How may GRBs form?

A review of progenitor theories

Dorottya Szécsi

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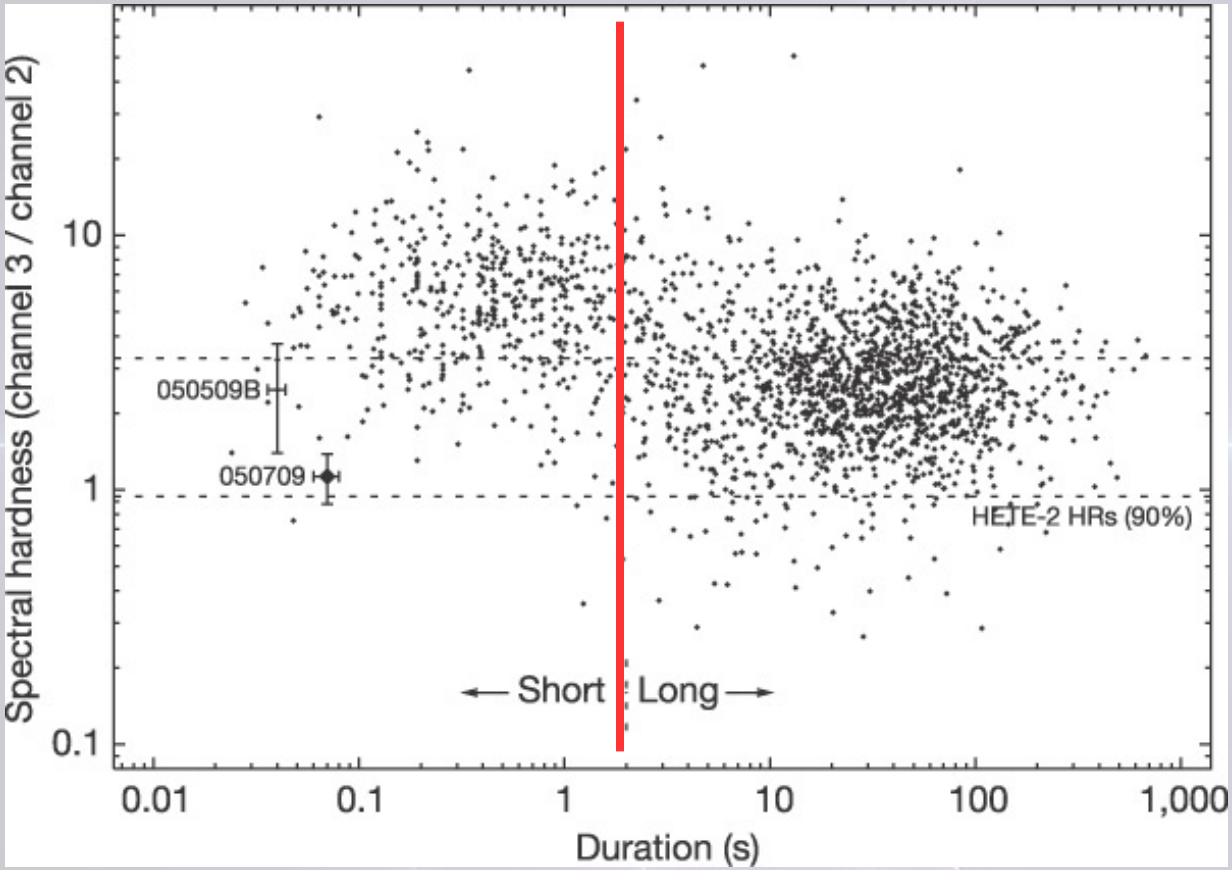
Karlovy Vary, 3-7 April 2017

At least two, physically distinct types of objects



Credit: Hjorth+2005

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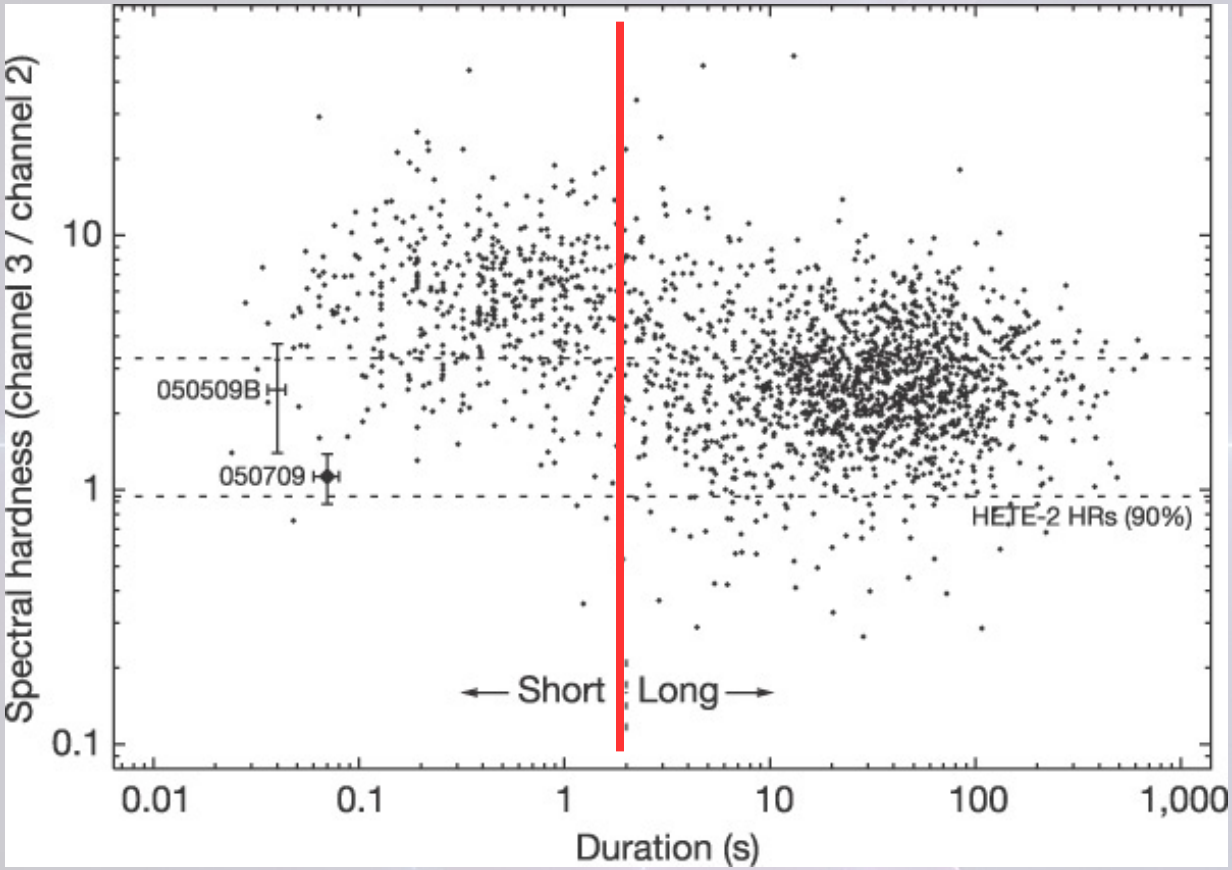

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Long/soft:

Massive Stars at collapse

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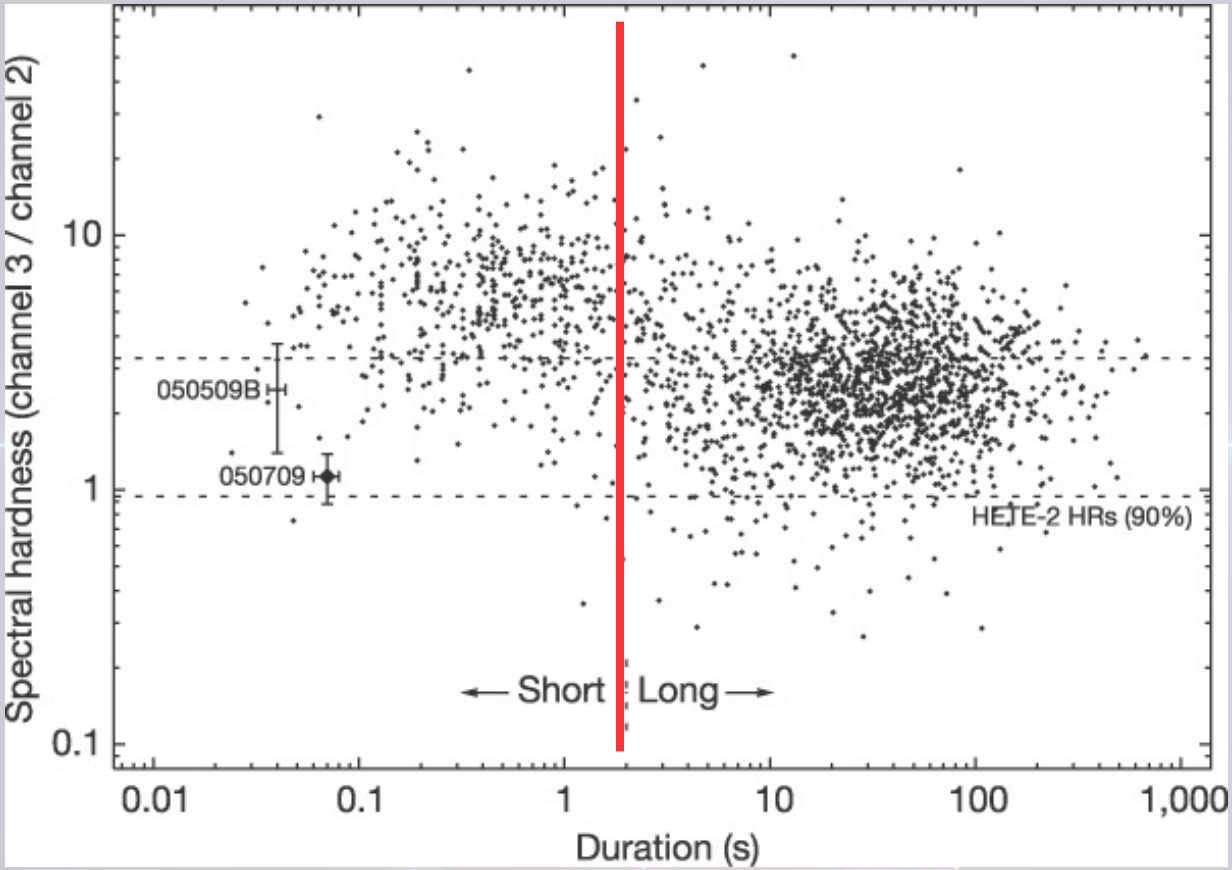

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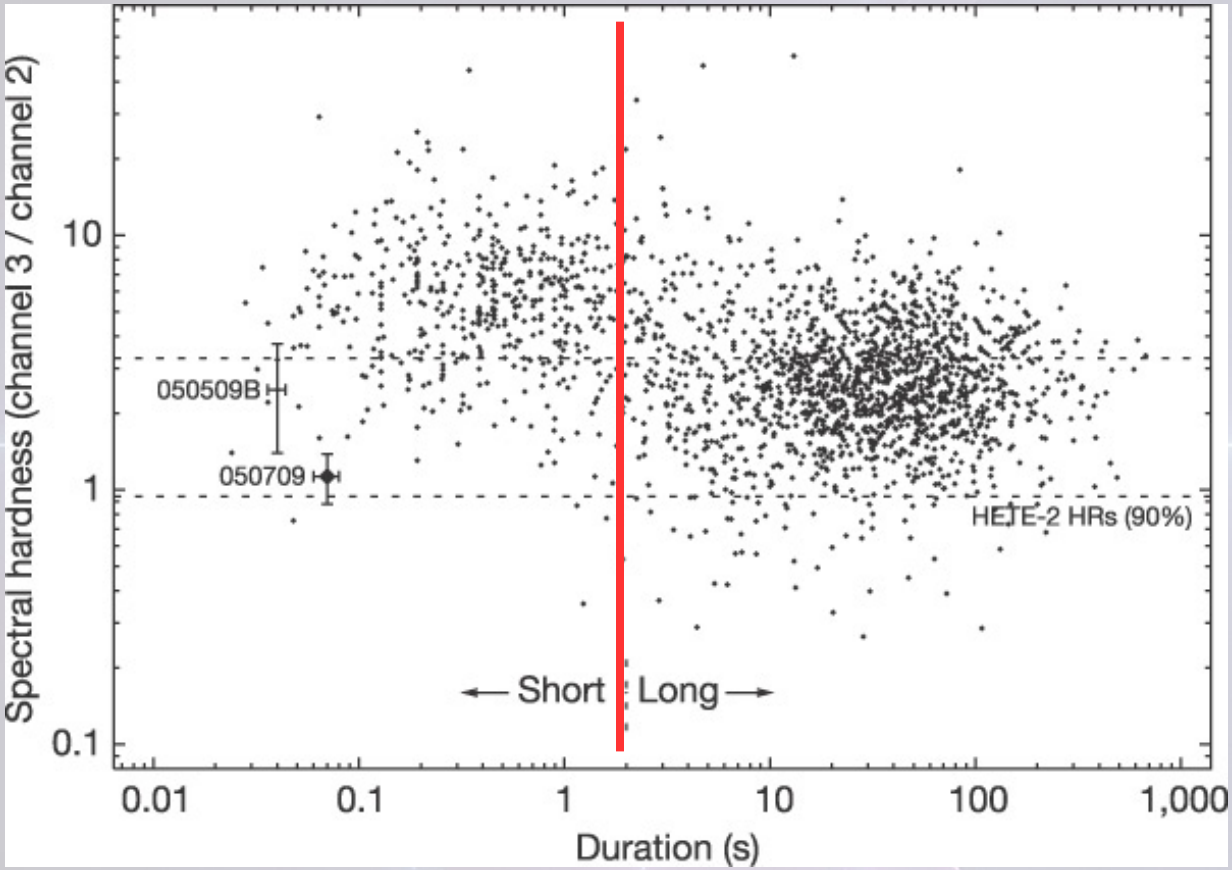

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Progenitor models...

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See the review of Berger+14

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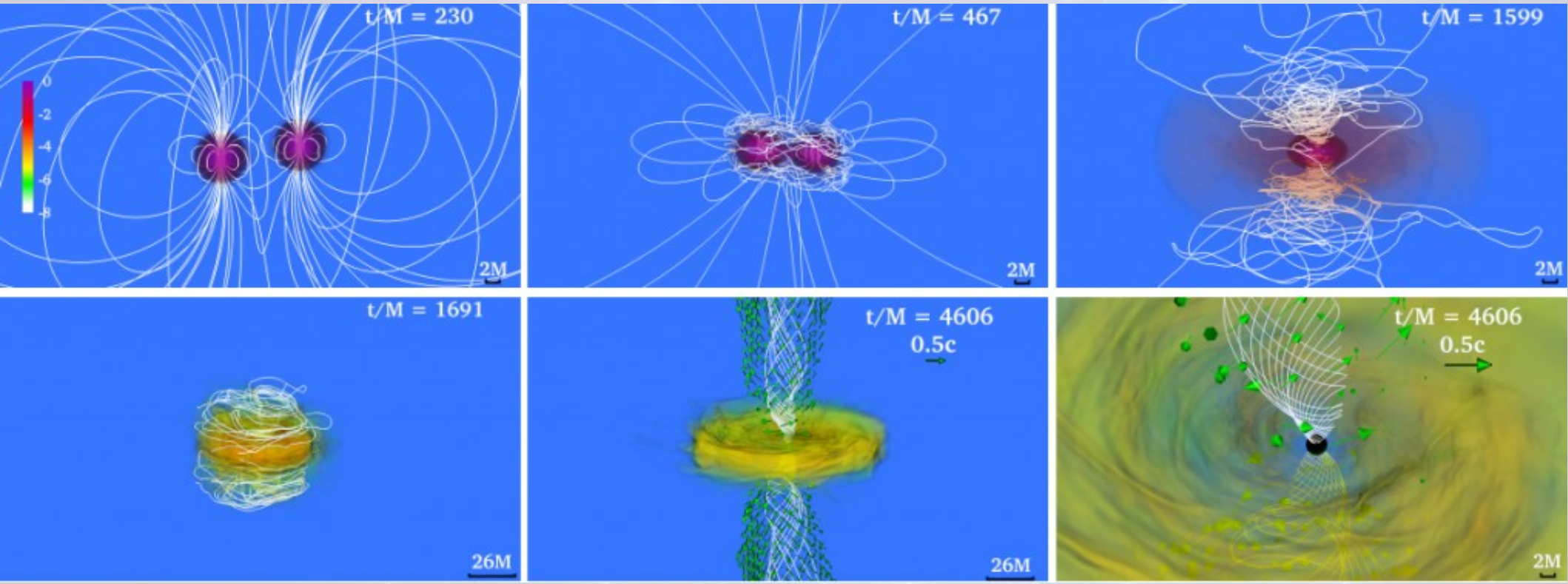

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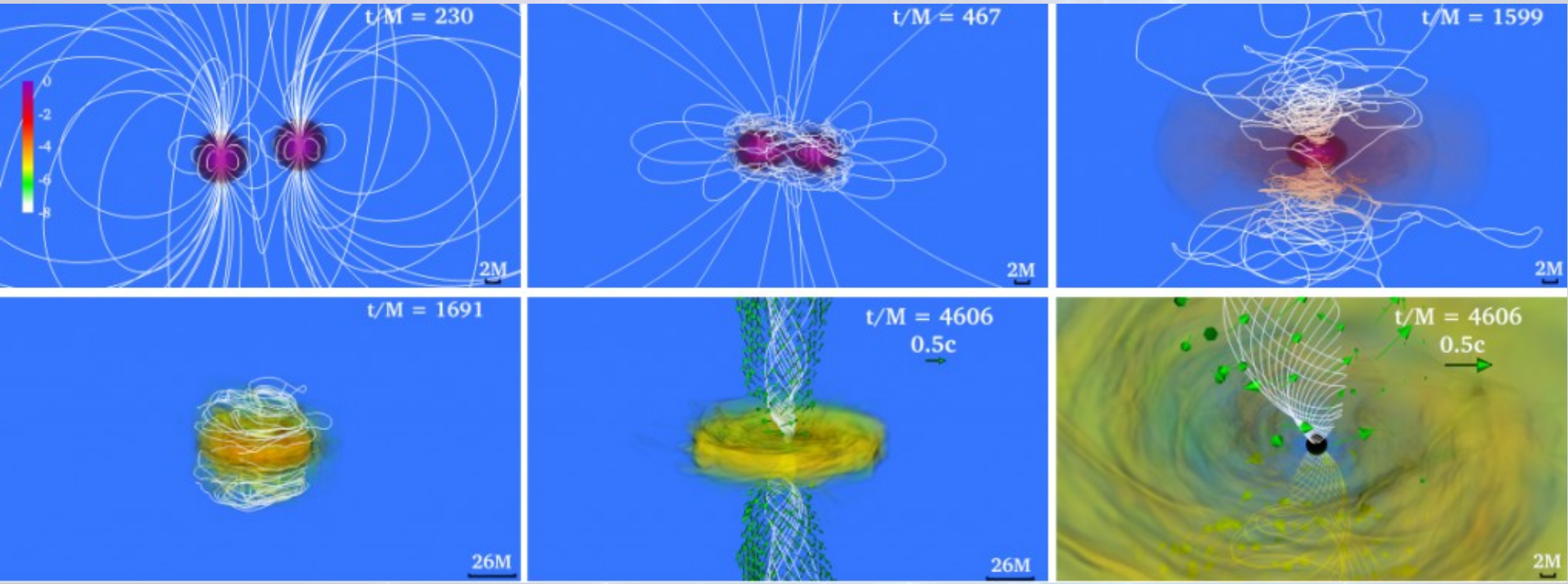

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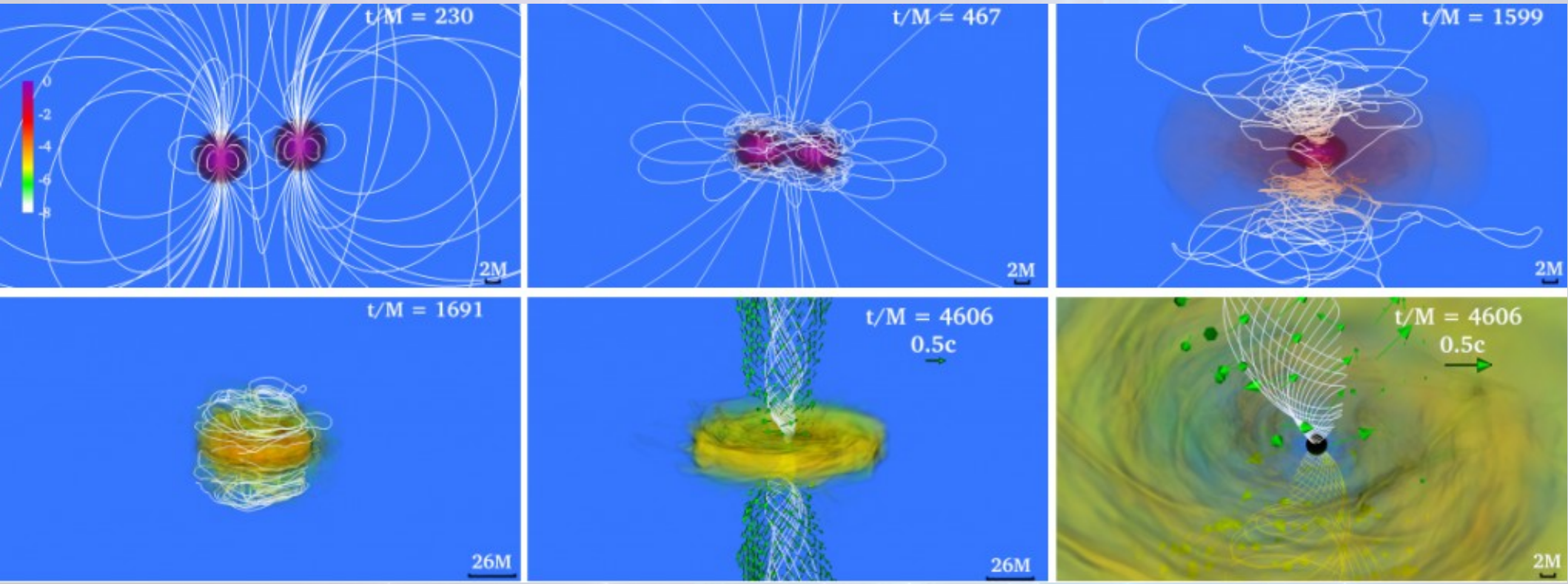

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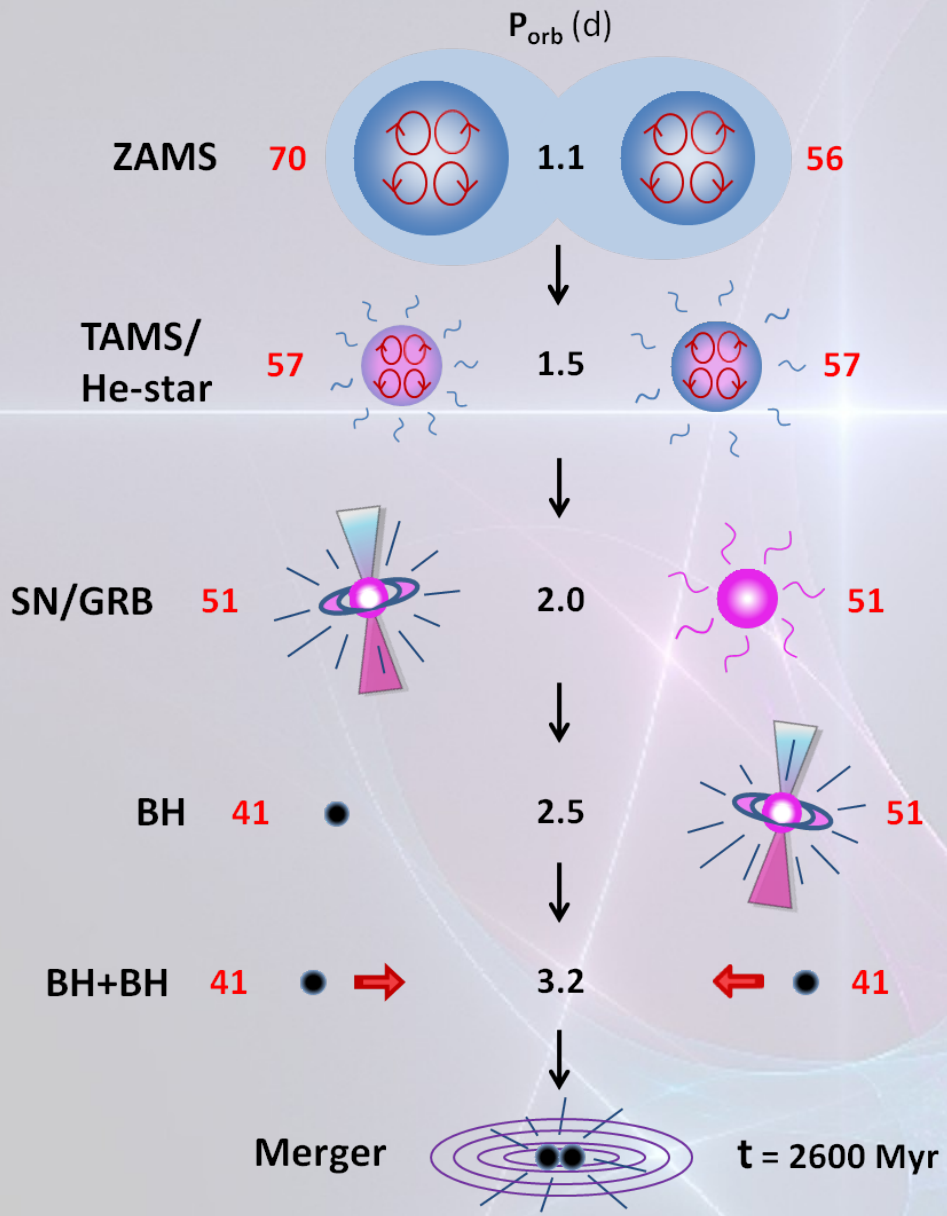

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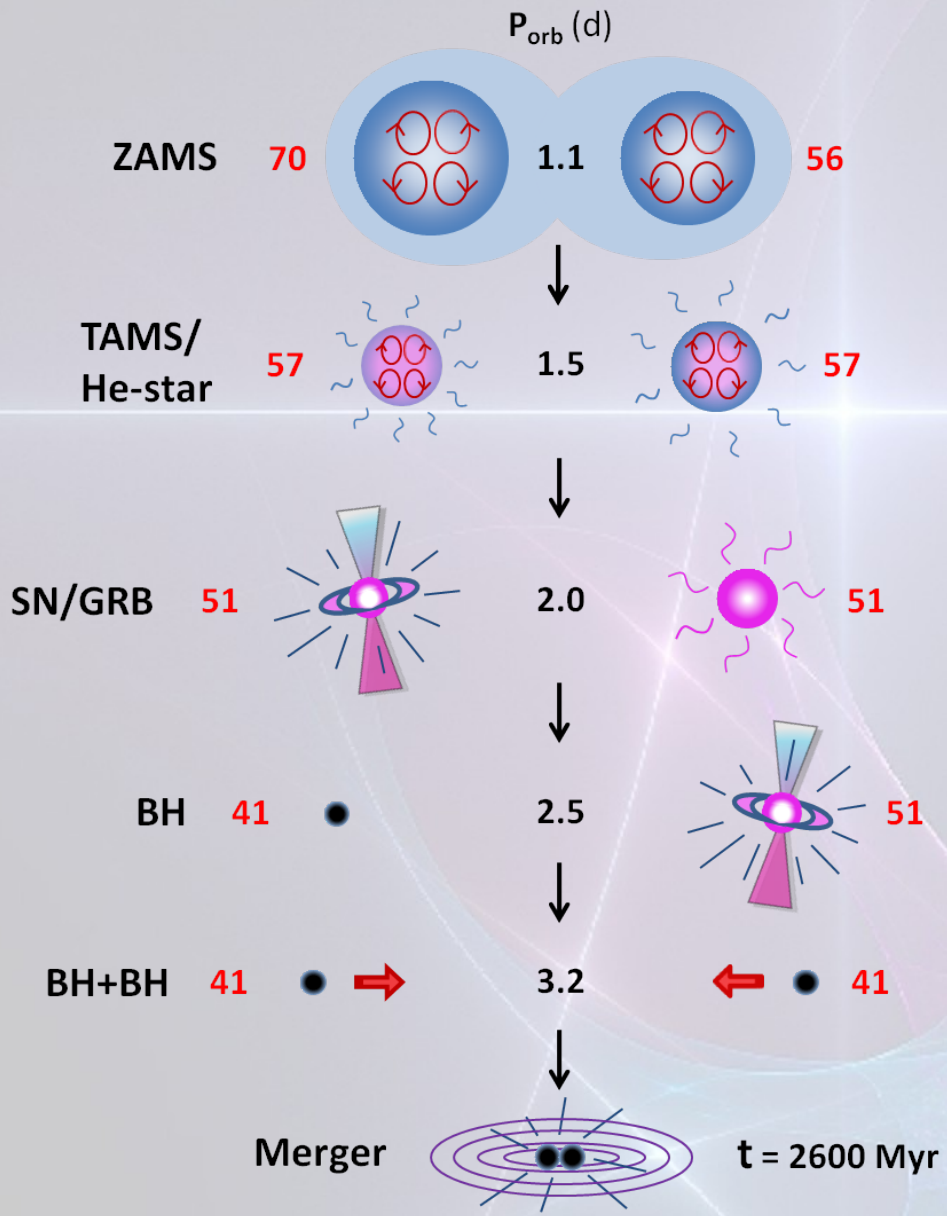
Perna+16:



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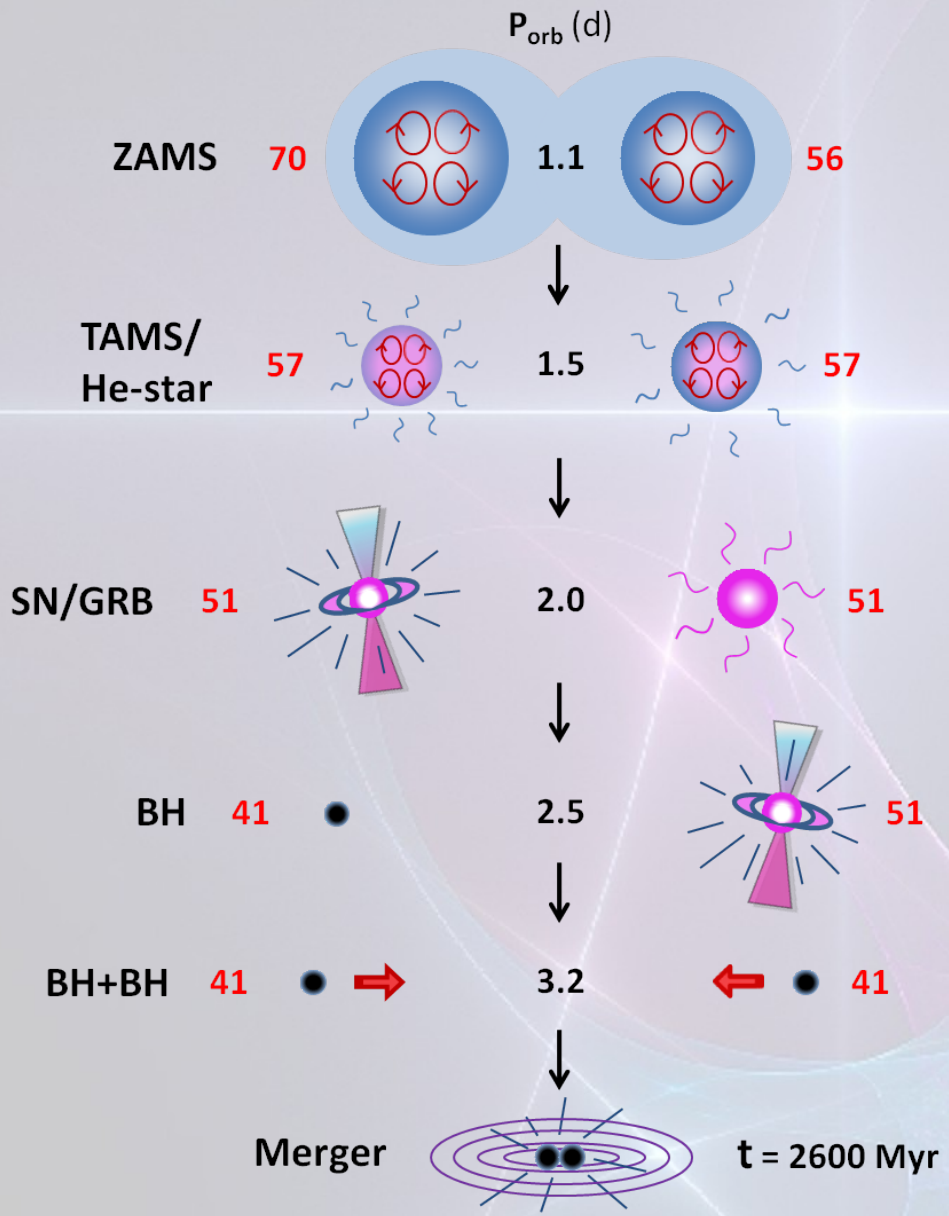

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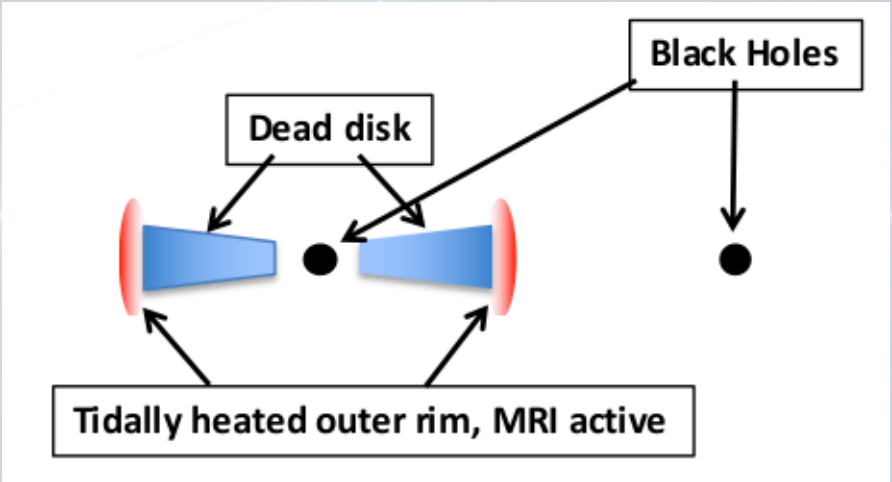
second SN may be weak → long-lived disk from stellar envelope



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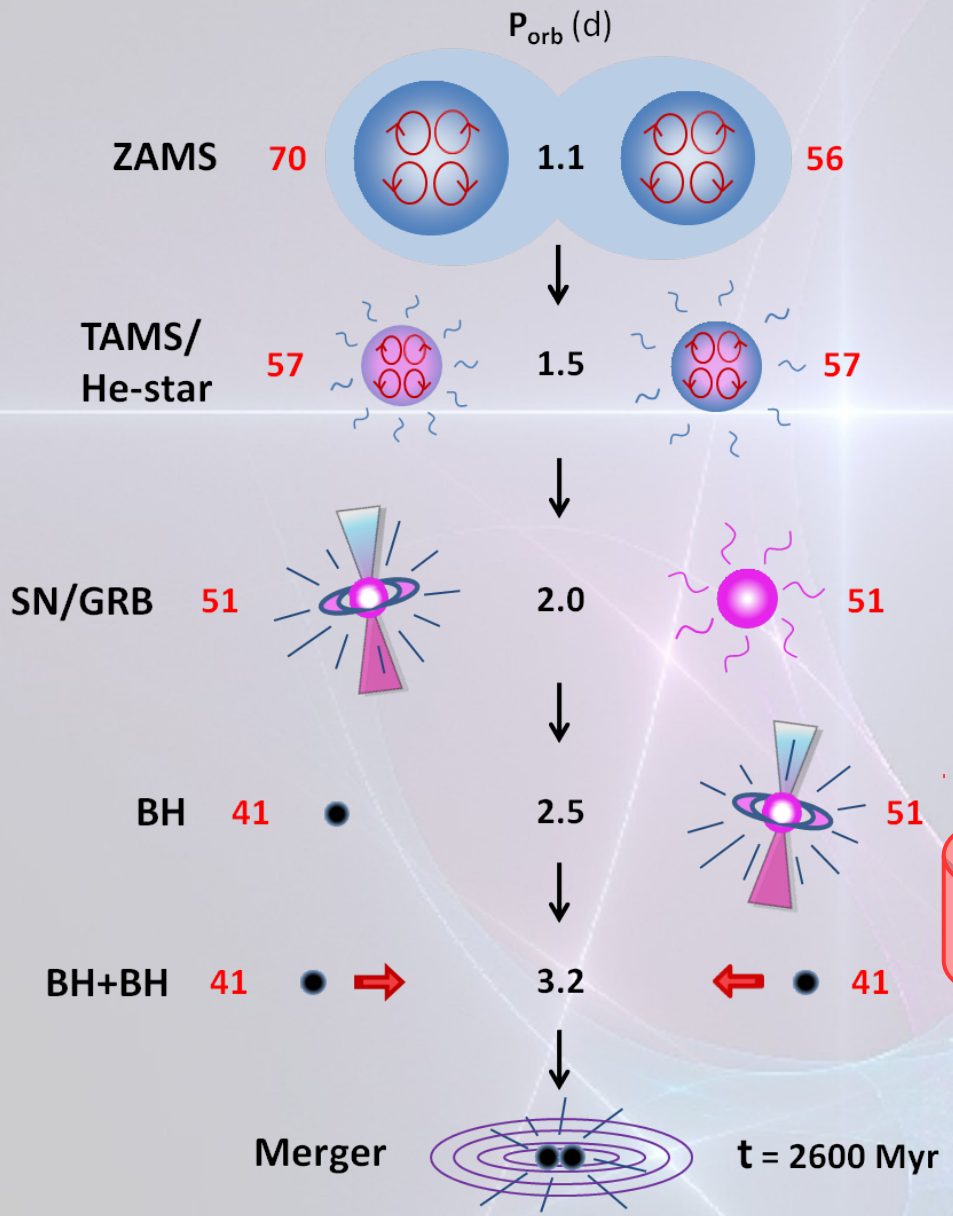

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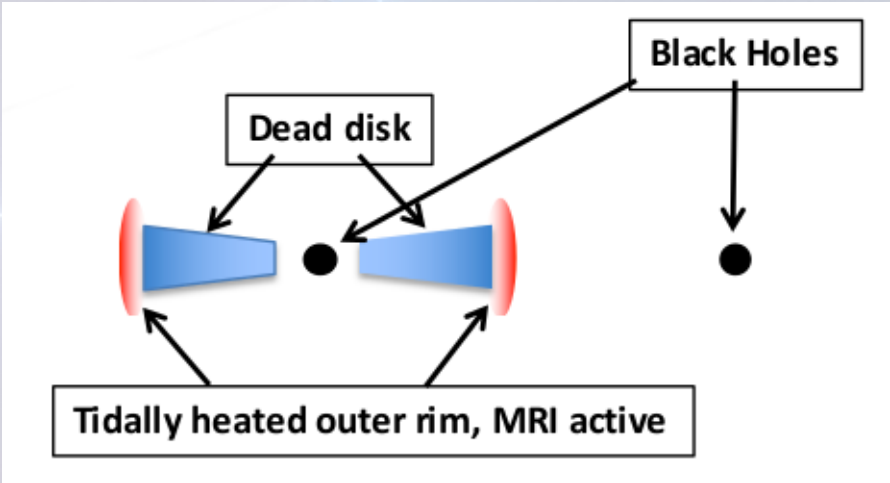

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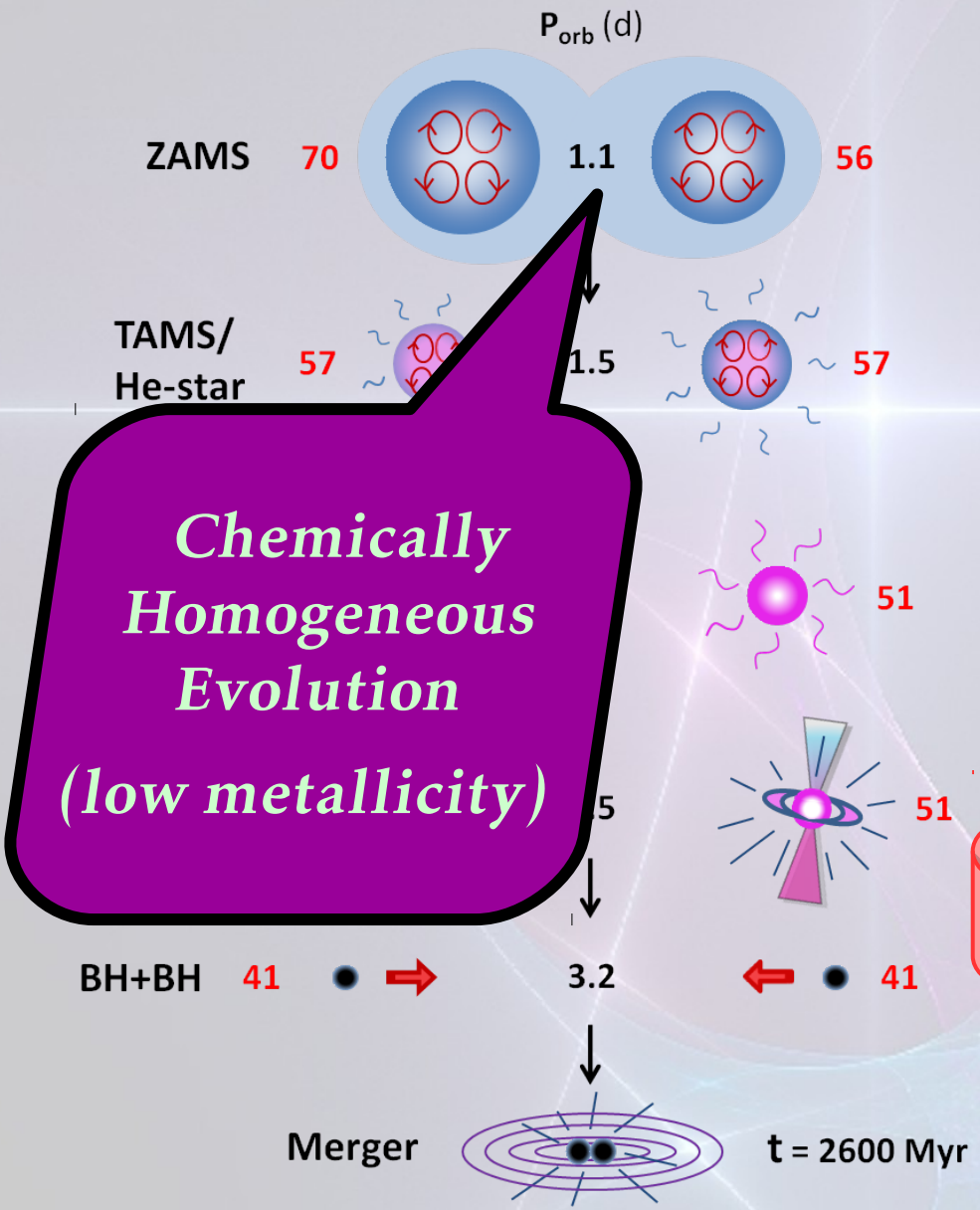

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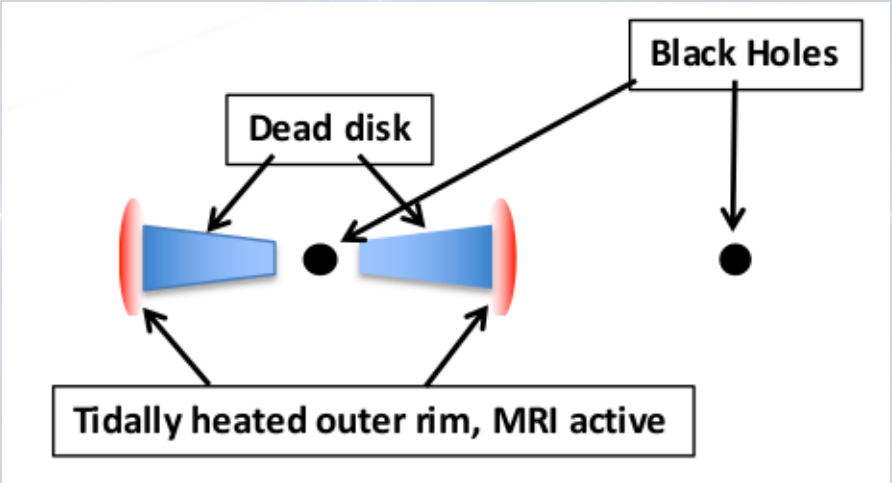

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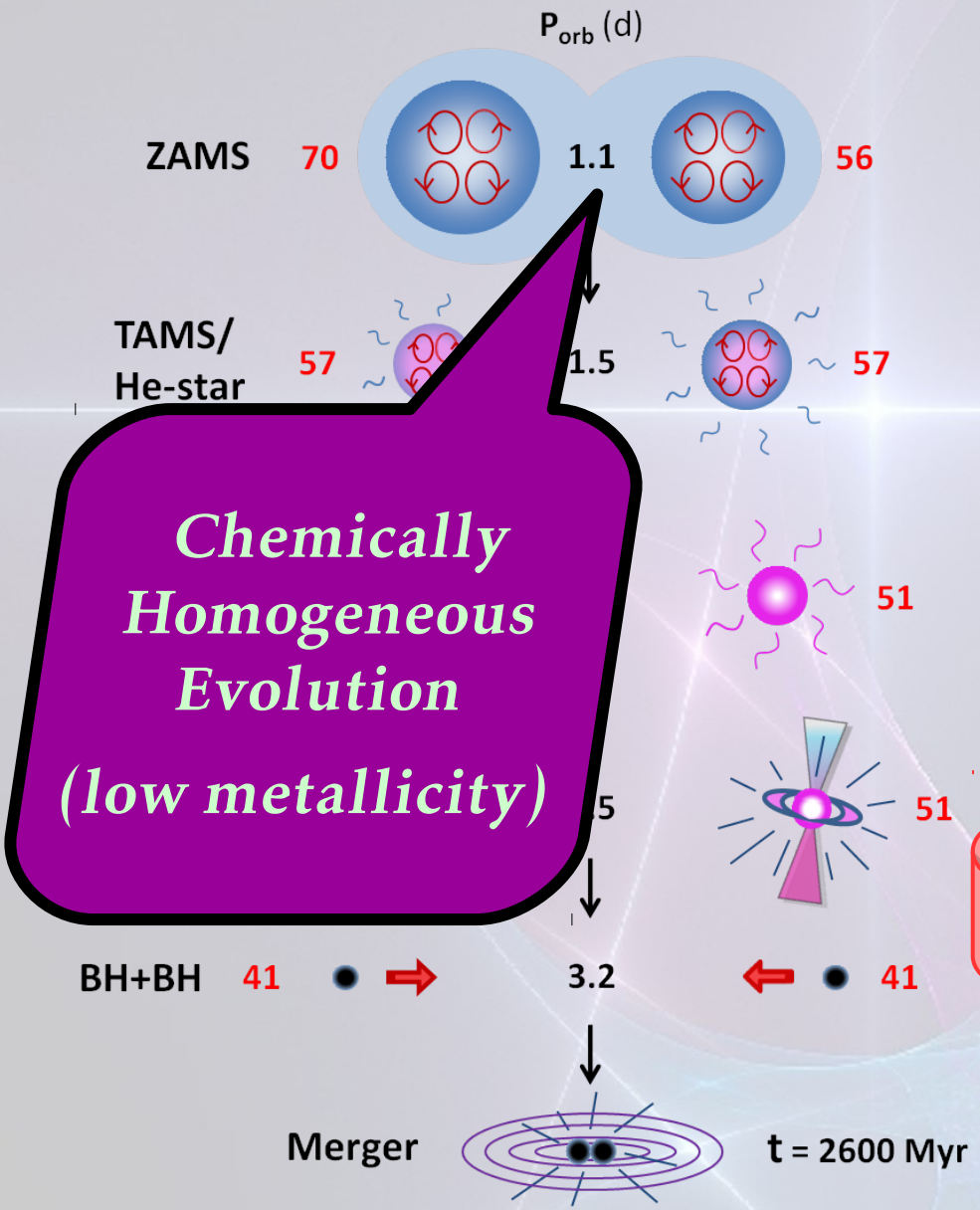

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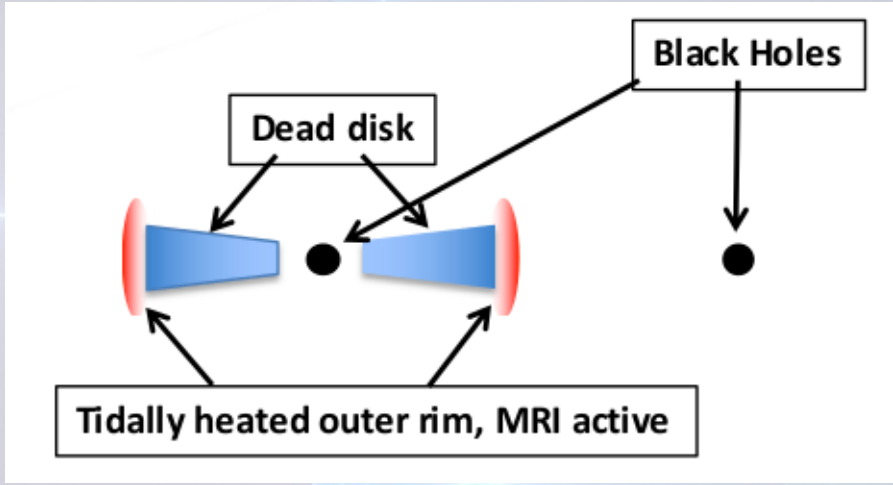

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Other models:

Zhang'16 – one of the BHs is charged

Belczynski+16, Kruckow+16 – common envelope evolution

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Special requirements depend on astrophysical scenario

Collapsar scenario

Magnetar scenario

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Woosley'93, Macfadyen+99, Yoon+05, Woosley+06

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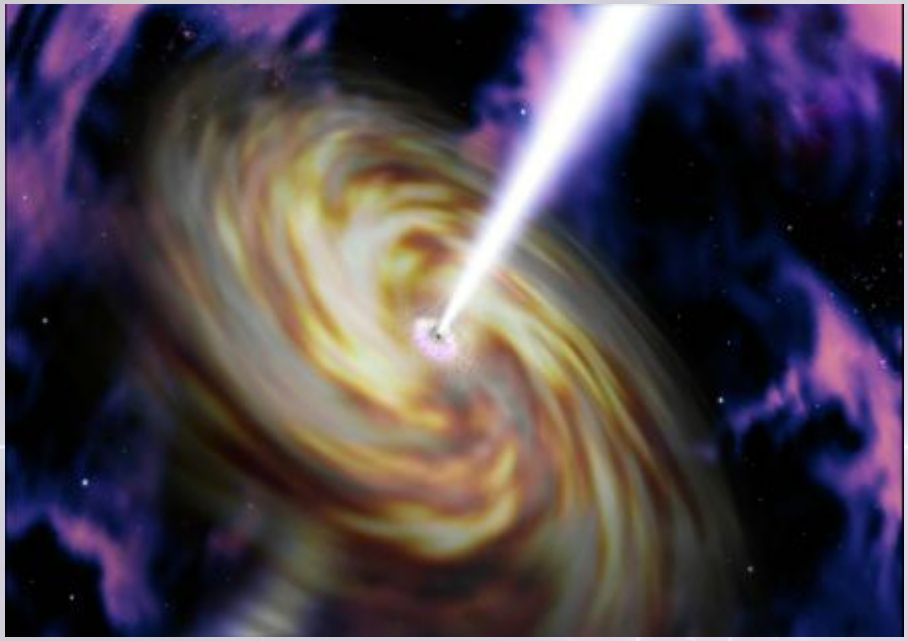

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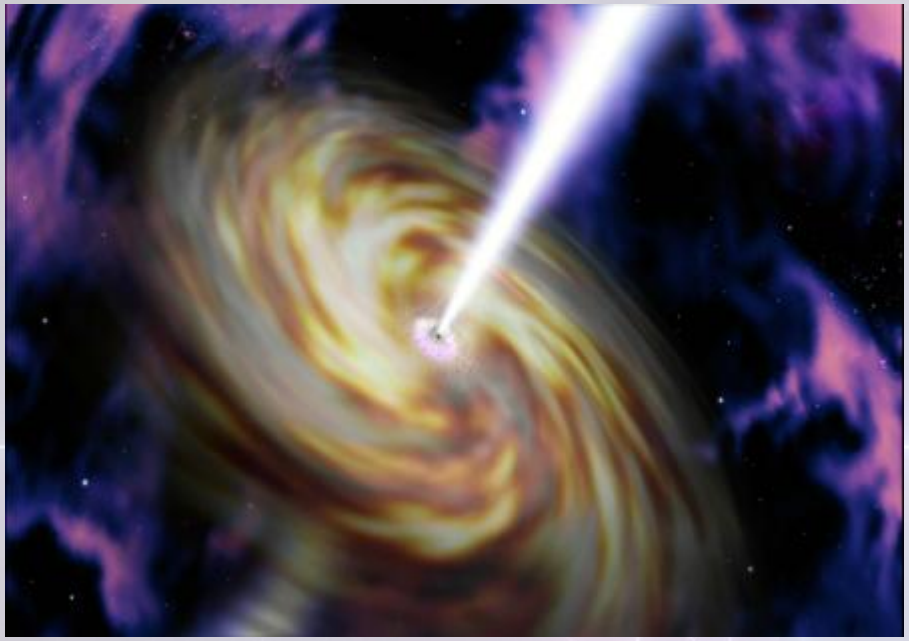

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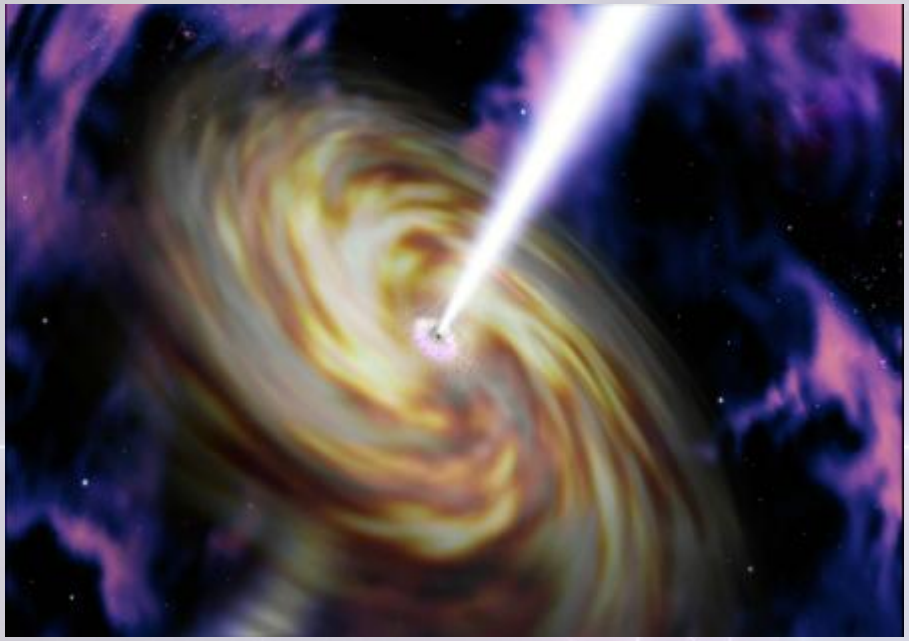

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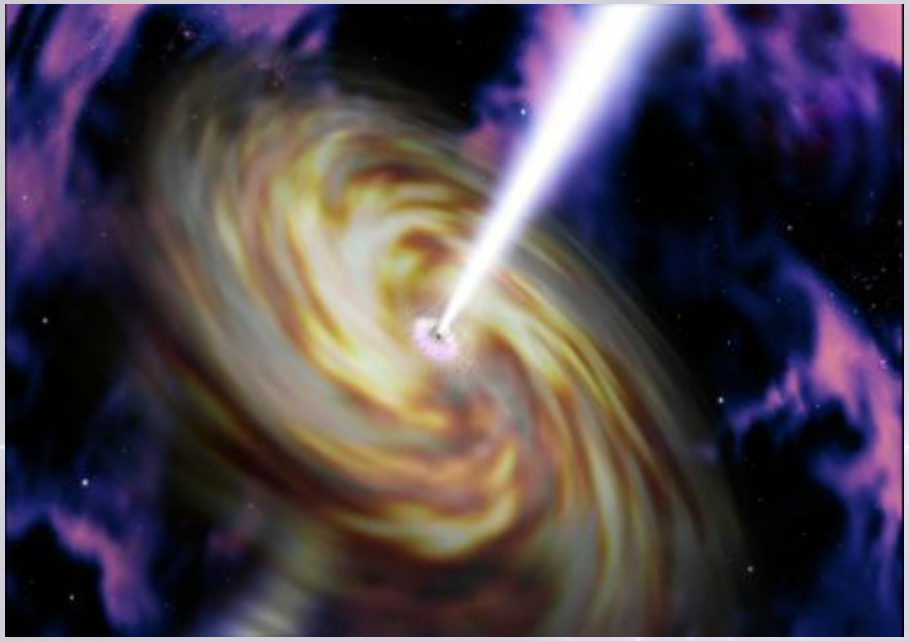

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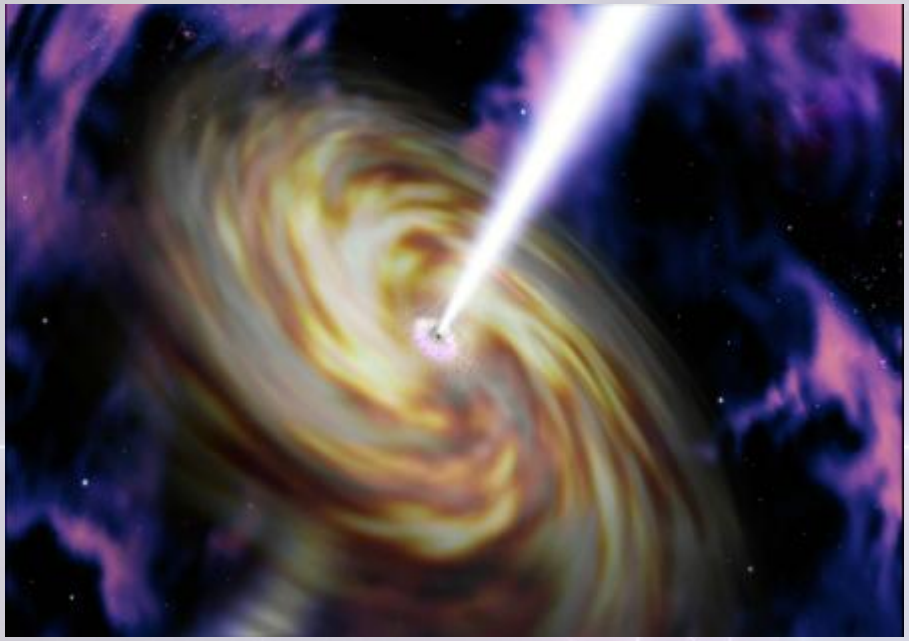

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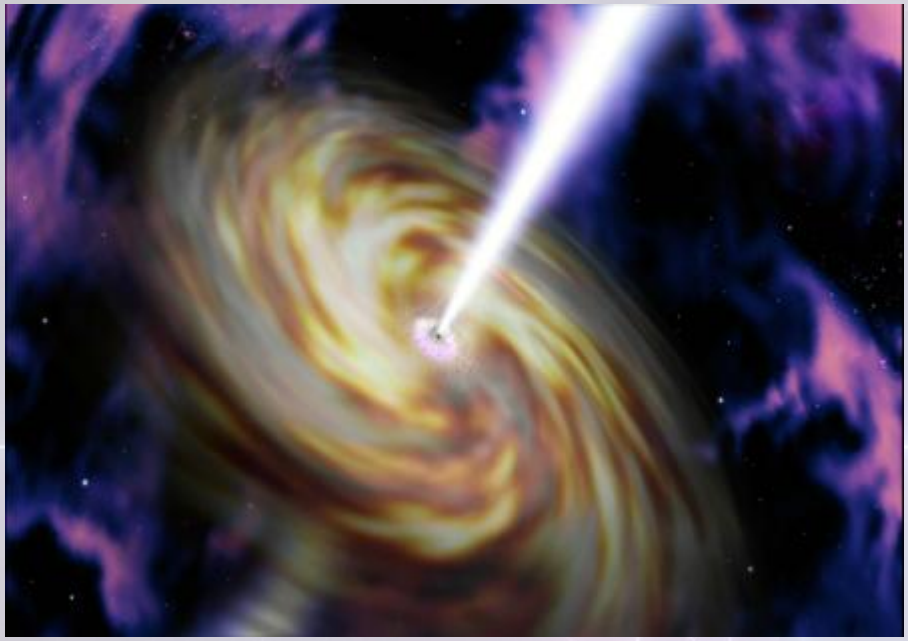

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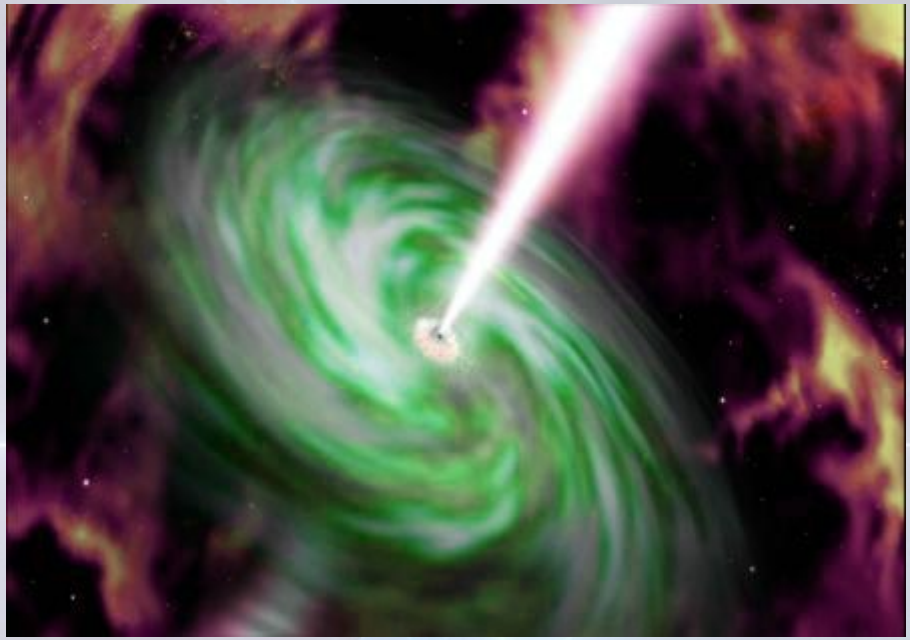

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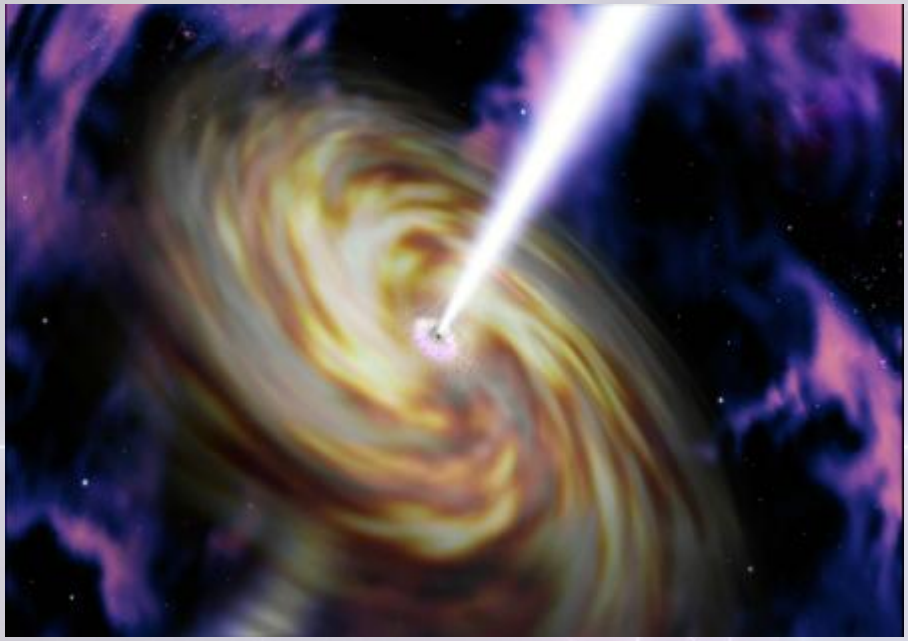

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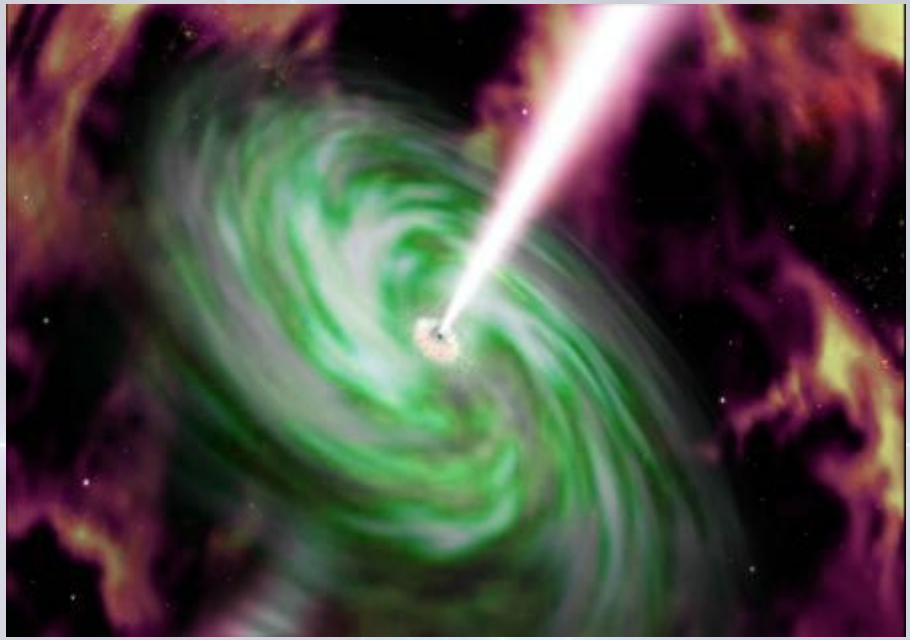

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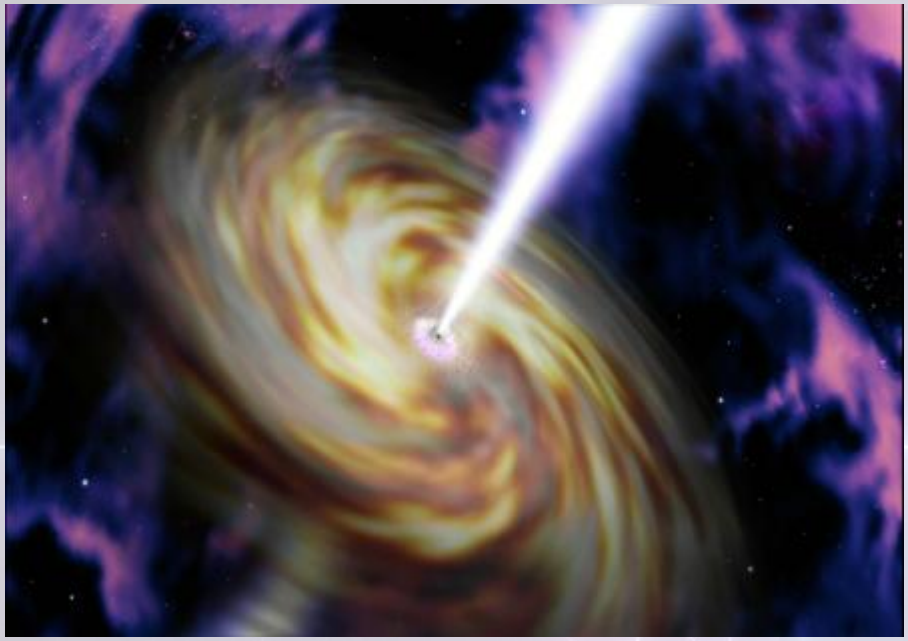

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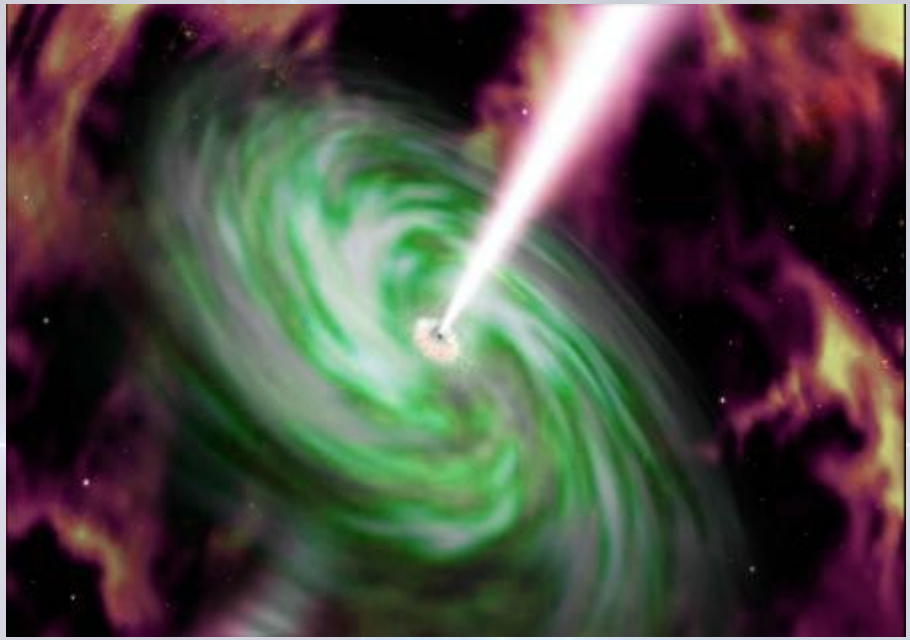

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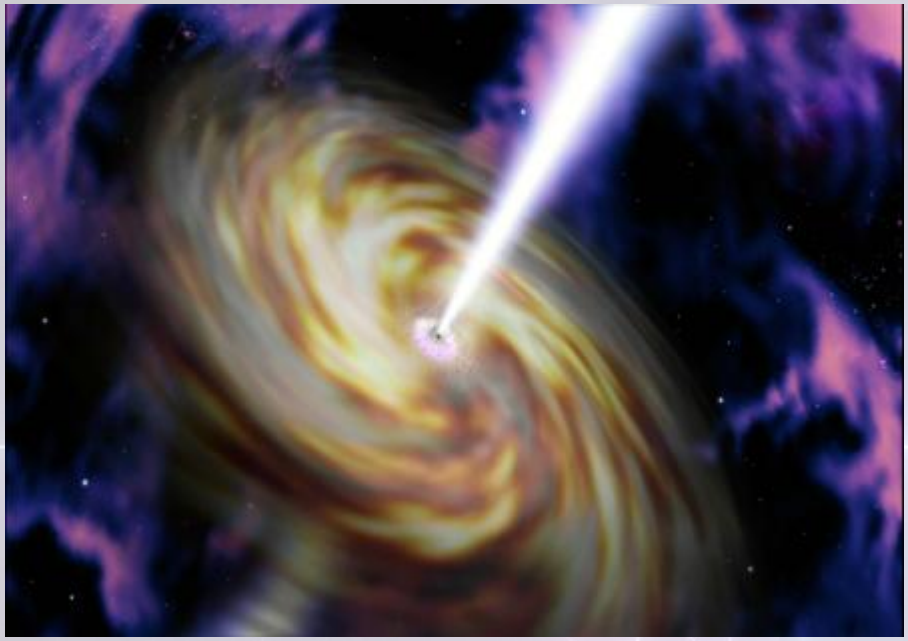

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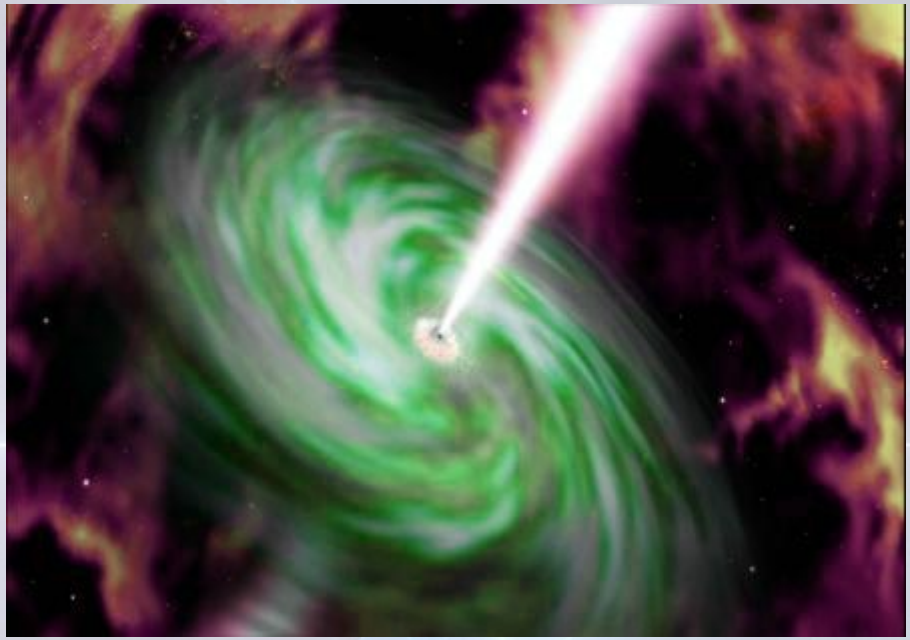

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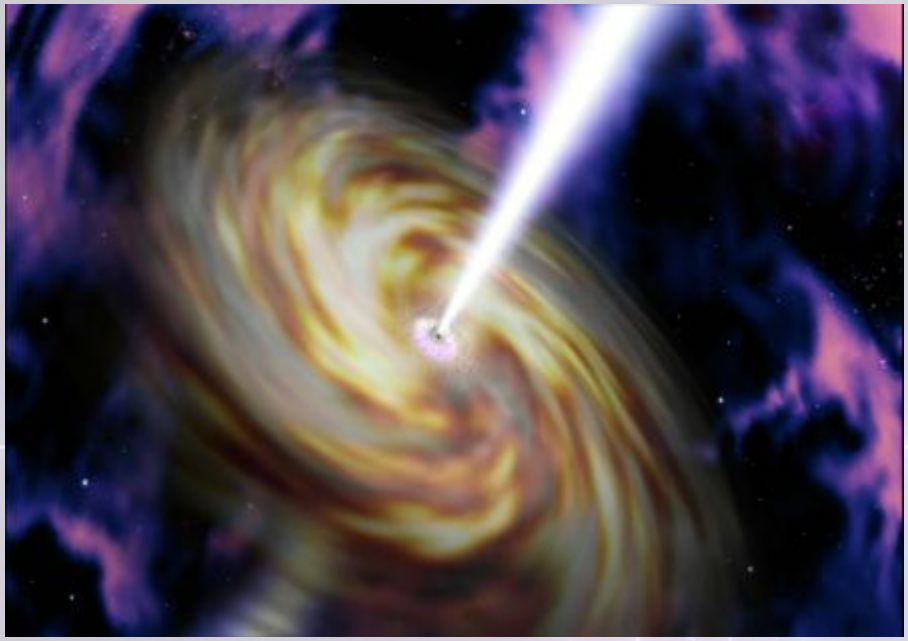

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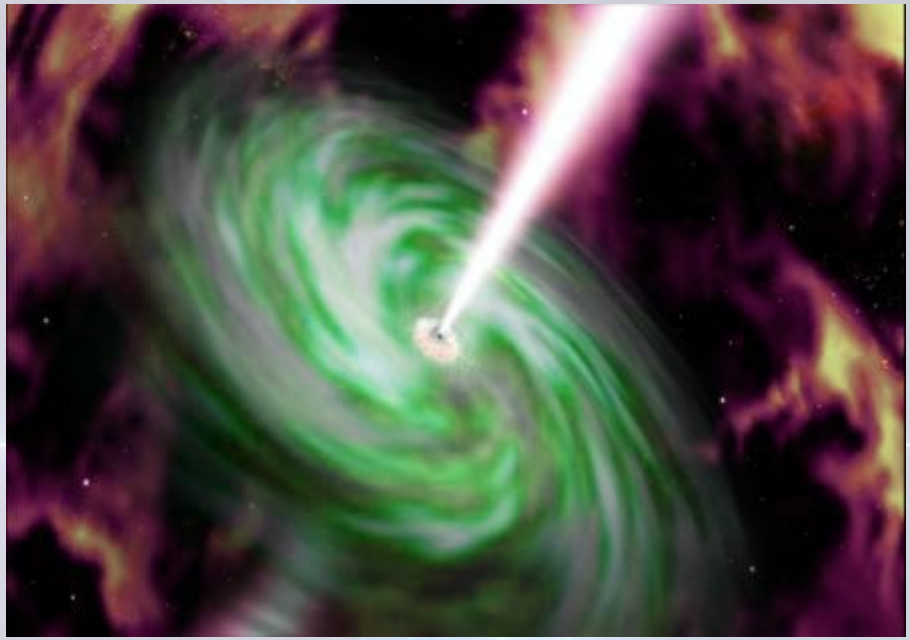

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classical Wolf–Rayet stars?

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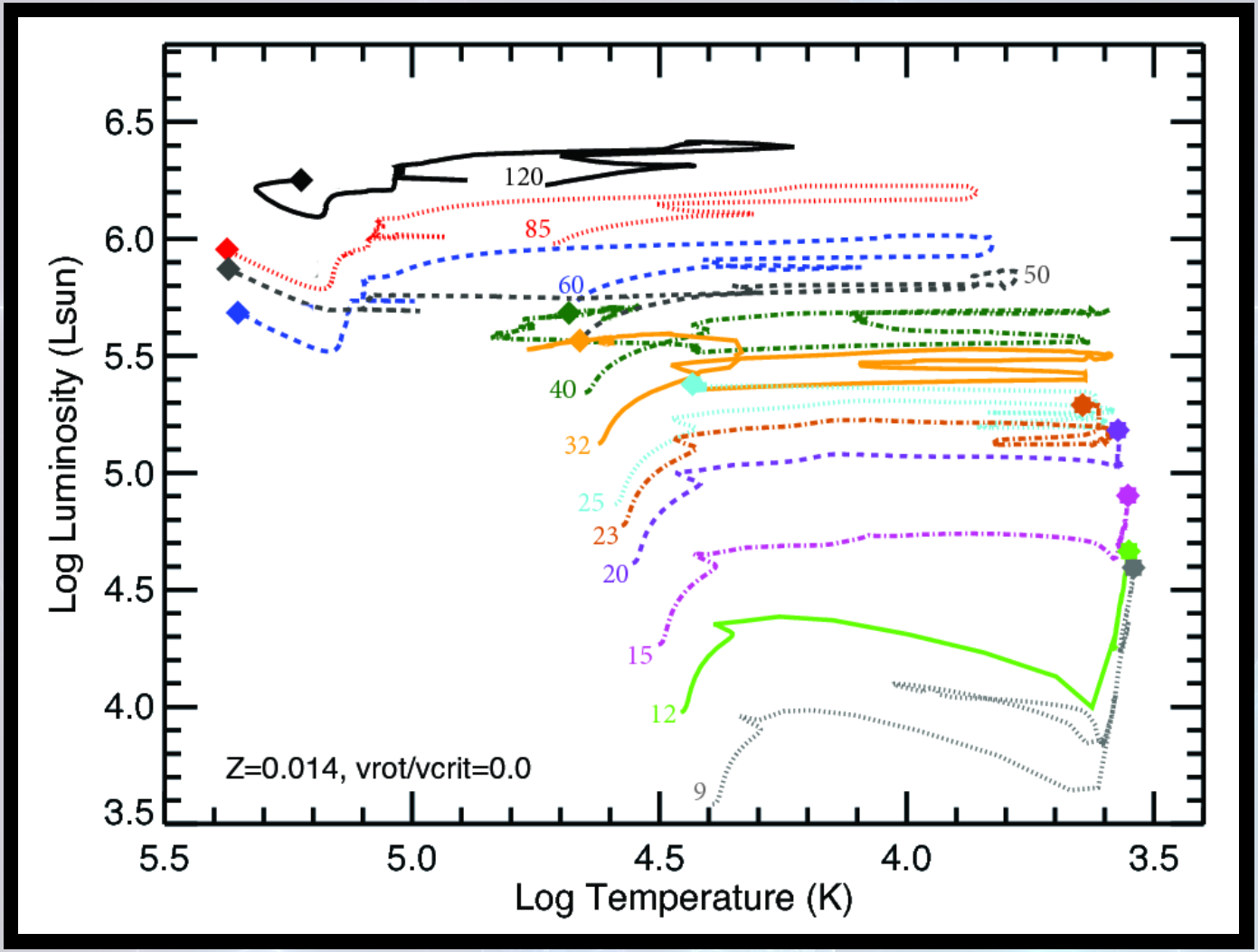

Groh et al. 2013

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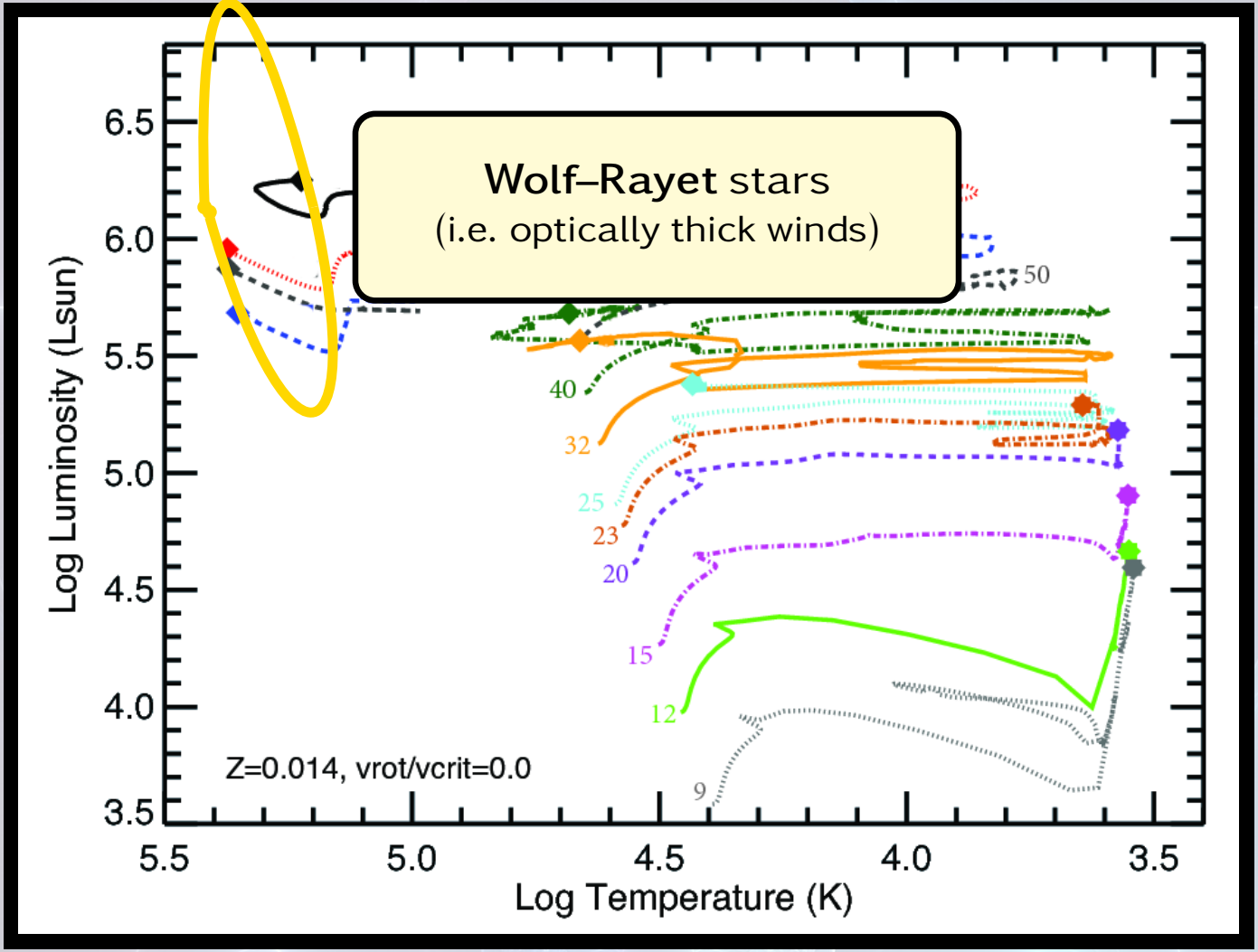

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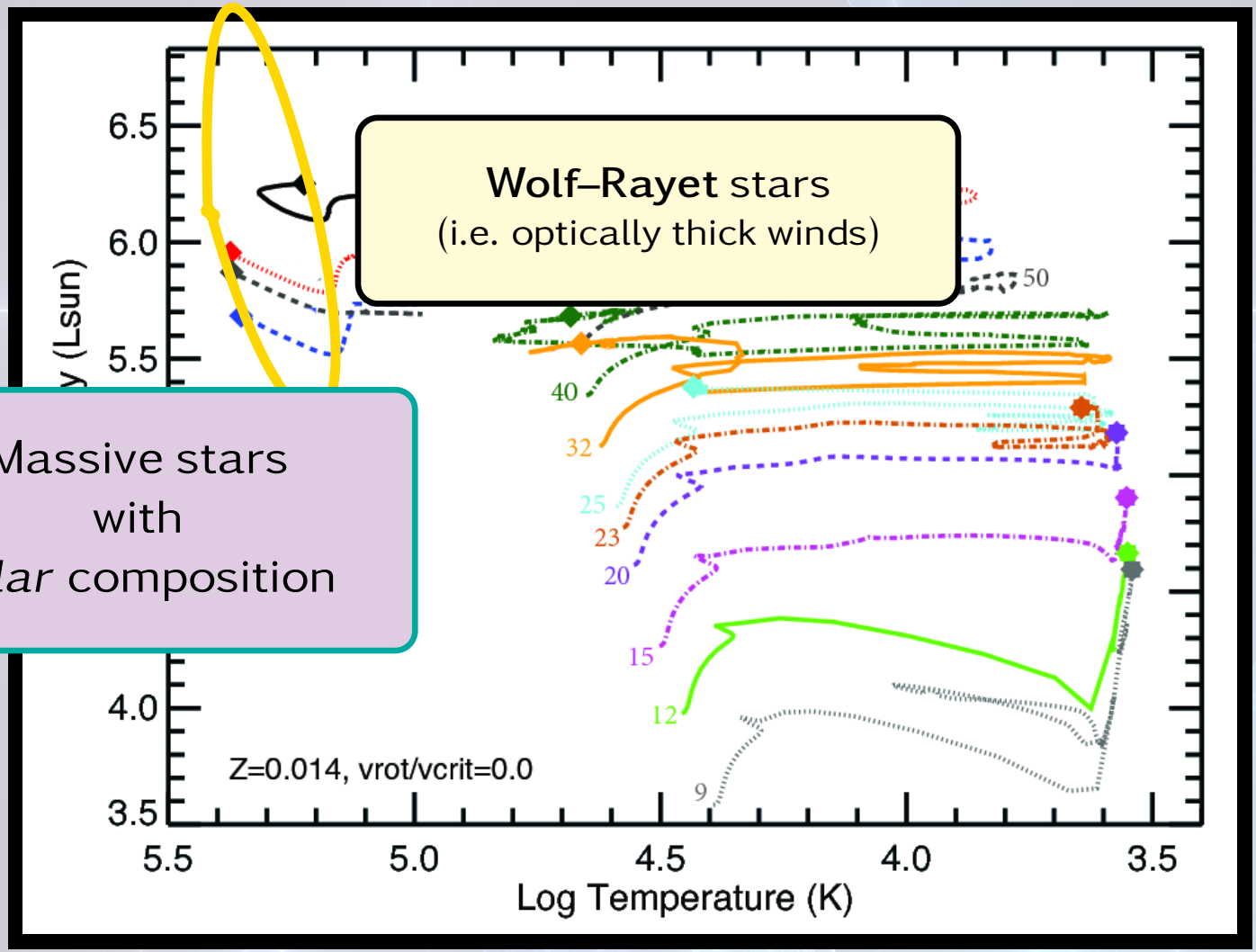

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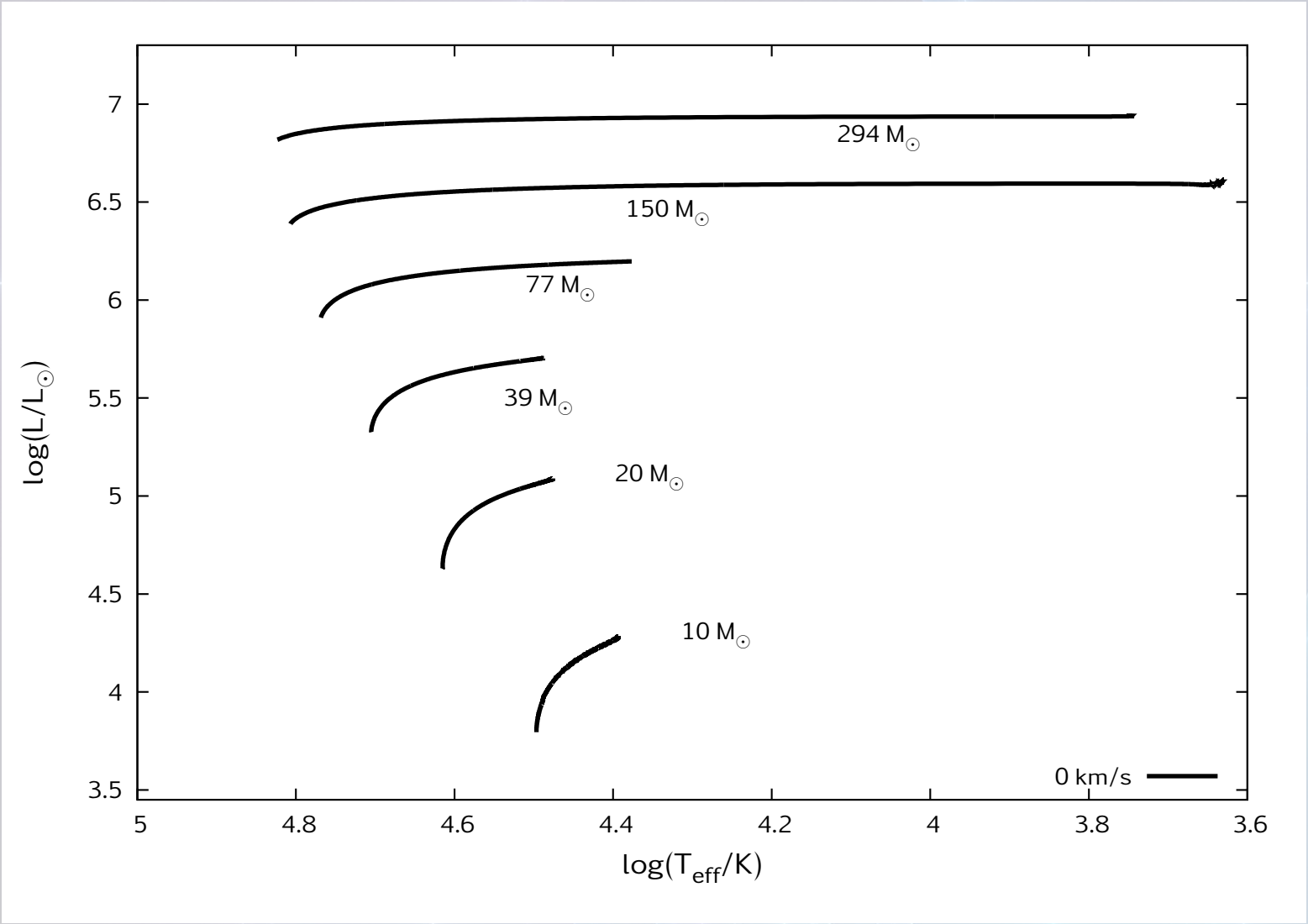

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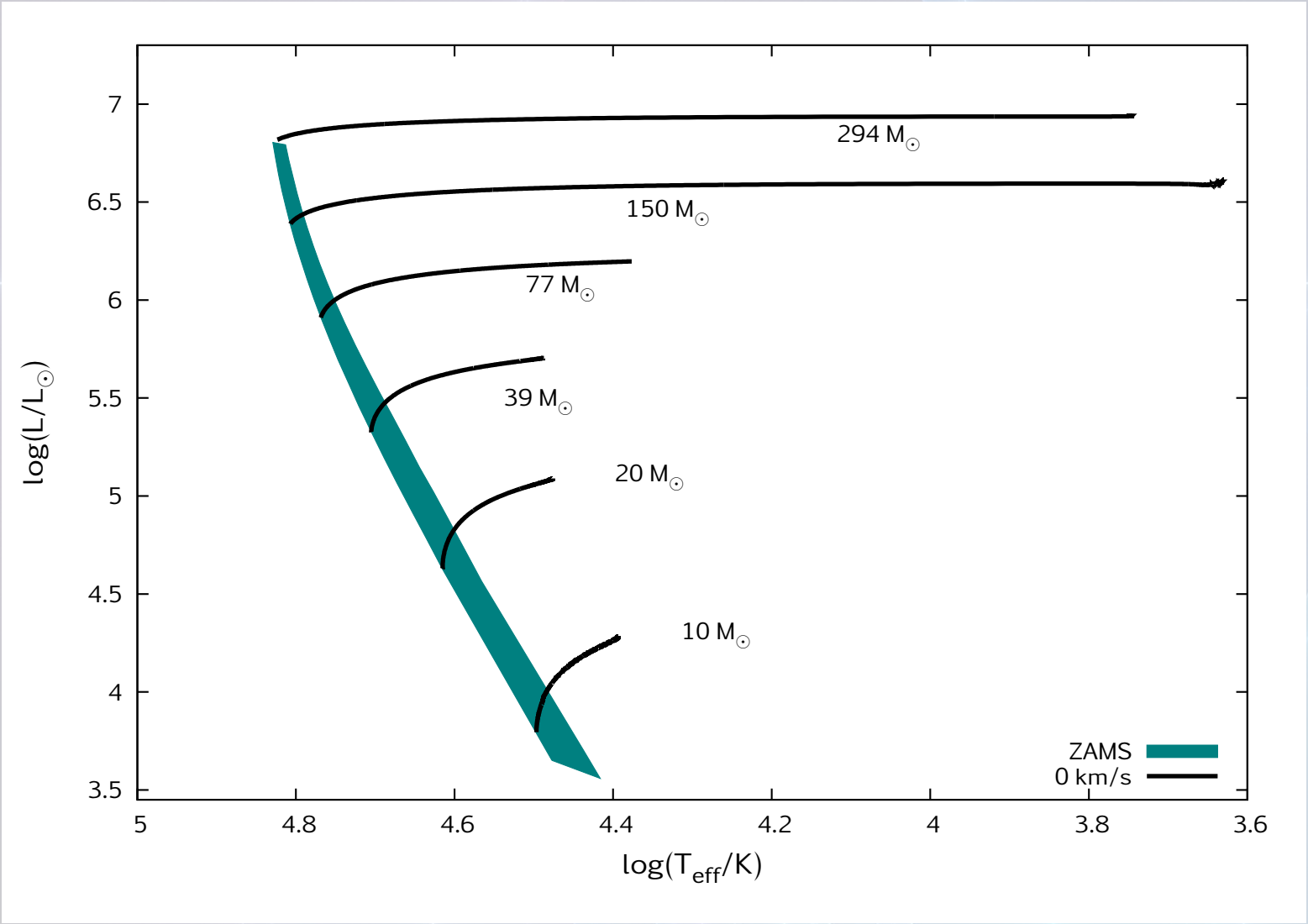

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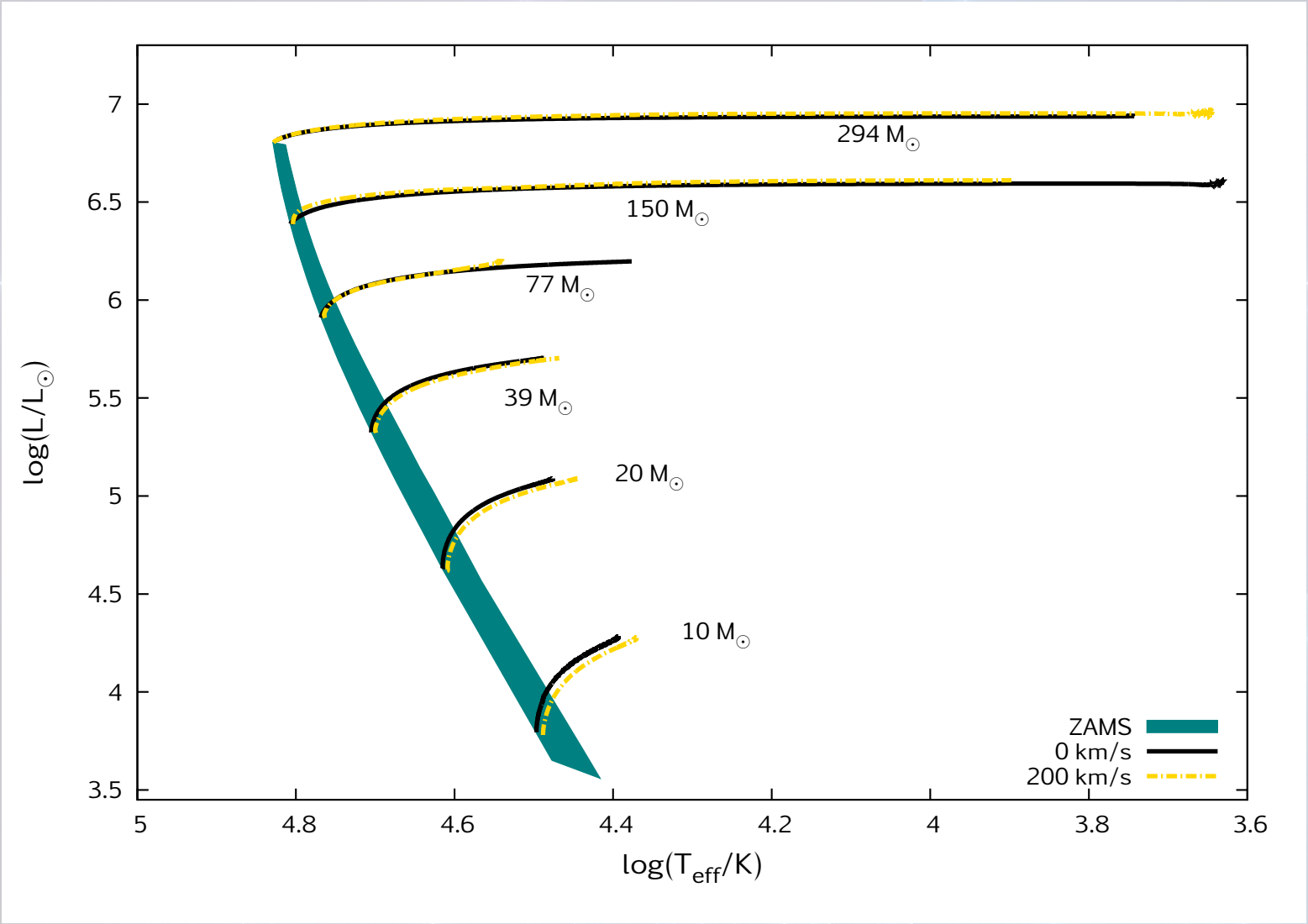

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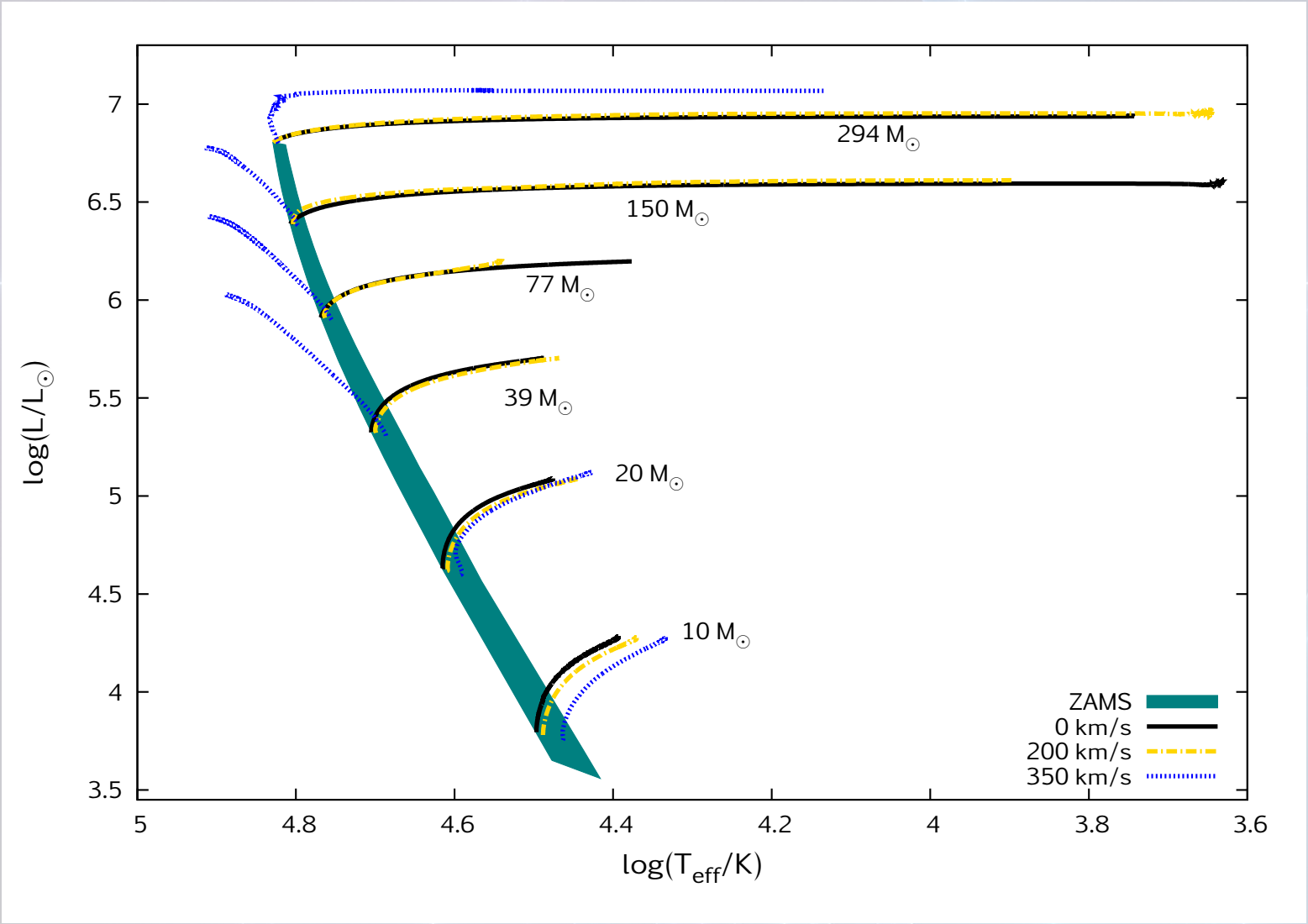

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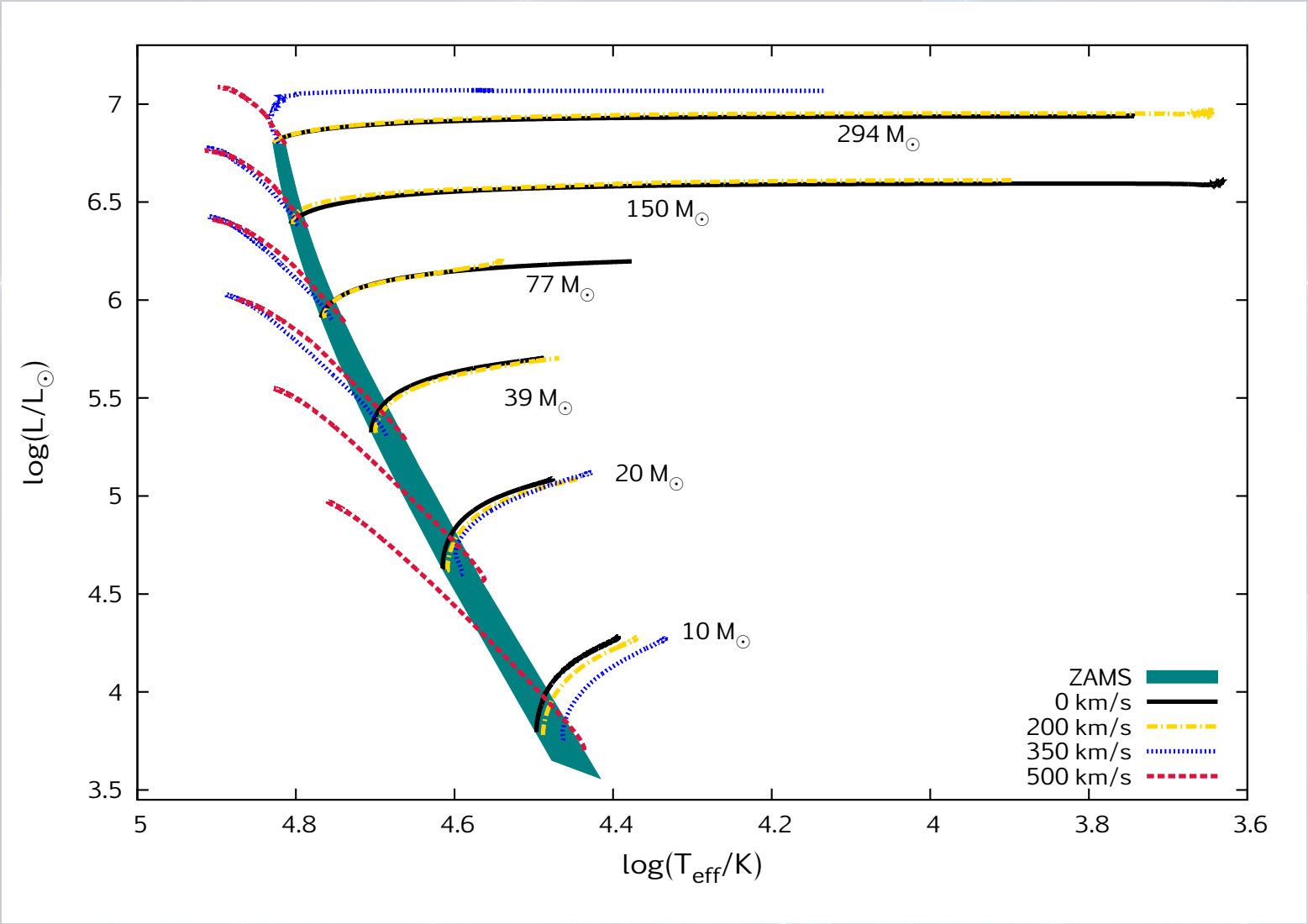

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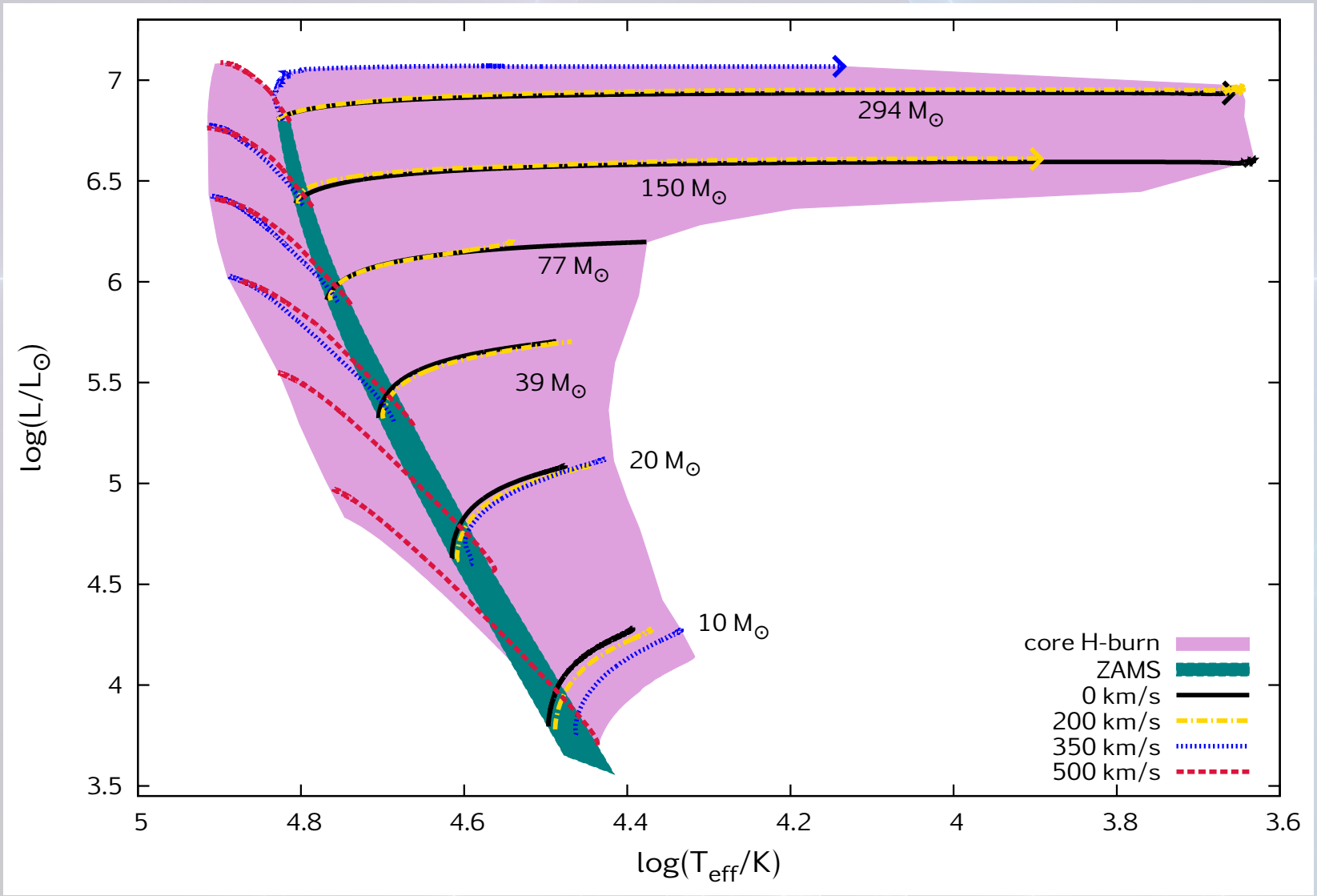

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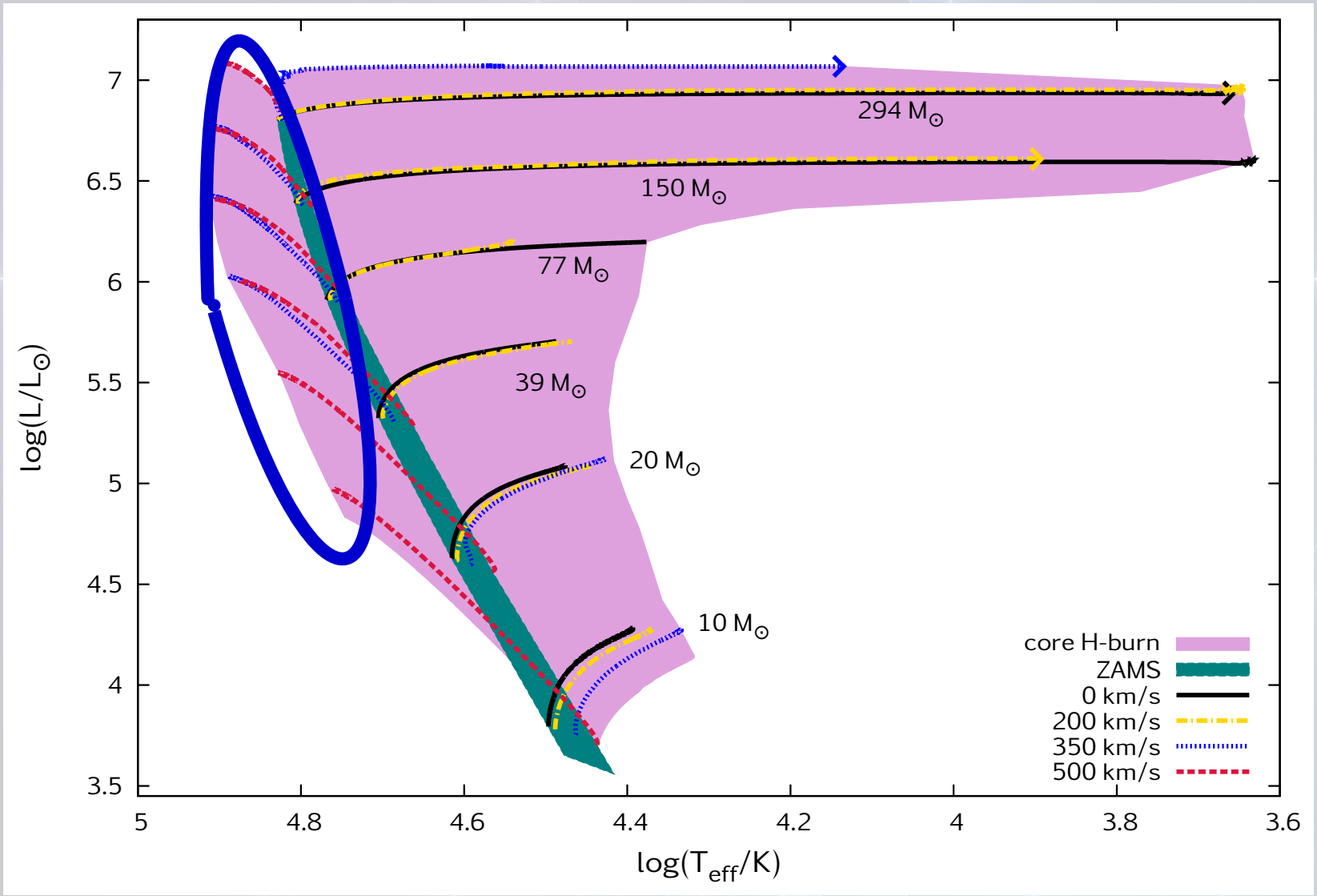

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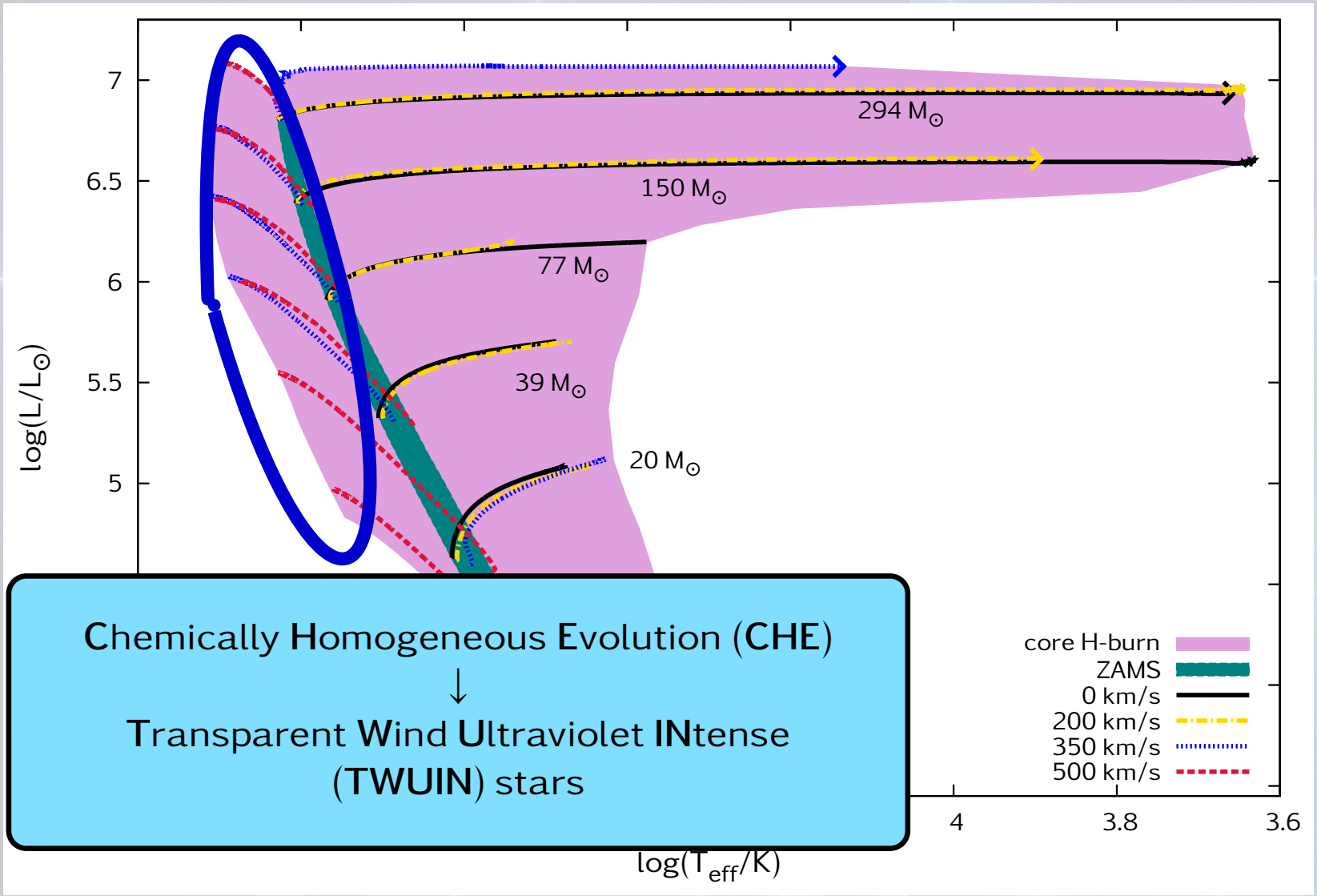

Chemically Homogeneous Evolution (**CHE**)

↓

Transparent **W**ind **U**ltraviolet **IN**tense (**TWUIN**) stars

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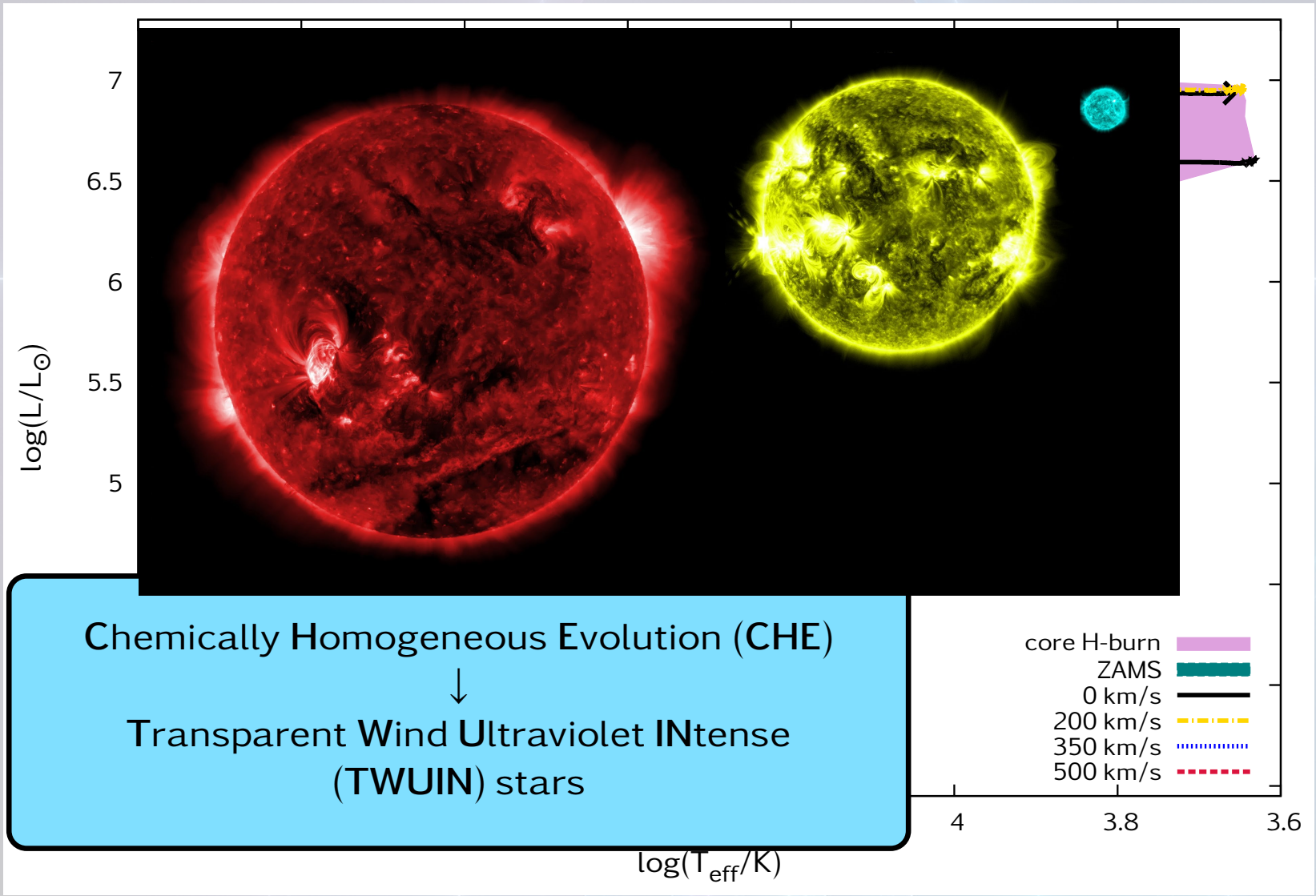

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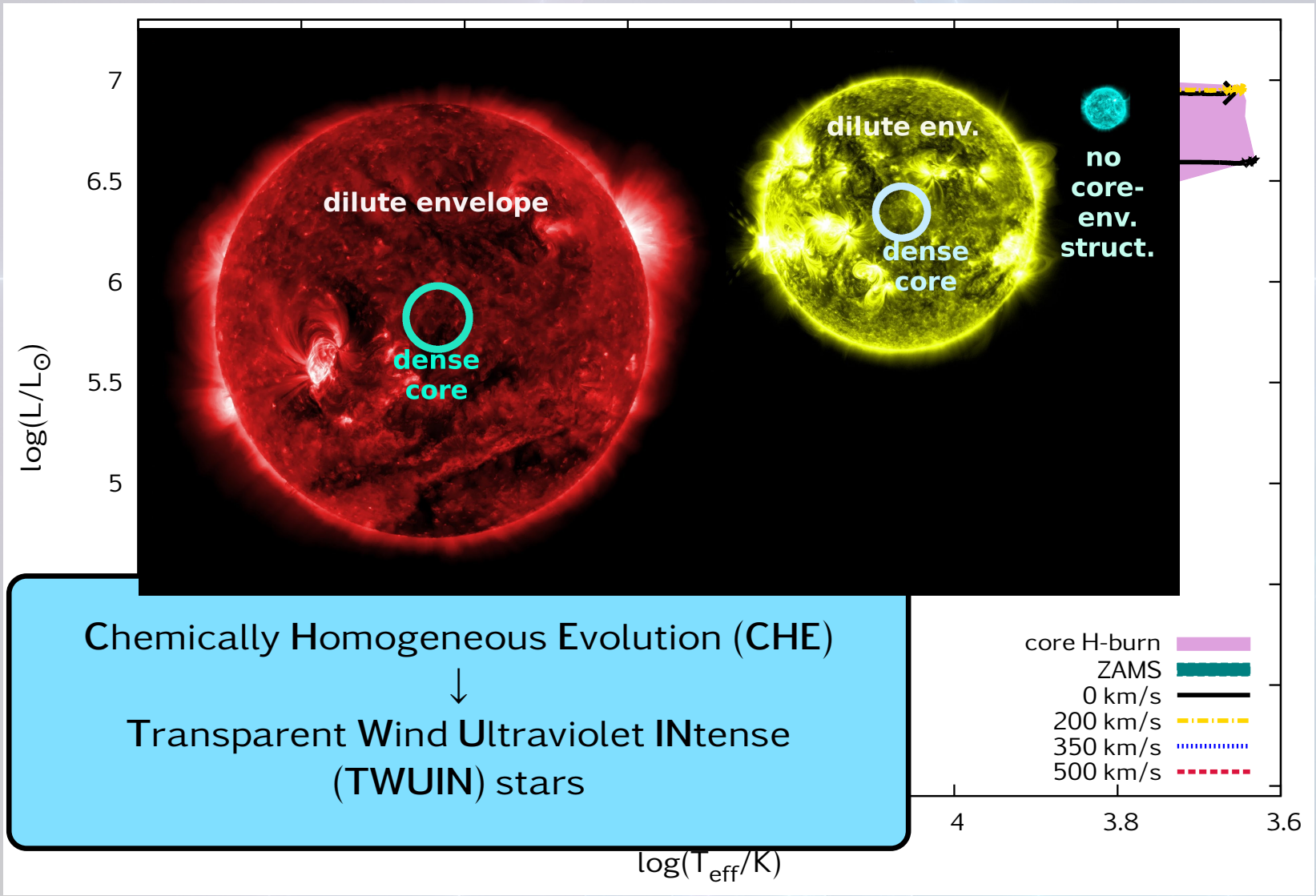

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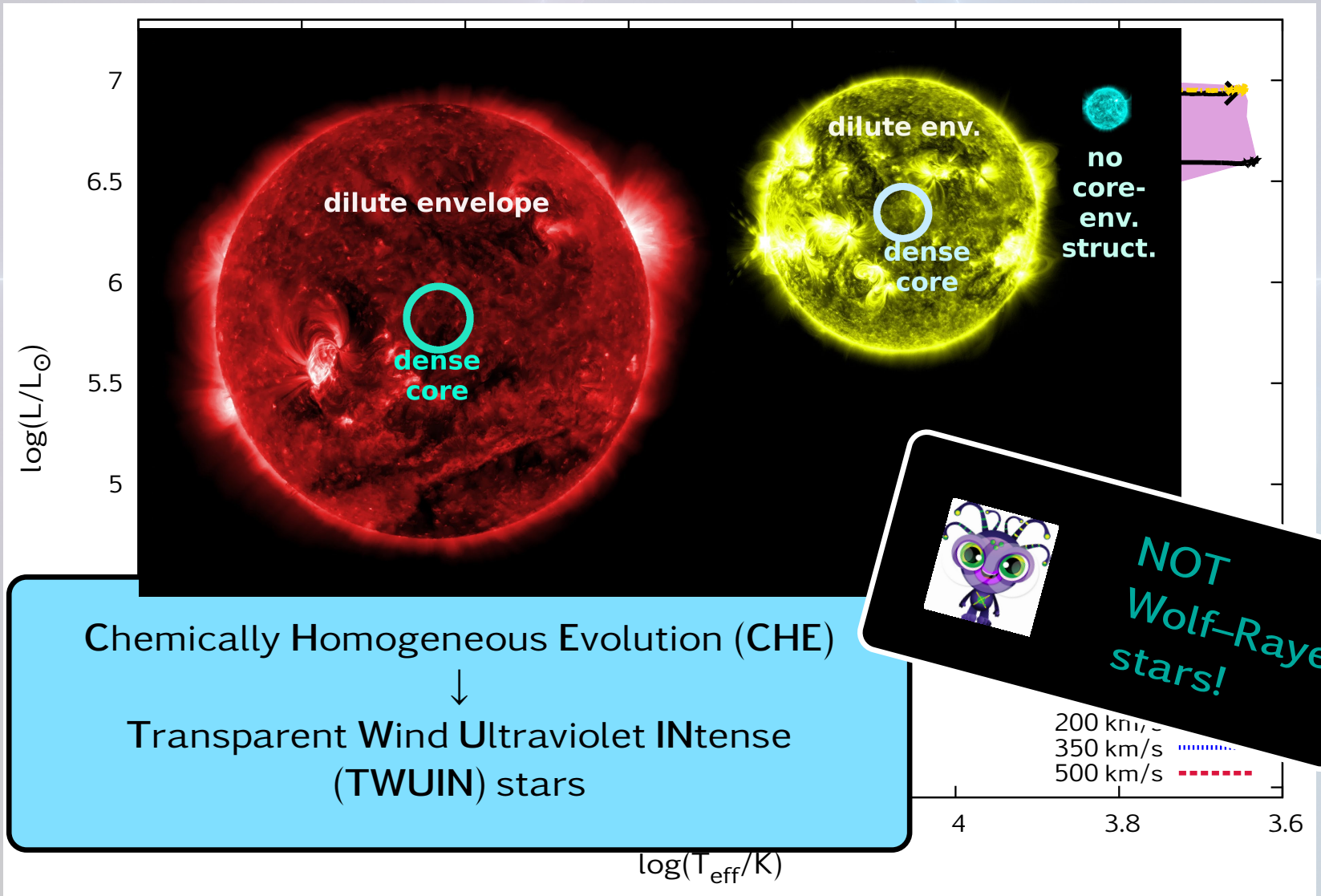

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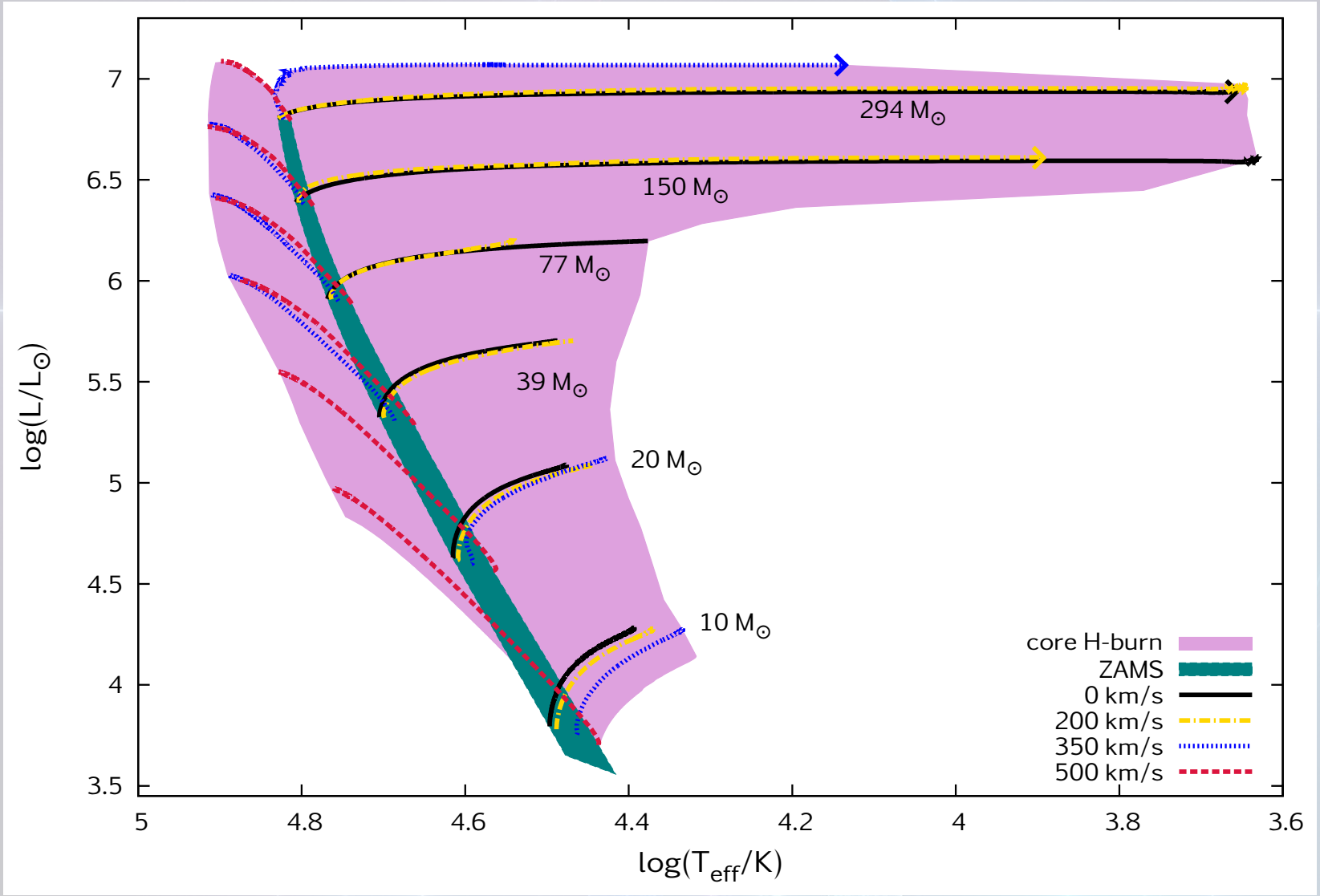
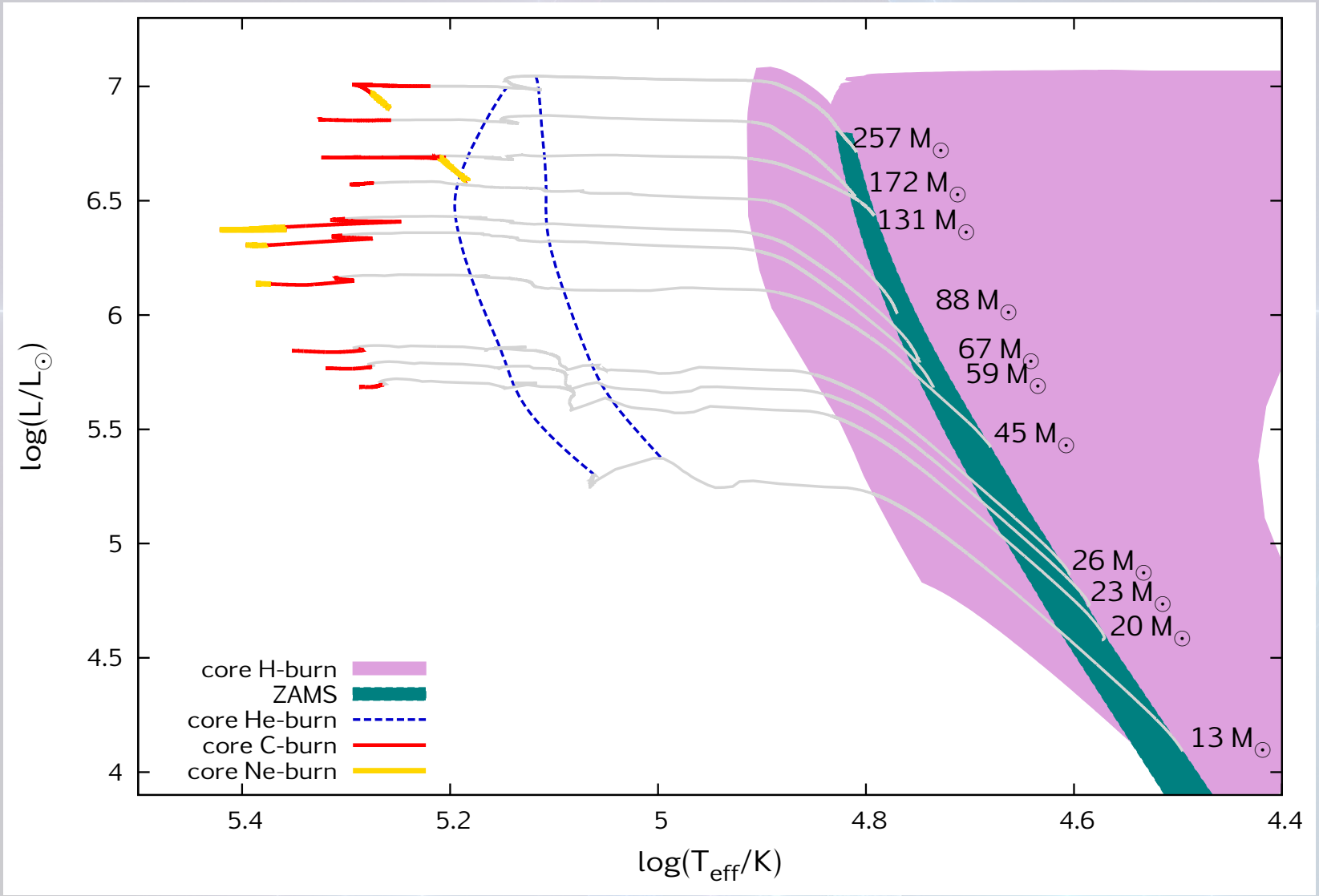
Post-main-sequence evolution → final fate



Post-main-sequence evolution → final fate



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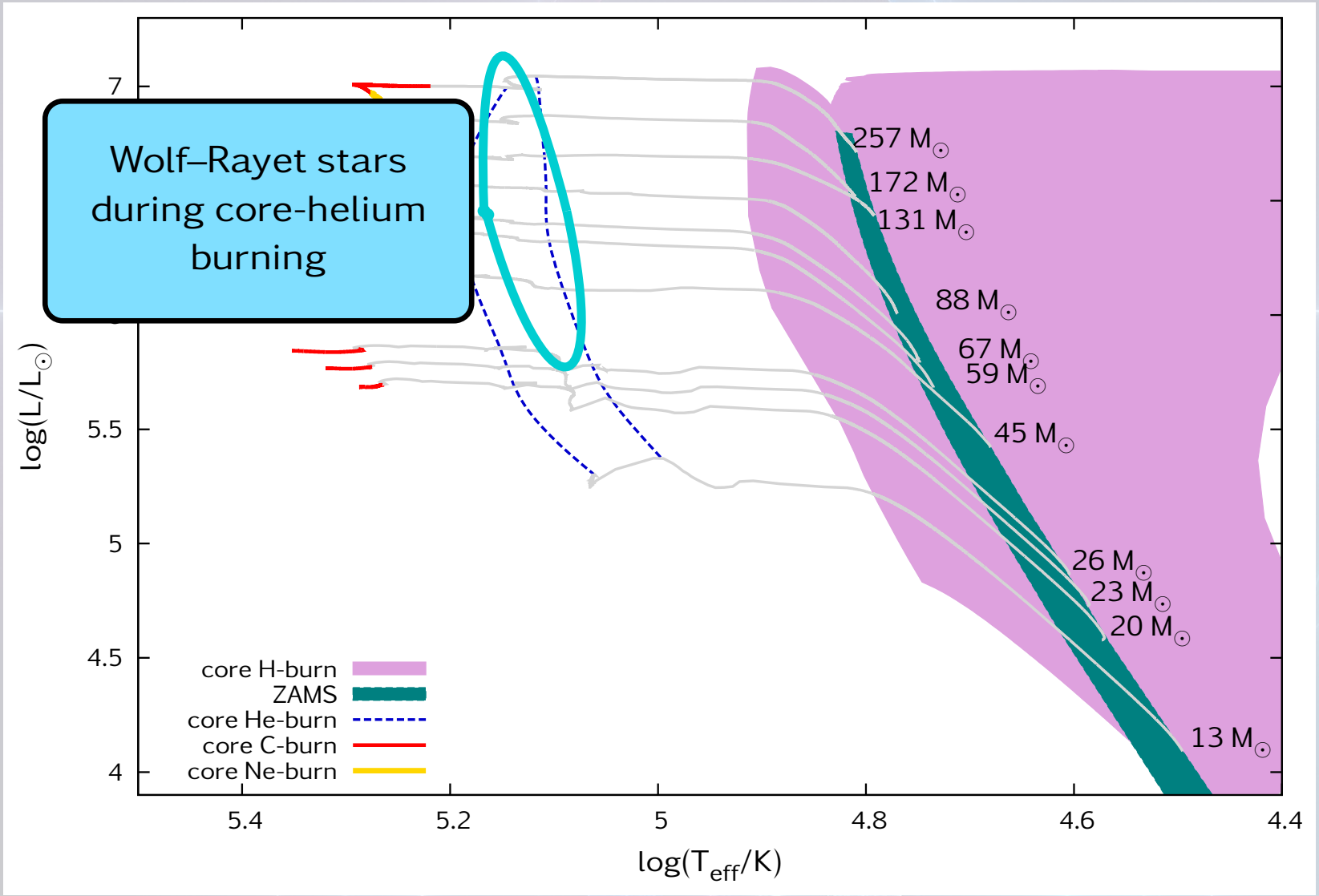
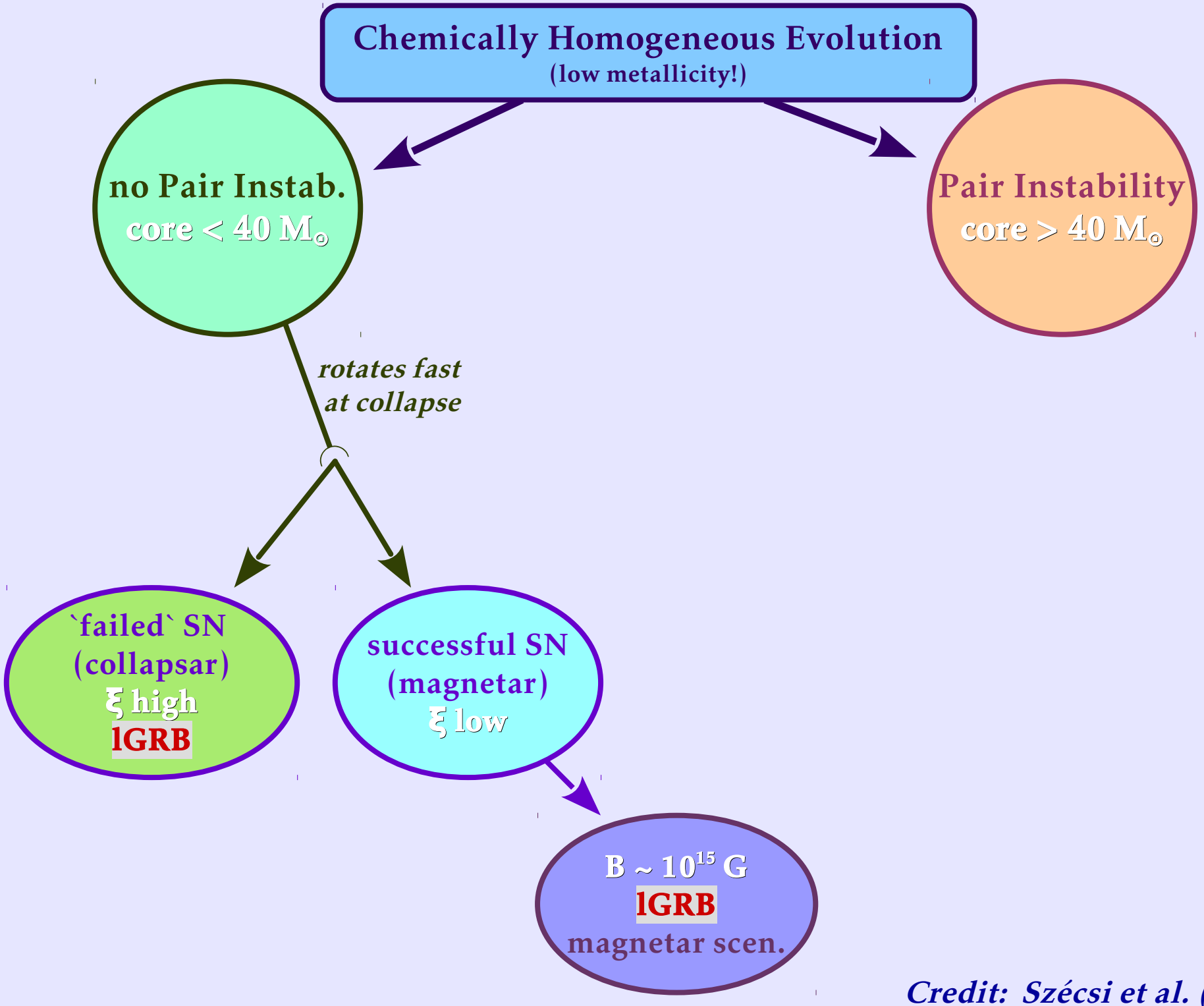
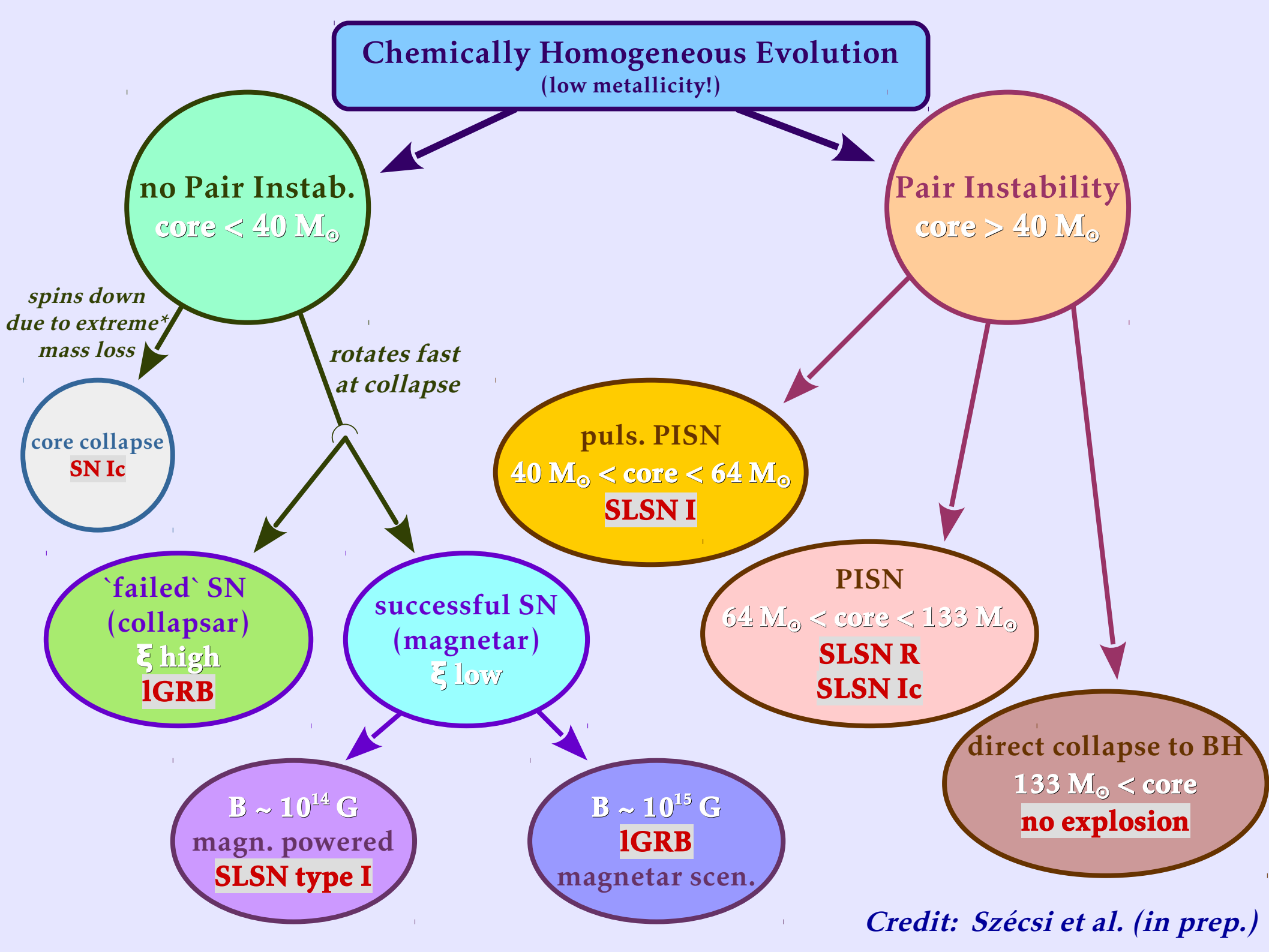
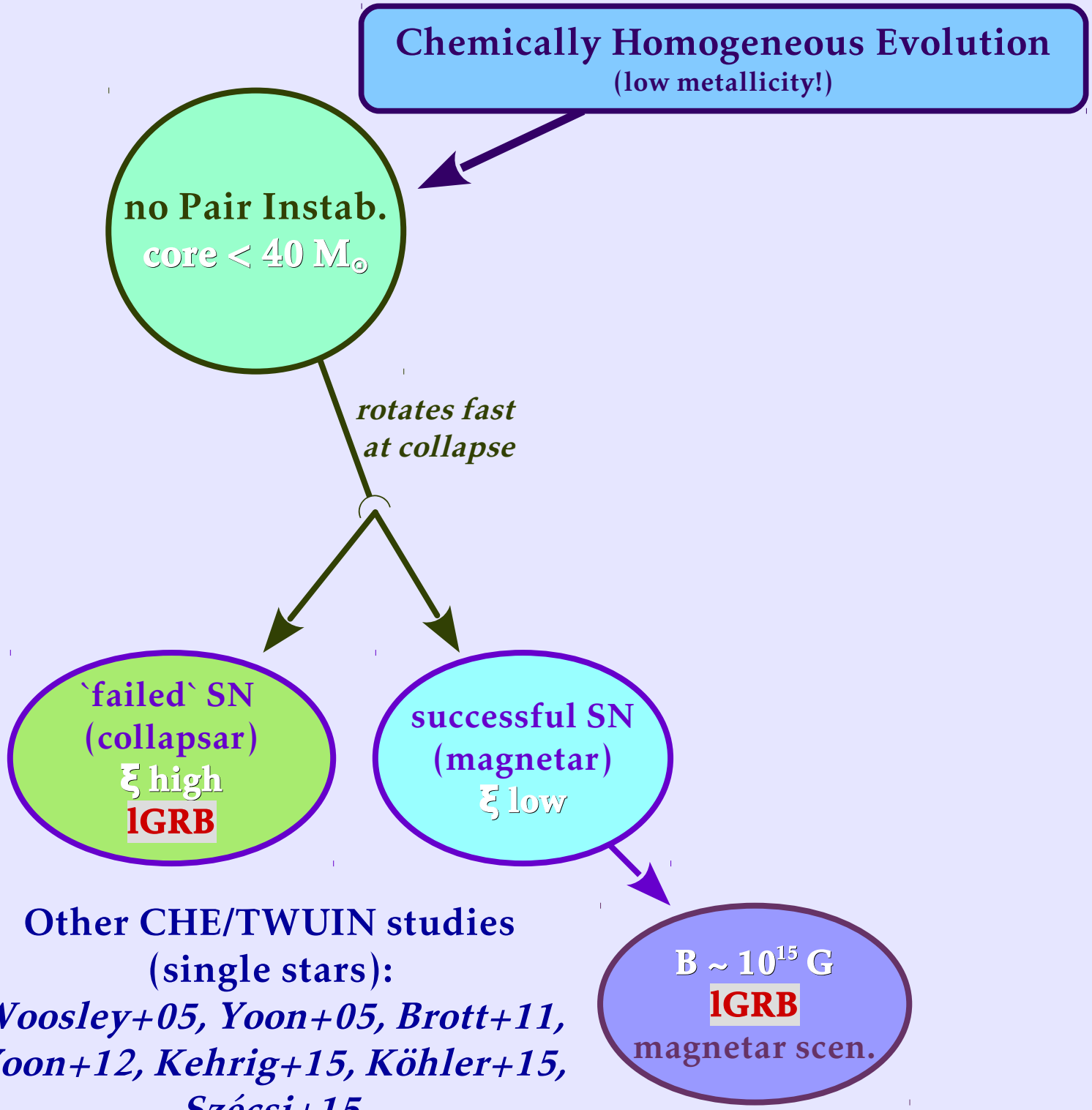




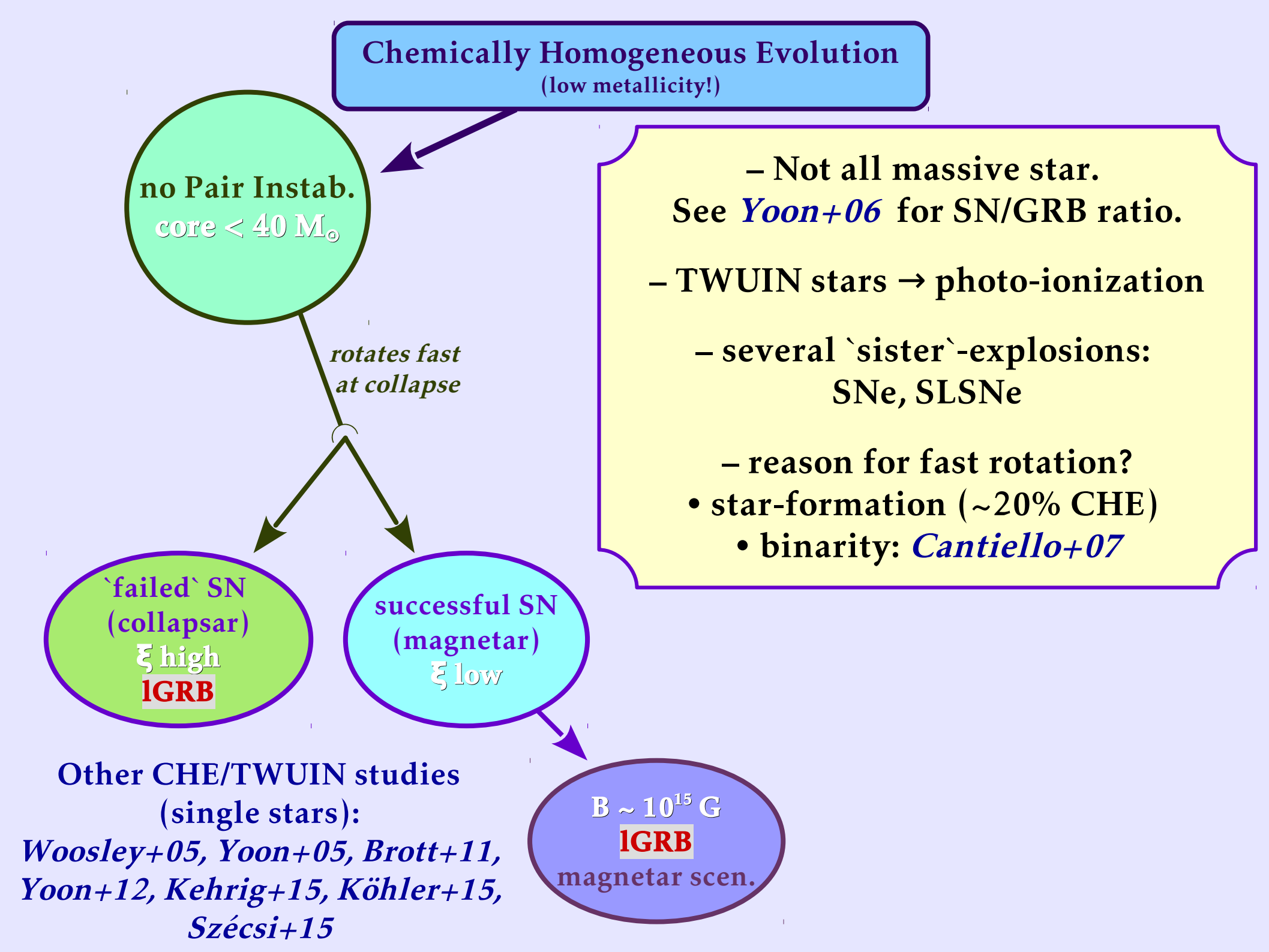
Credit: Szécsi et al. (in prep.)


Chemically Homogeneous Evolution
(low metallicity!)
no Pair Instab.
core < 40 M⊙
Pair Instability
core > 40 M⊙
spins down
due to extreme*
mass loss
rotates fast
at collapse
core collapse
SN Ic
puls. PISN
40 M⊙ < core < 64 M⊙
SLSN I
`failed` SN
(collapsar)
ξ high
lGRB
successful SN
(magnetar)
ξ low
PISN
64 M⊙ < core < 133 M⊙
SLSN R
SLSN Ic
direct collapse to BH
133 M⊙ < core
no explosion
B ~ 10^14 G
magn. powered
SLSN type I
B ~ 10^15 G
lGRB
magnetar scen.
Credit: Szécsi et al. (in prep.)



Other CHE/TWUIN studies (single stars):

Woosley+05, Yoon+05, Brott+11, Yoon+12, Kehrig+15, Köhler+15, Szécsi+15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core < 40 M⊙
rotates fast
at collapse
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(collapsar)
ξ high
lGRB
successful SN
(magnetar)
ξ low
B ~ 10^15 G
lGRB
magnetar scen.
– Not all massive star.
See Yoon+06 for SN/GRB ratio.
– TWUIN stars → photo-ionization
– several `sister`-explosions:
SNe, SLSNe
– reason for fast rotation?
• star-formation (~20% CHE)
• binarity: Cantiello+07
Other CHE/TWUIN studies
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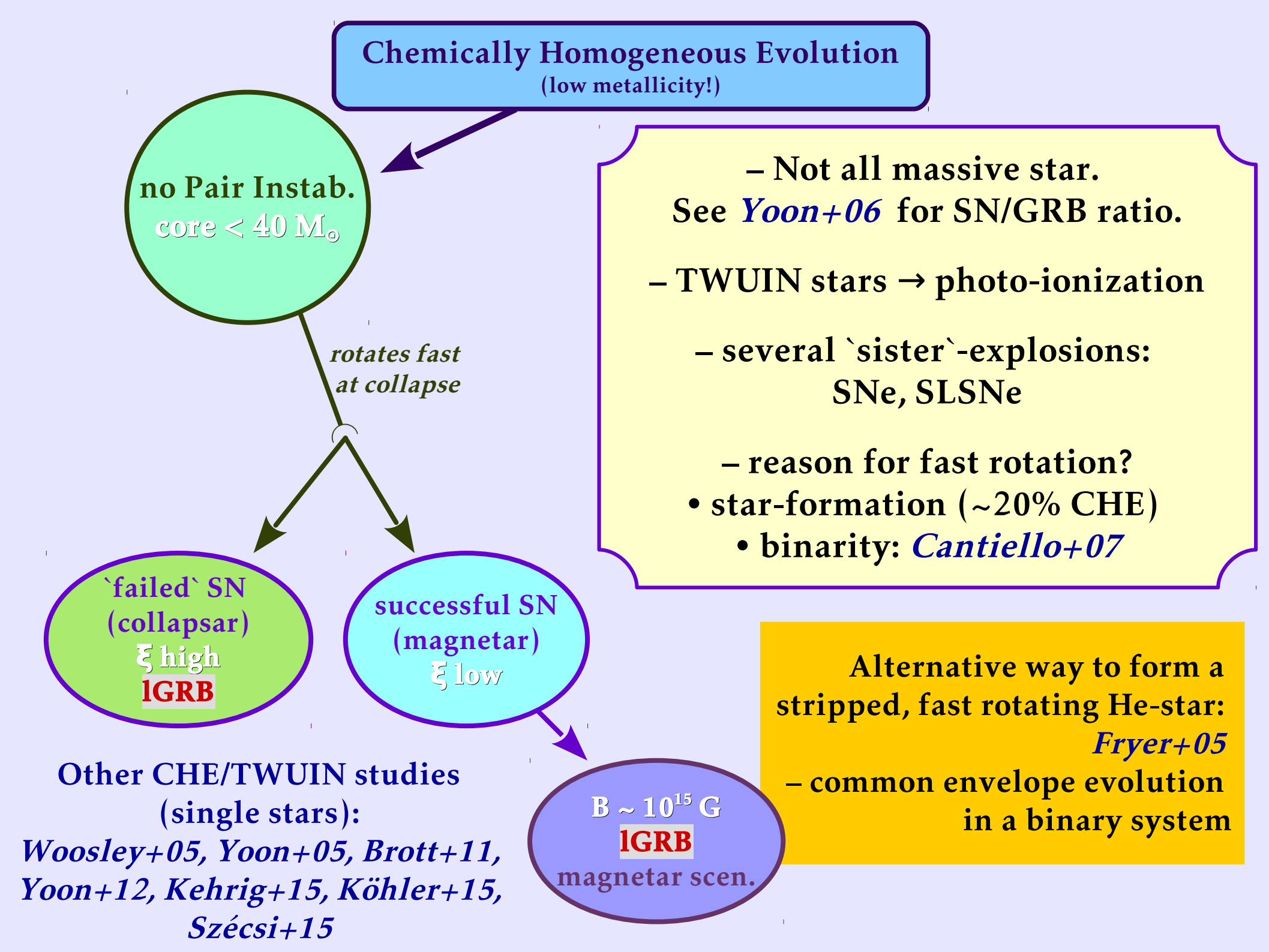
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Alternative way to form a
stripped, fast rotating He-star:
Fryer+05
– common envelope evolution
in a binary system
Other CHE/TWUIN studies
(single stars):
Woosley+05, Yoon+05, Brott+11,
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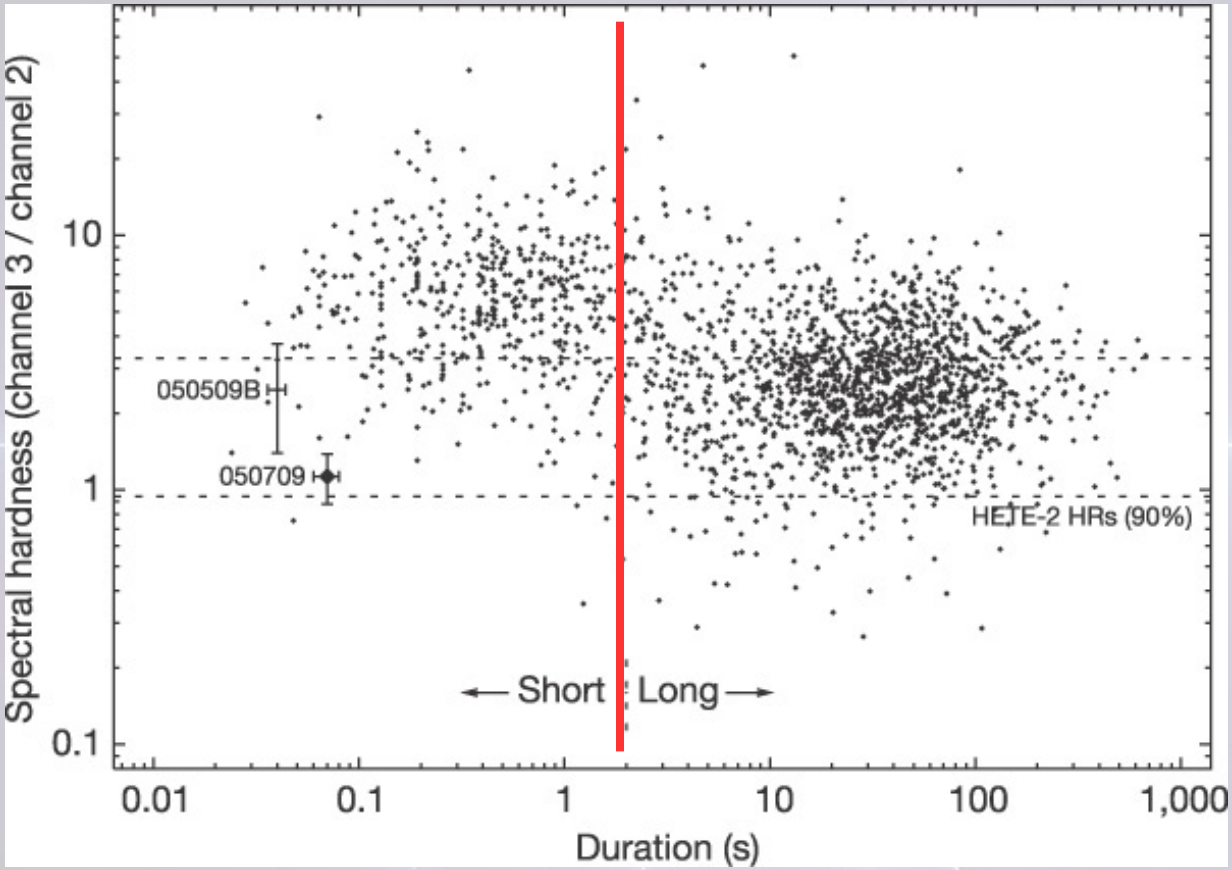
How may GRBs form? *A review by Dorottya Szécsi*



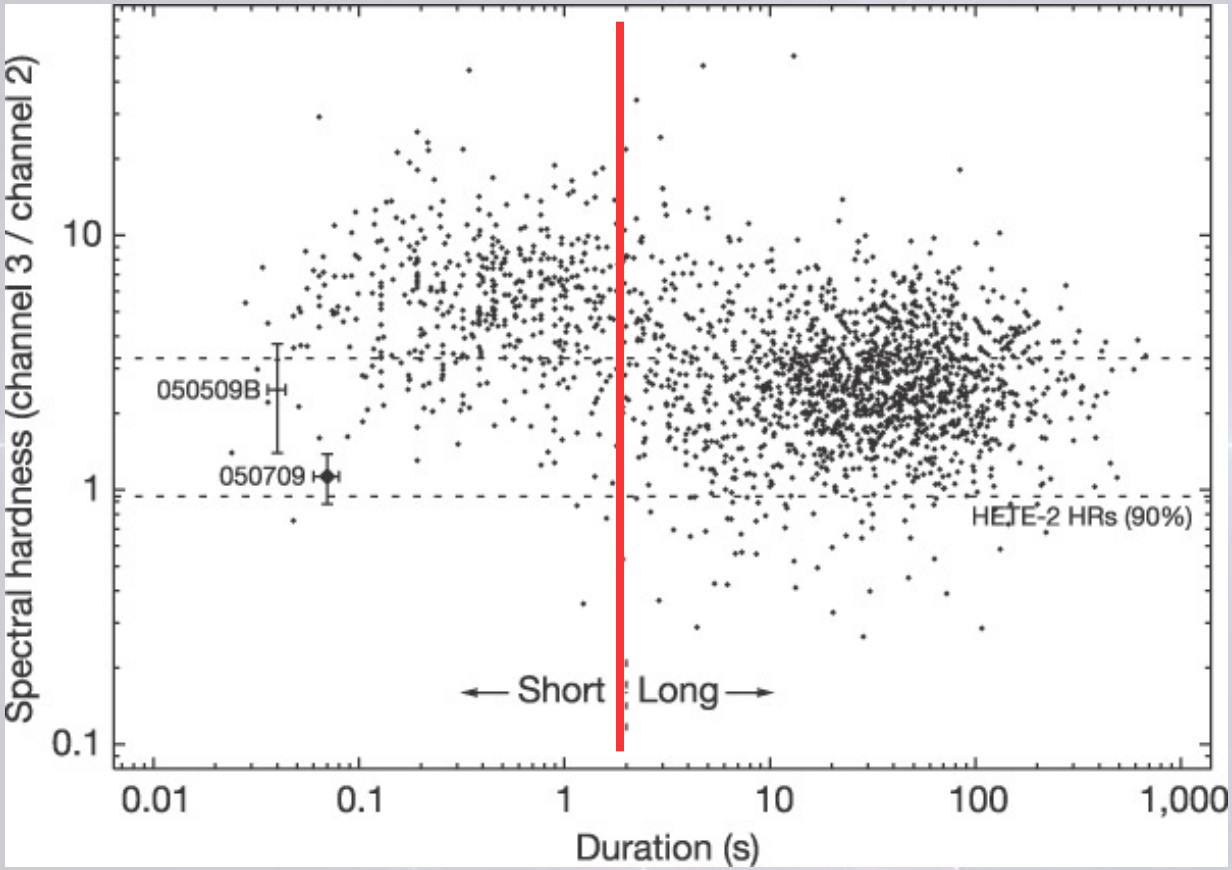
Credit: Hjorth+2005

Long/soft:

Massive Stars at collapse

Short/hard: two Compact Objects at merger

How may GRBs form? *A review by Dorottya Szécsi*



Credit: Hjorth+2005

Long/soft:

Massive Stars at collapse

THANK YOU!

Short/hard: two Compact Objects at merger