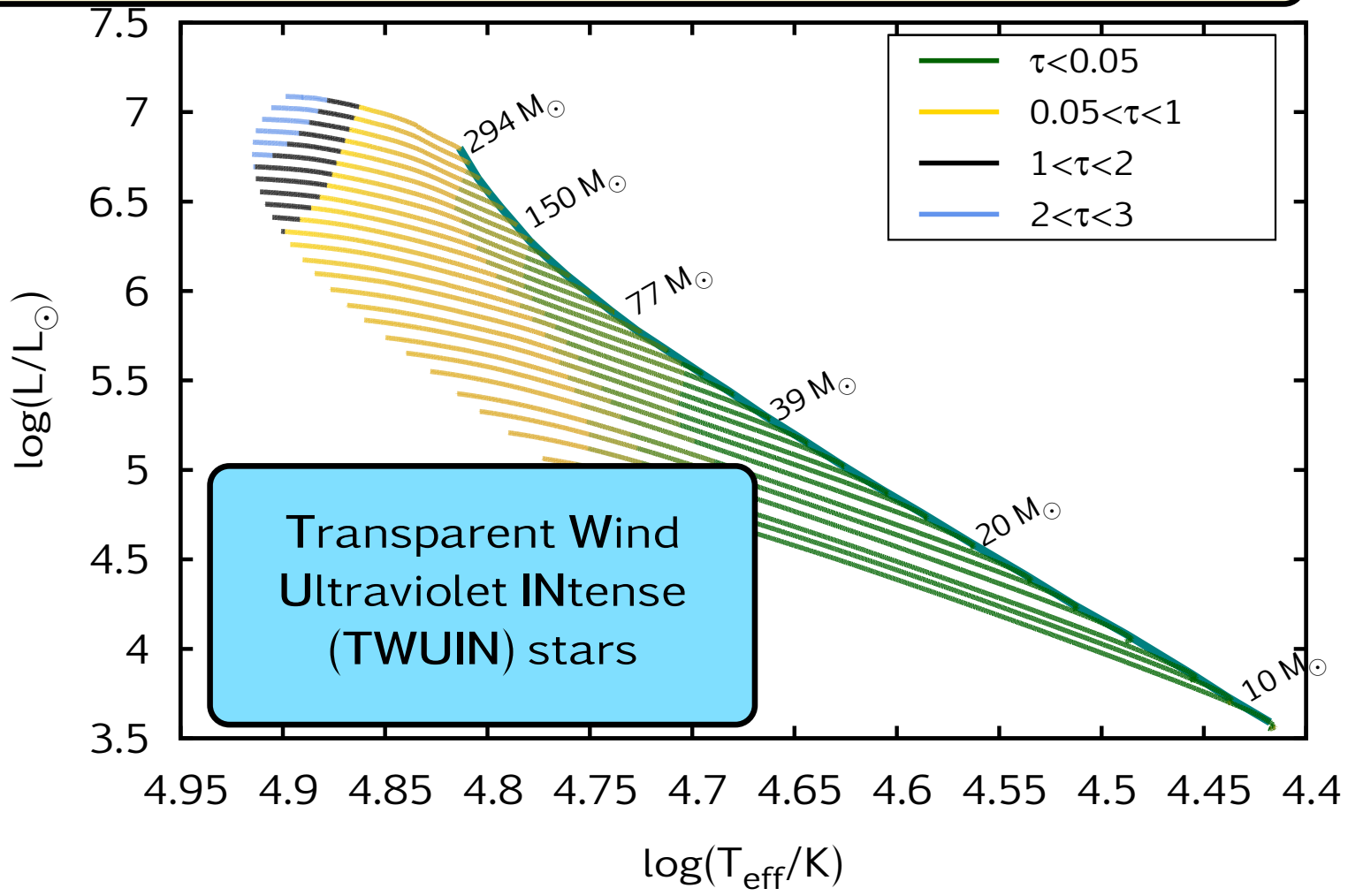

Back to I Zw 18

I Zwicky 18

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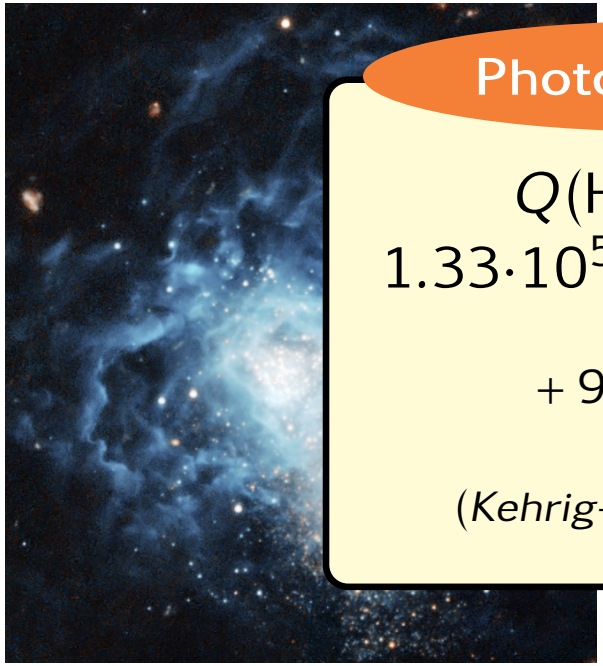


Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars

(*Kehrig+15, Crowther+06*)

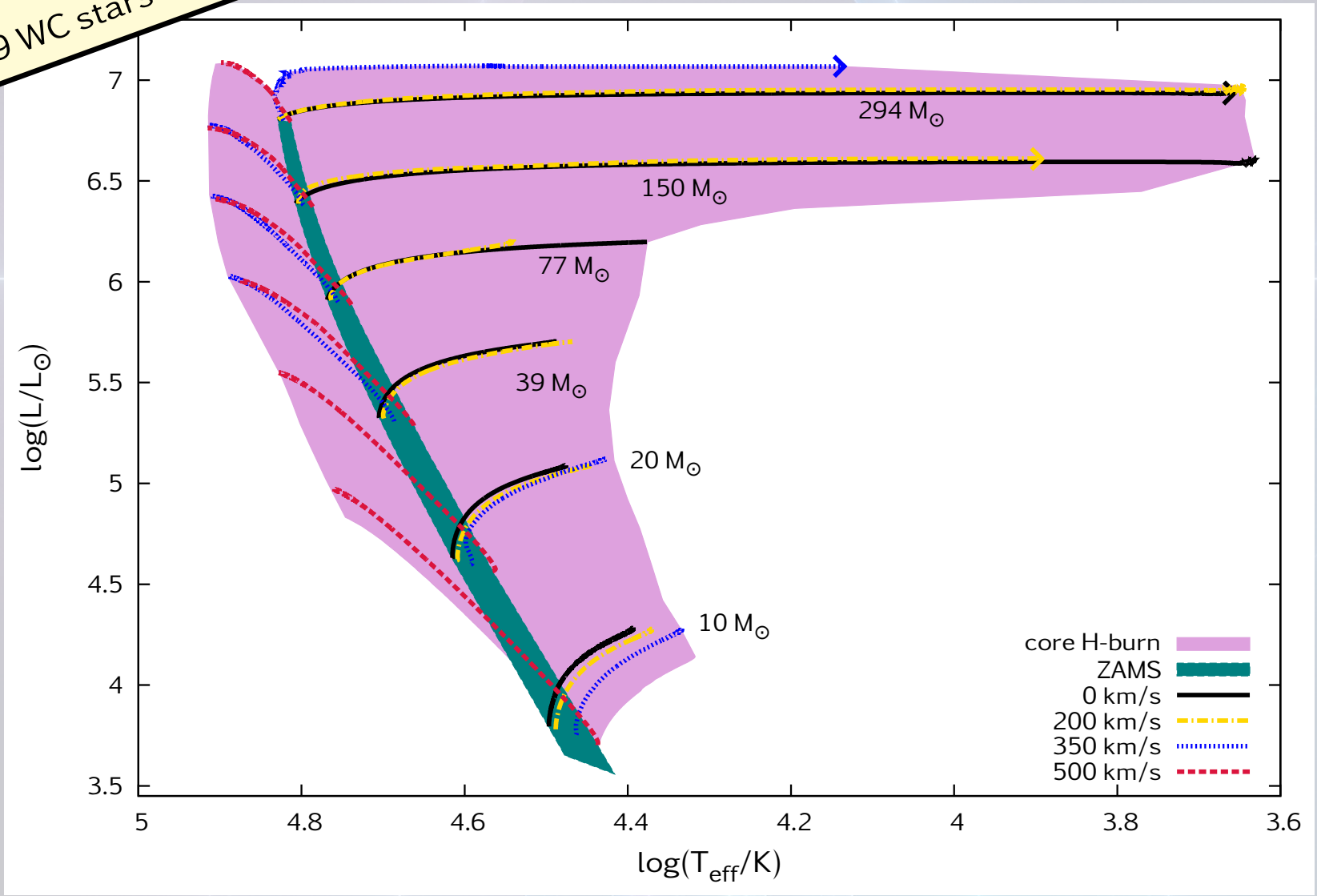
Legrand+07, Aloisi+09, Annibali+13, Kehrig+13, Lebouteiller+13

Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars



Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

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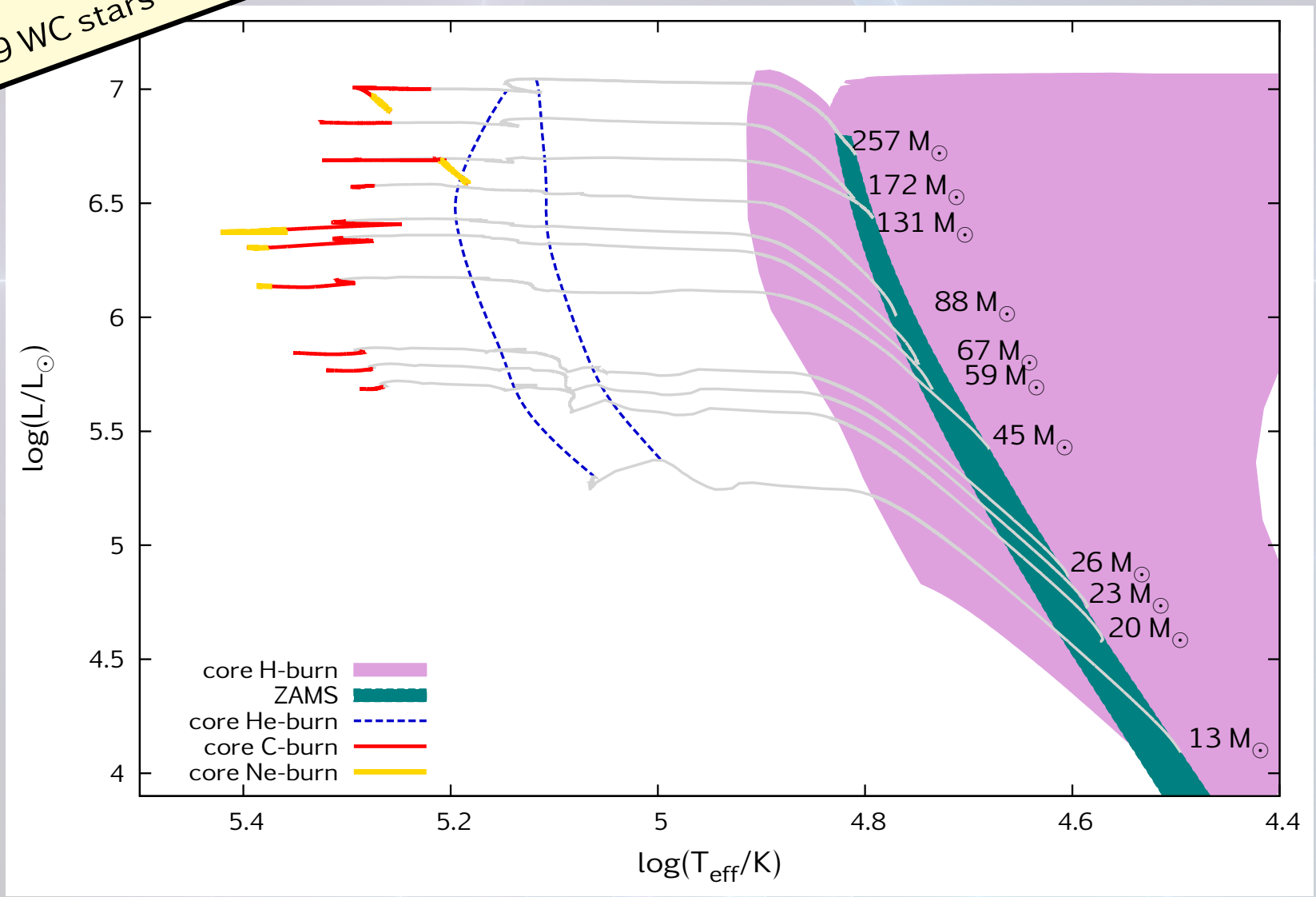
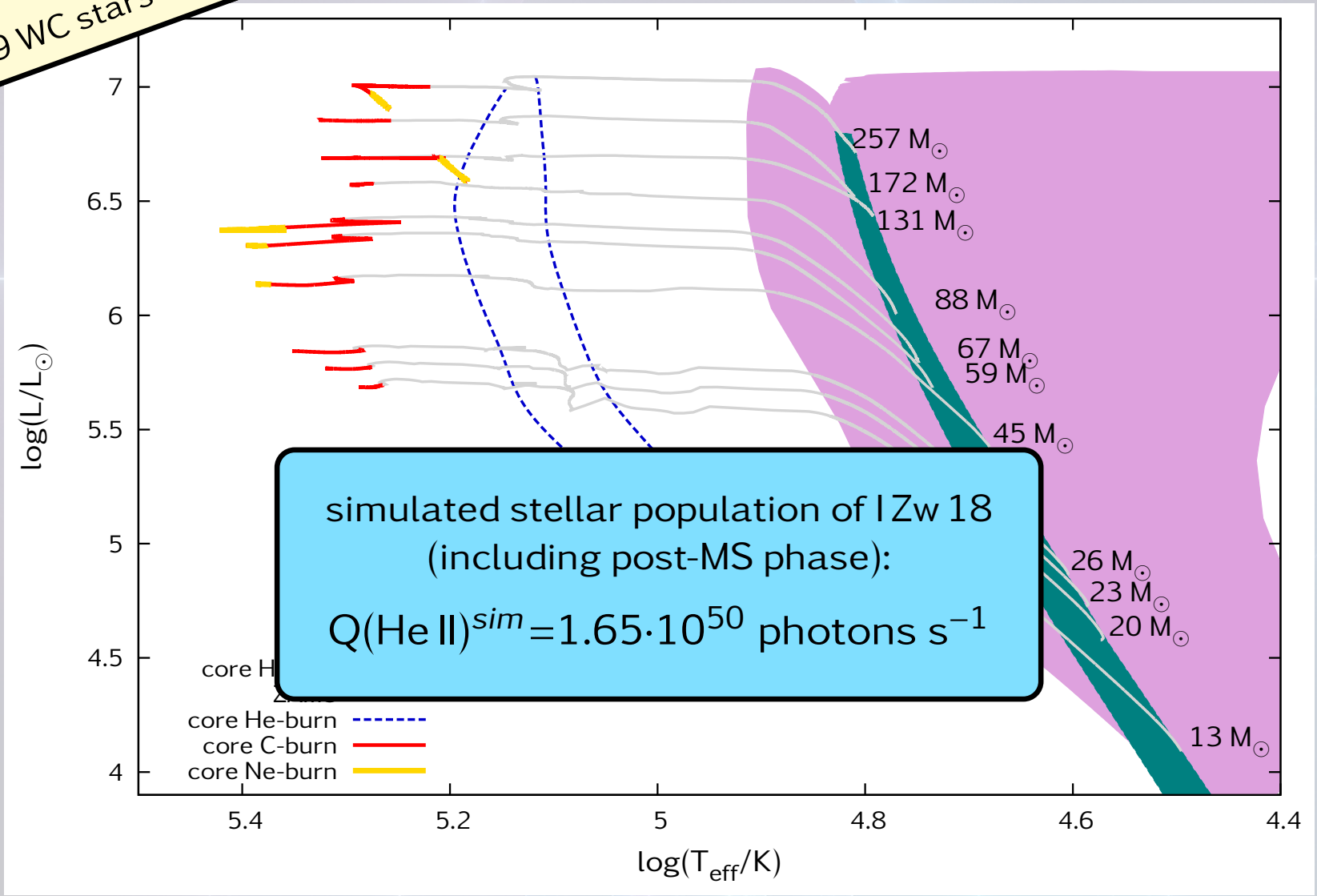


Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars



simulated stellar population of I Zw 18 (including post-MS phase):

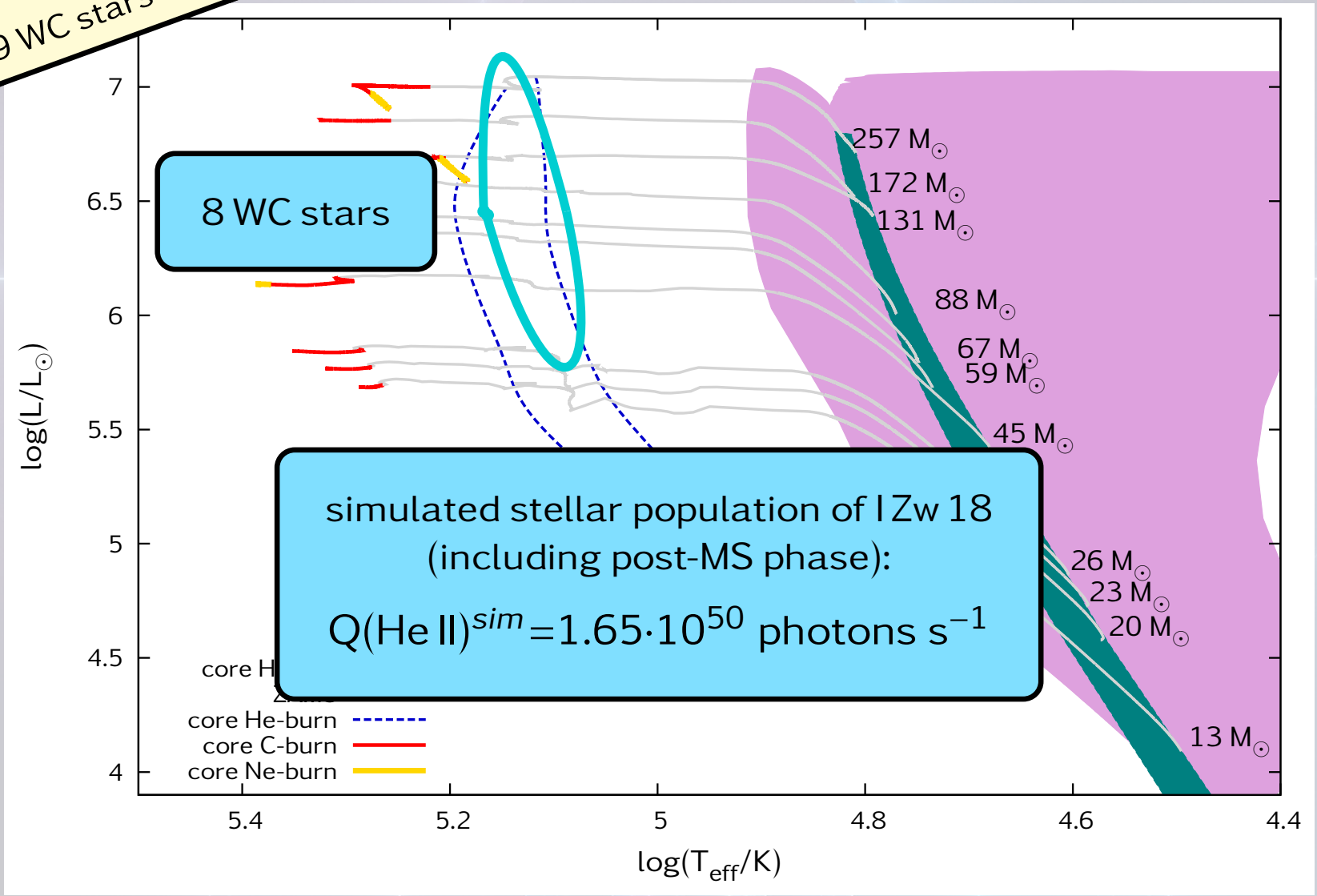
$Q(\mathrm{He\,II})^{sim} = 1.65 \cdot 10^{50}$ photons s^{-1}

Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars

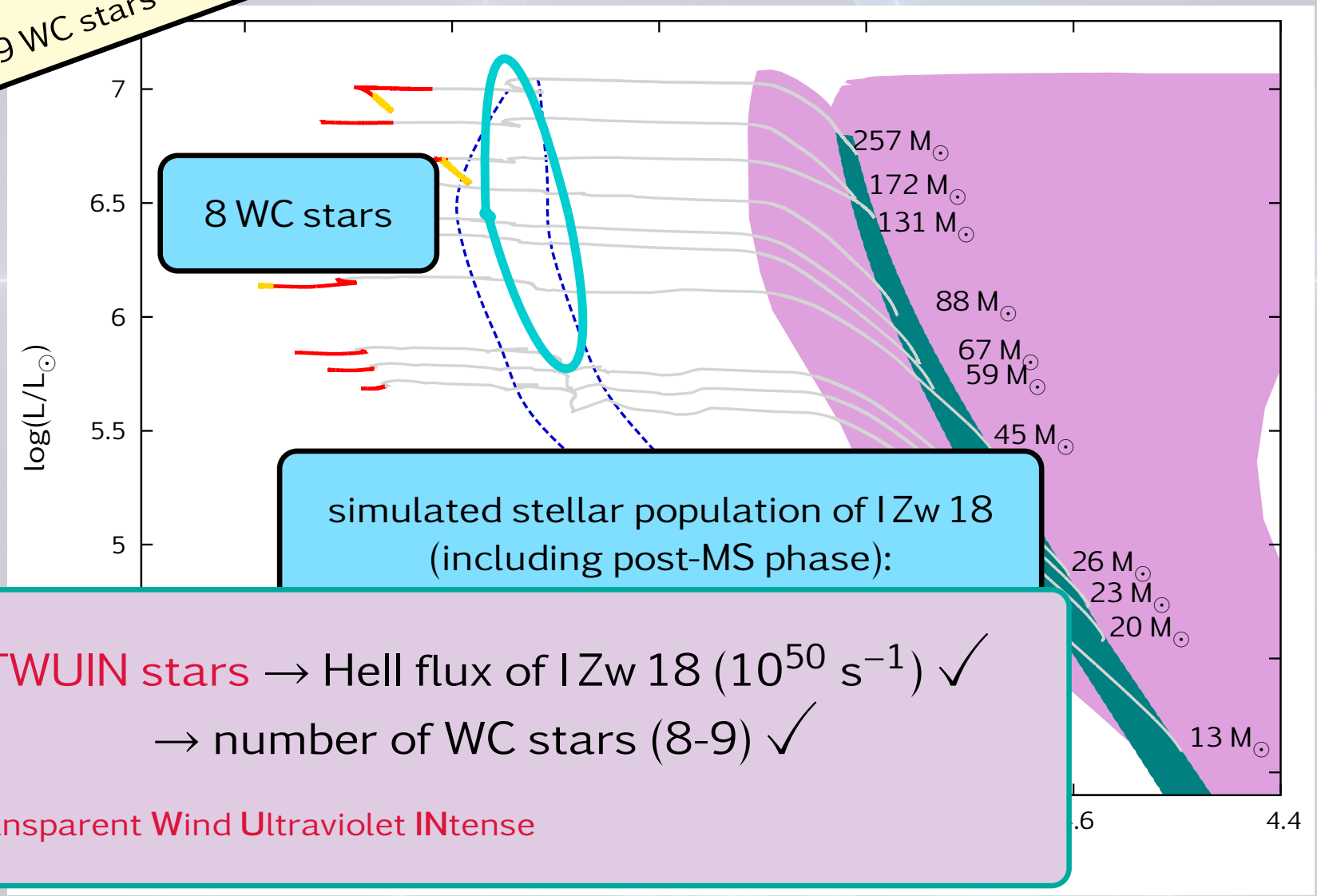


Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars



TWUIN stars → HeII flux of I Zw 18 (10^{50} s^{-1}) ✓

→ number of WC stars (8-9) ✓

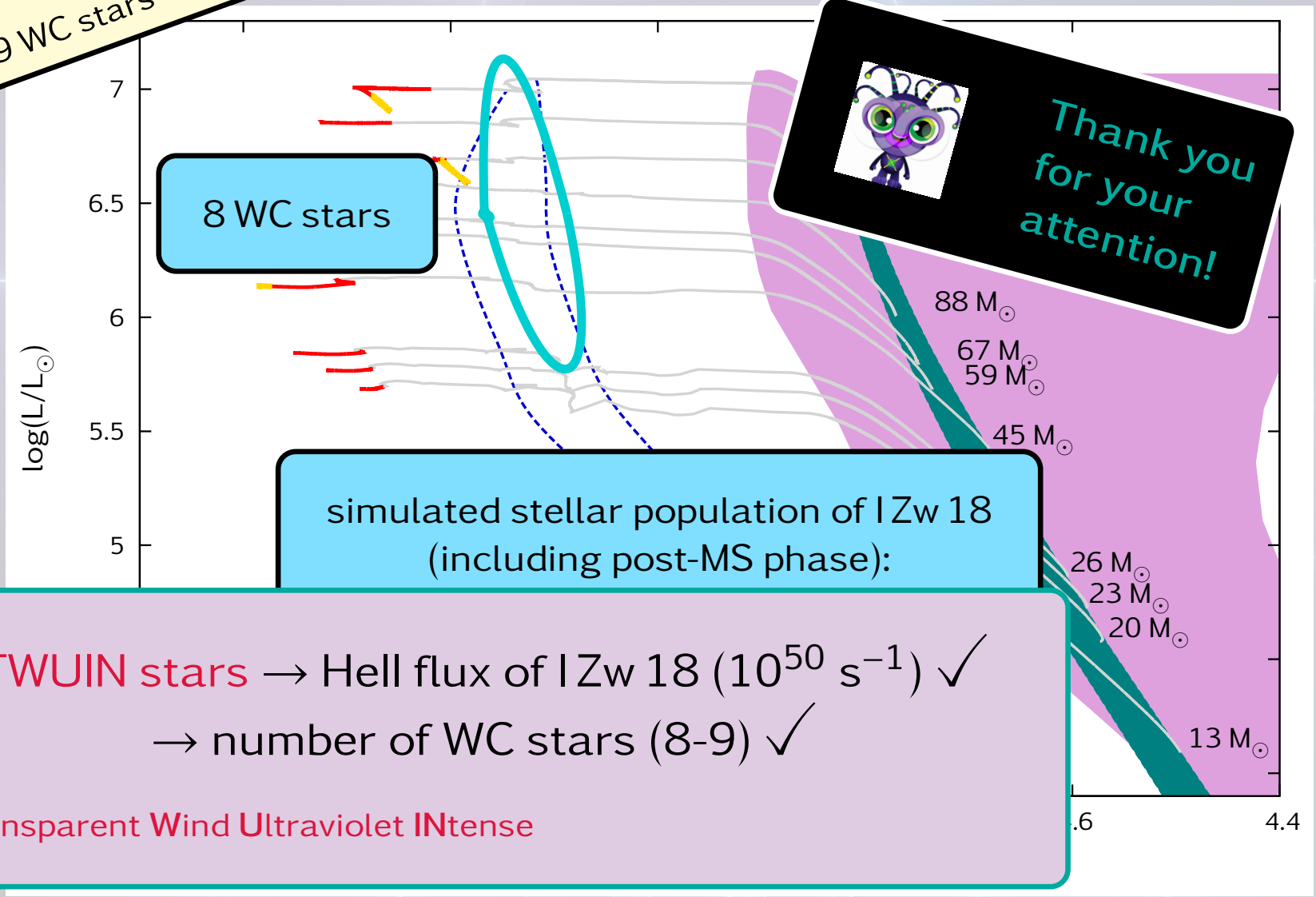
Transparent **W**ind **U**ltraviolet **IN**tense

Photoionization in I Zw 18

Photoionization

$Q(\mathrm{HeII})^{obs} = 1.33 \cdot 10^{50}$ photons s^{-1}

+ 9 WC stars



TWUIN stars → HeII flux of I Zw 18 (10^{50} s^{-1}) ✓

→ number of WC stars (8-9) ✓

Transparent **W**ind **U**ltraviolet **IN**tense