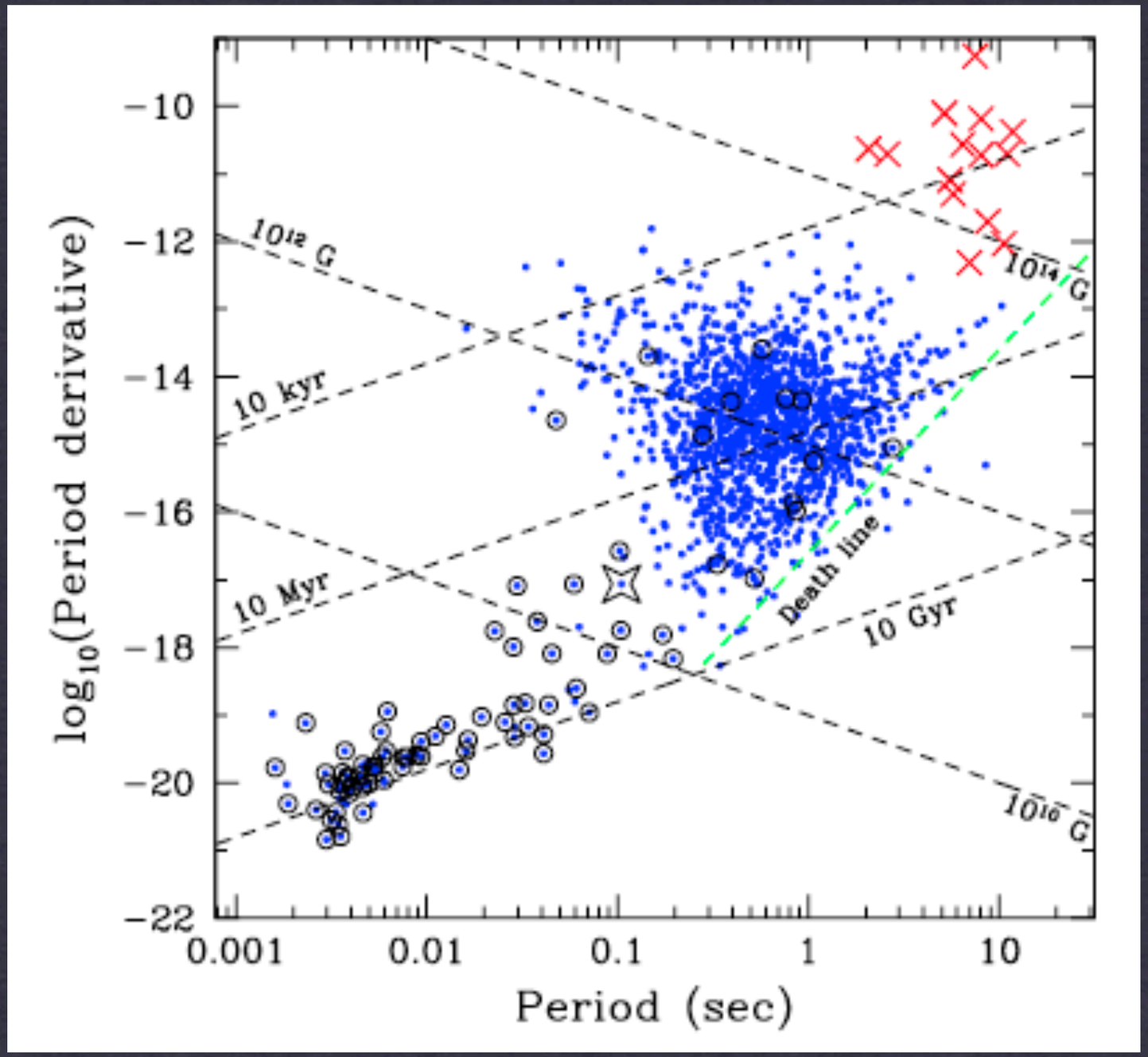
Ben Davies (RIT / Leeds)
Don Figer (RIT)
Rolf-Peter Kudritzki (UHawaii)
Chryssa Kouveliotou (NASA/MSFC)
Christine Trombley (RIT)
Stefanie Wachter (IPAC)
Maria Messineo (ESA-ESTEC)

The Progenitors of Neutron Stars & Magnetars

Distribution of Neutron Stars



Halpern & Gotthelf 2009 arXiv/0911.0093

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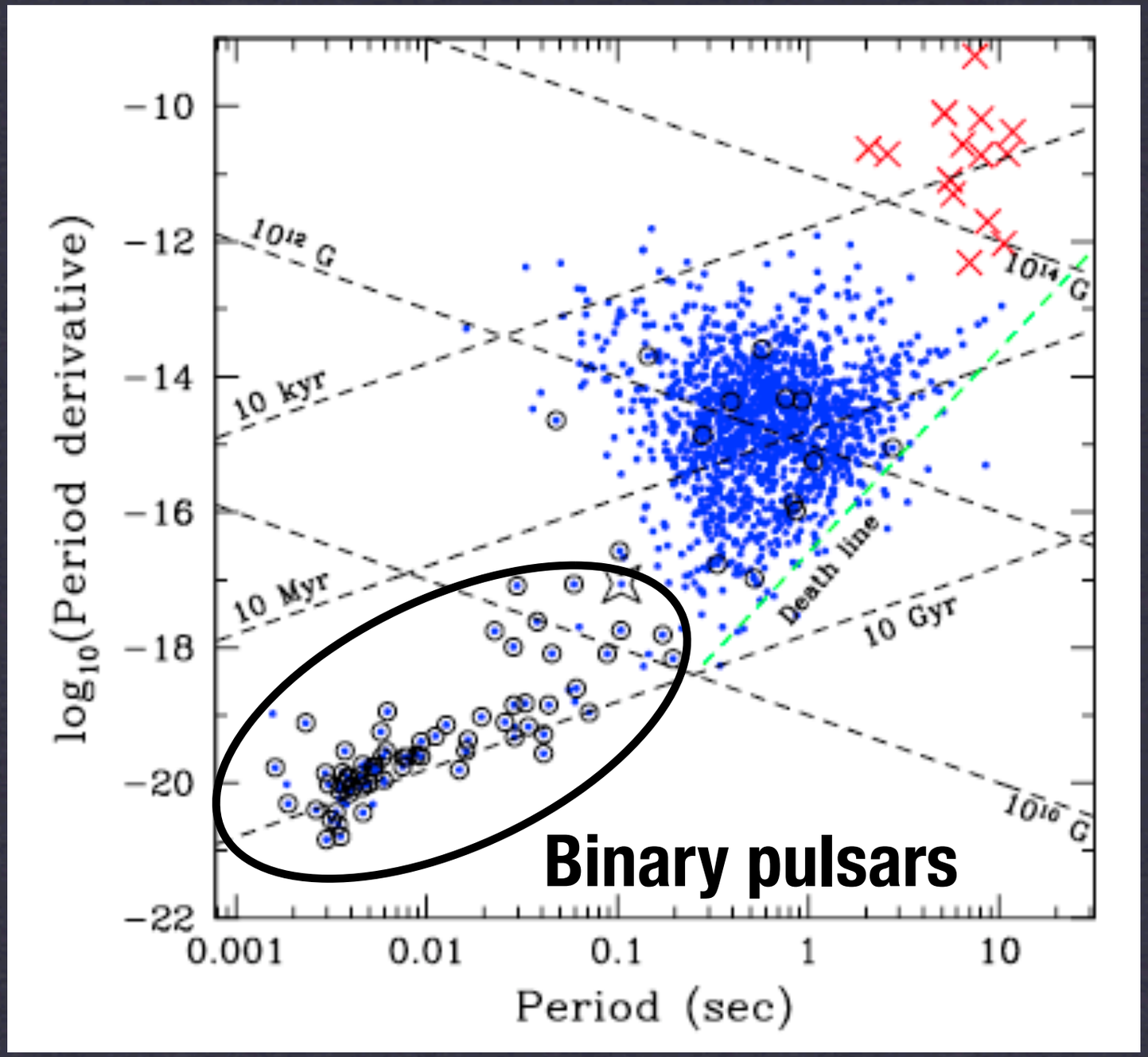

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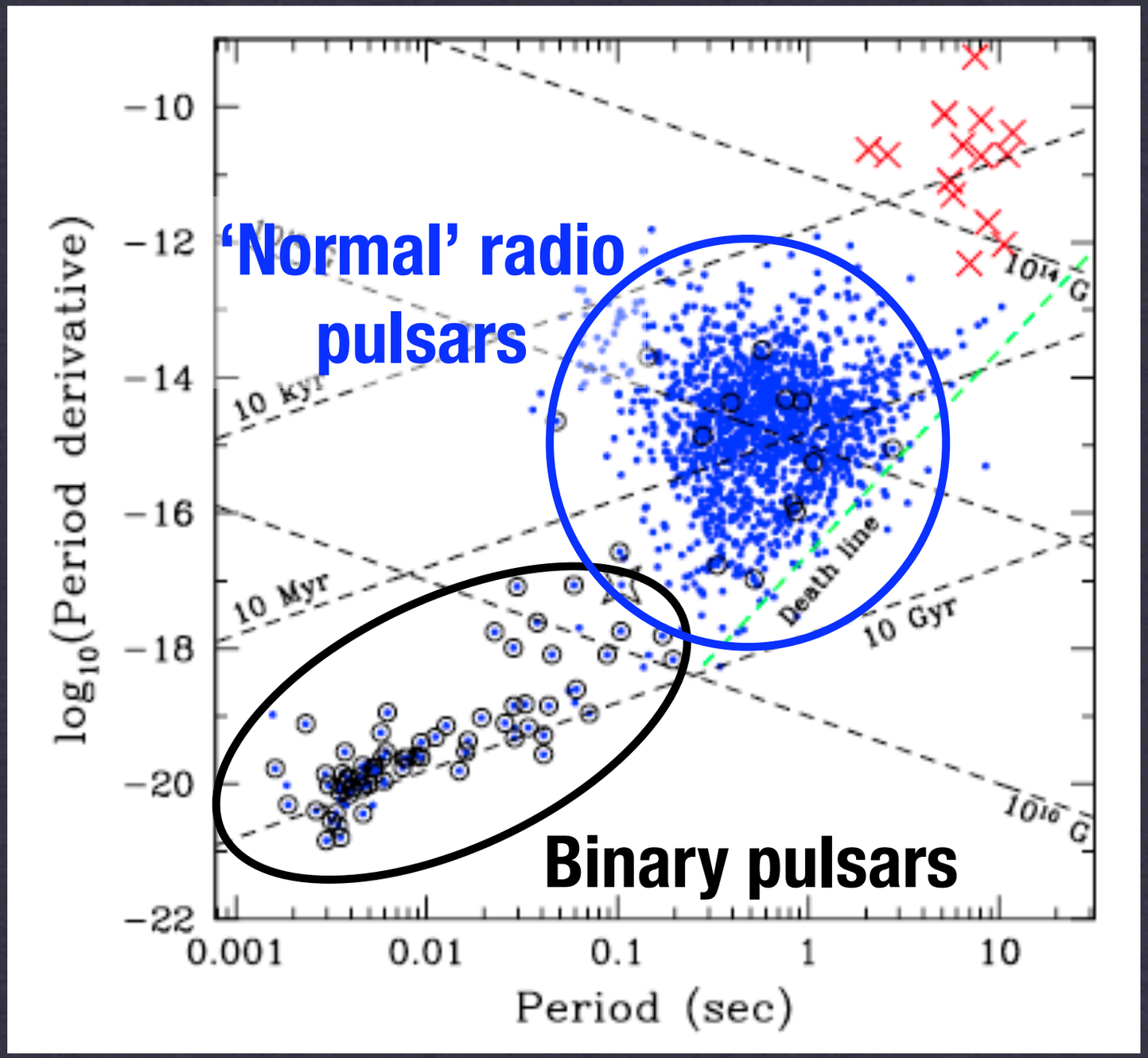

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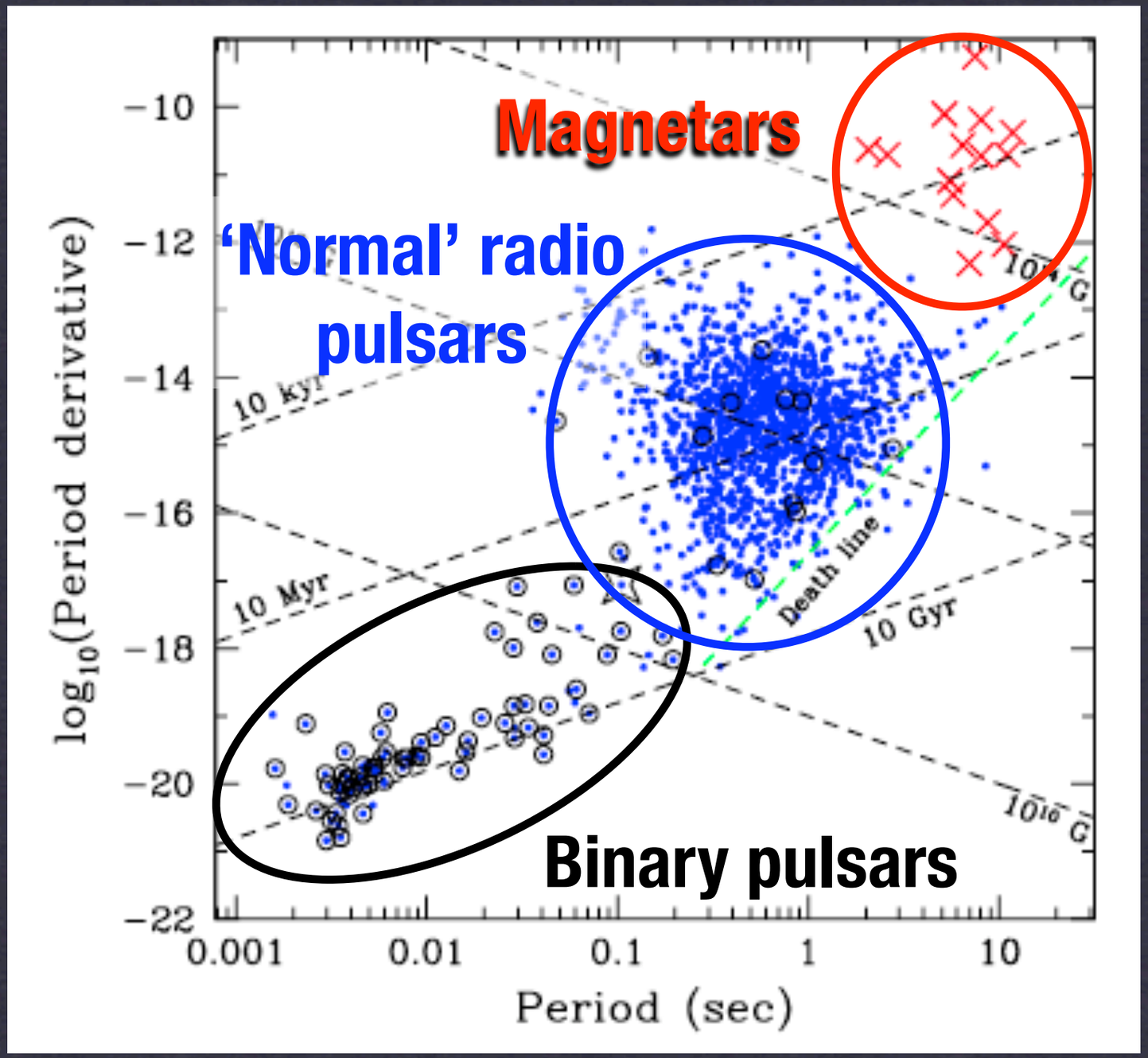

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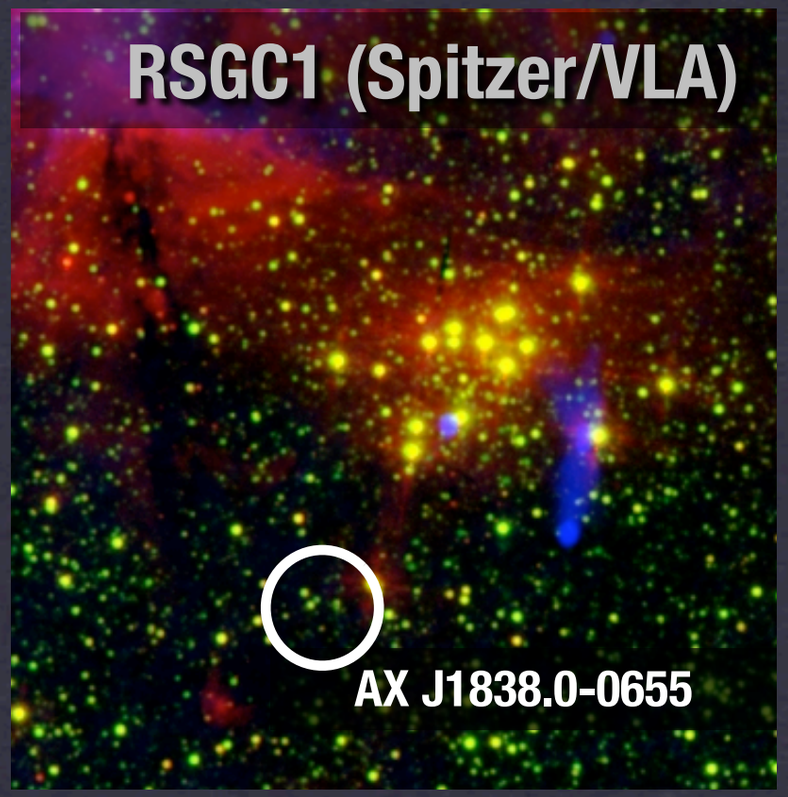
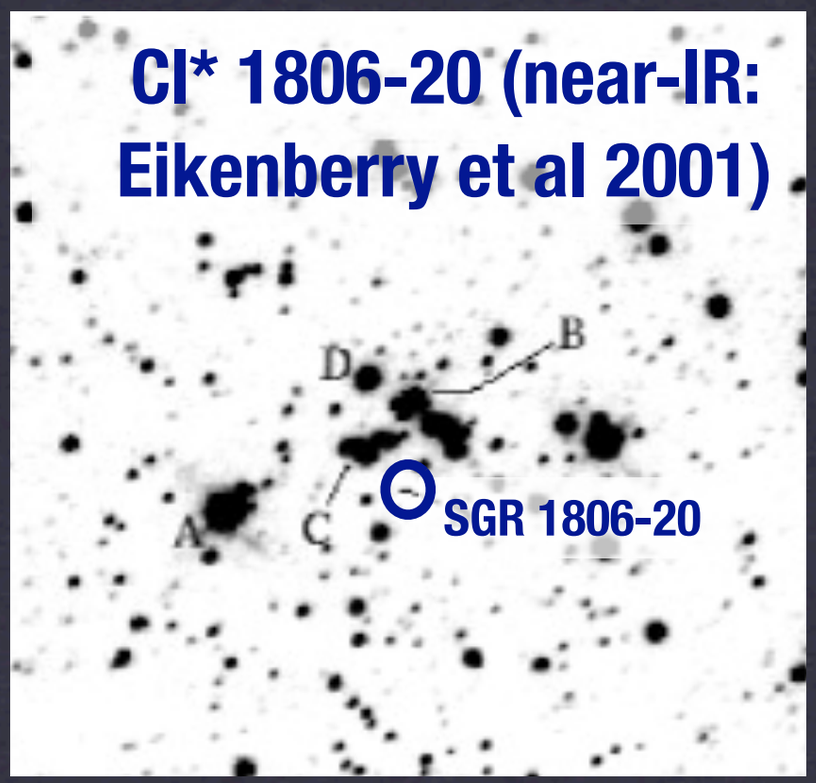
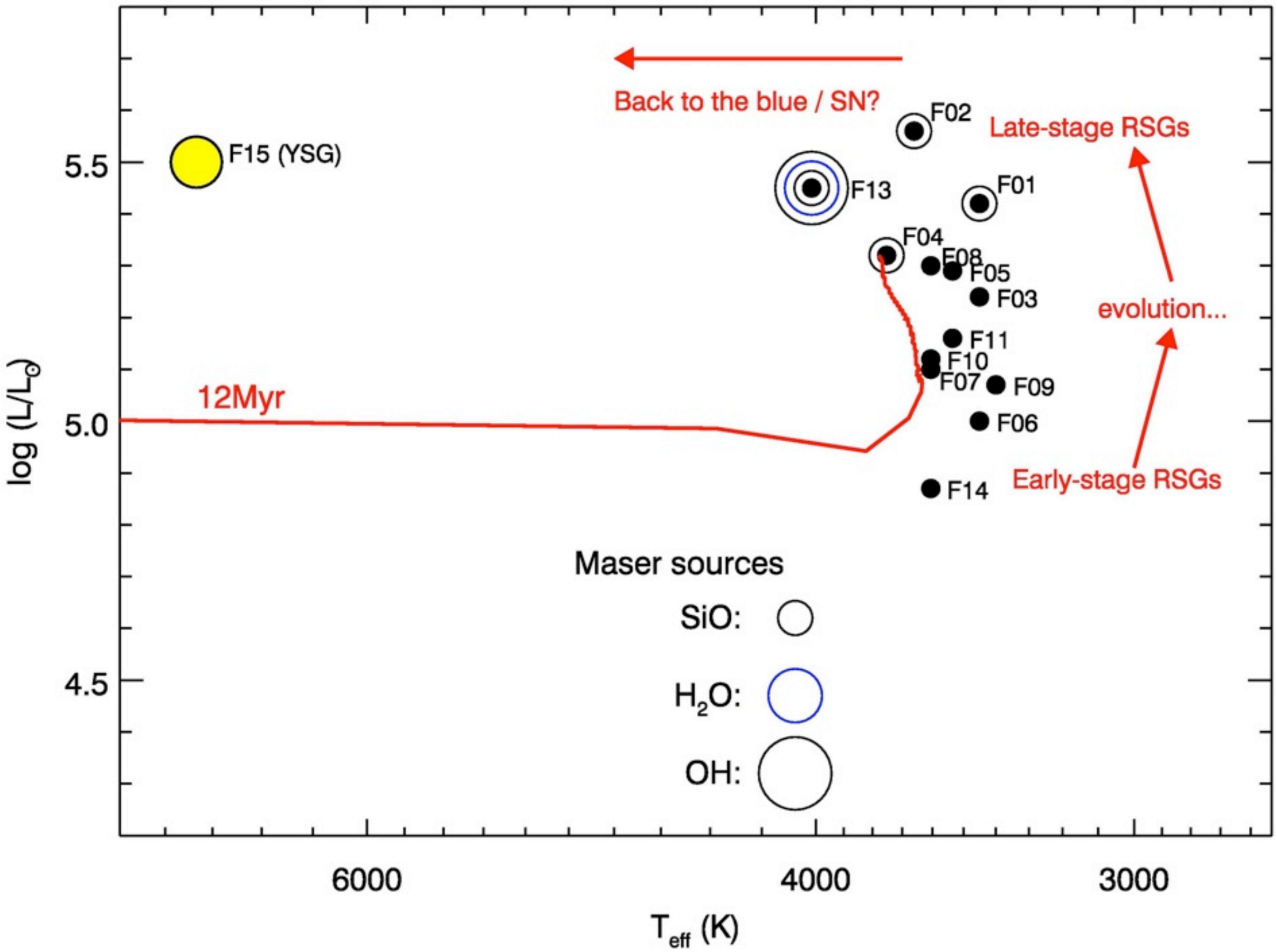
Observations of neutron stars in clusters...





Age of cluster ➜ mass of neutron star's progenitor



Observations of magnetars...

Object [+ cluster]	$M_{prog}/M_{\odot}$	Remnant	B ($x10^{14}$G)
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SGR 1900+14	???	Magnetar	2-8

Davies et al 2009, ApJ 707, 844 (+ refs therein)

➜ magnetic fields of neutron stars some function of initial stellar mass..?

Magnetars produced by SNe of very massive stars..?

Gaensler et al. (2005) :
(referencing Duncan & Thompson 1992; Heger et al. 2003)

$M > 35M_\odot$	O star - WR star - SN - magnetar
$35M_\odot > M > 8M_\odot$	O star - RSG (+) - SN - neutron star

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What about this bloke..?

The host cluster of the magnetar SGR 1900+14

2MASS H-band (1.6μm)

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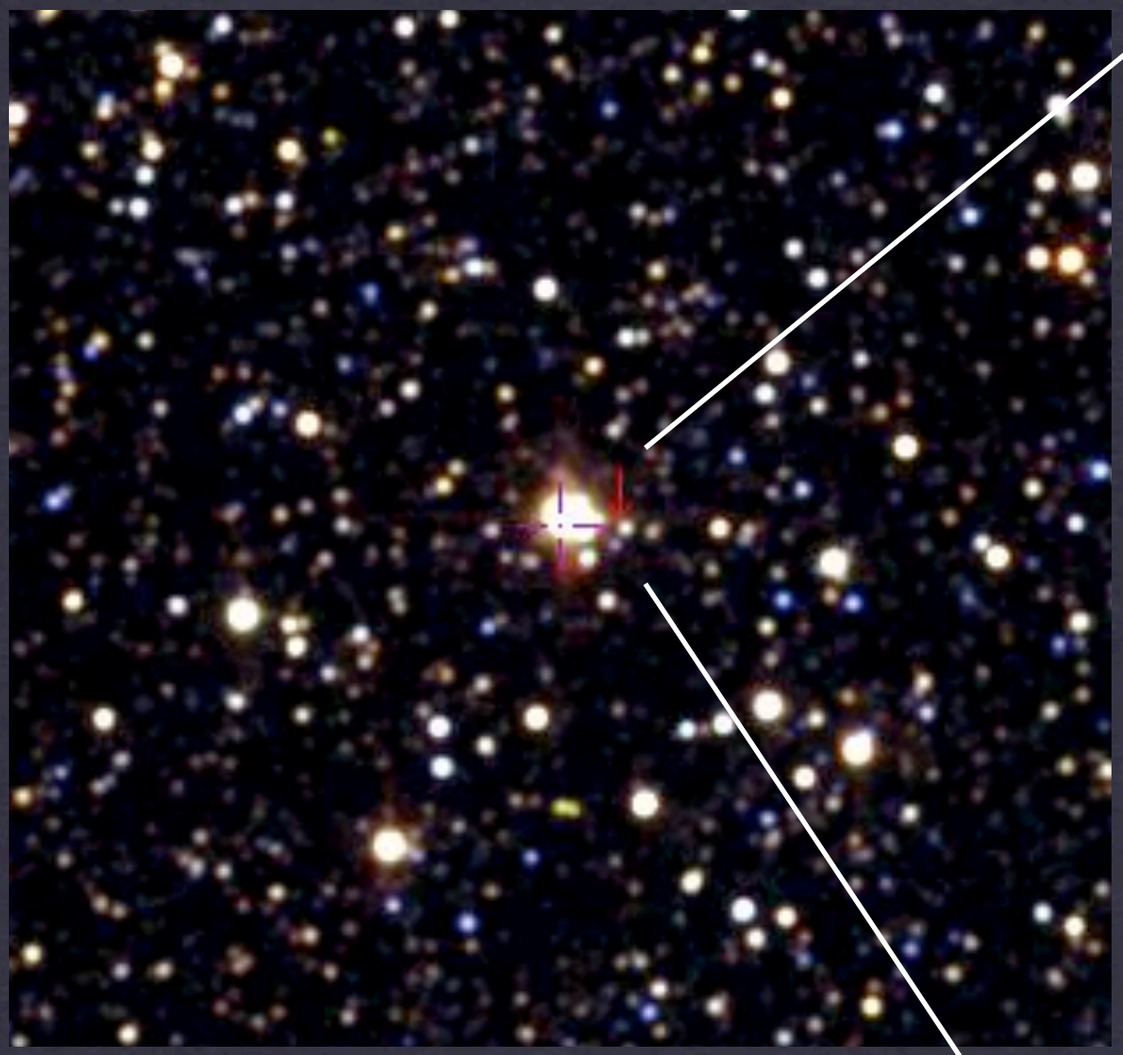

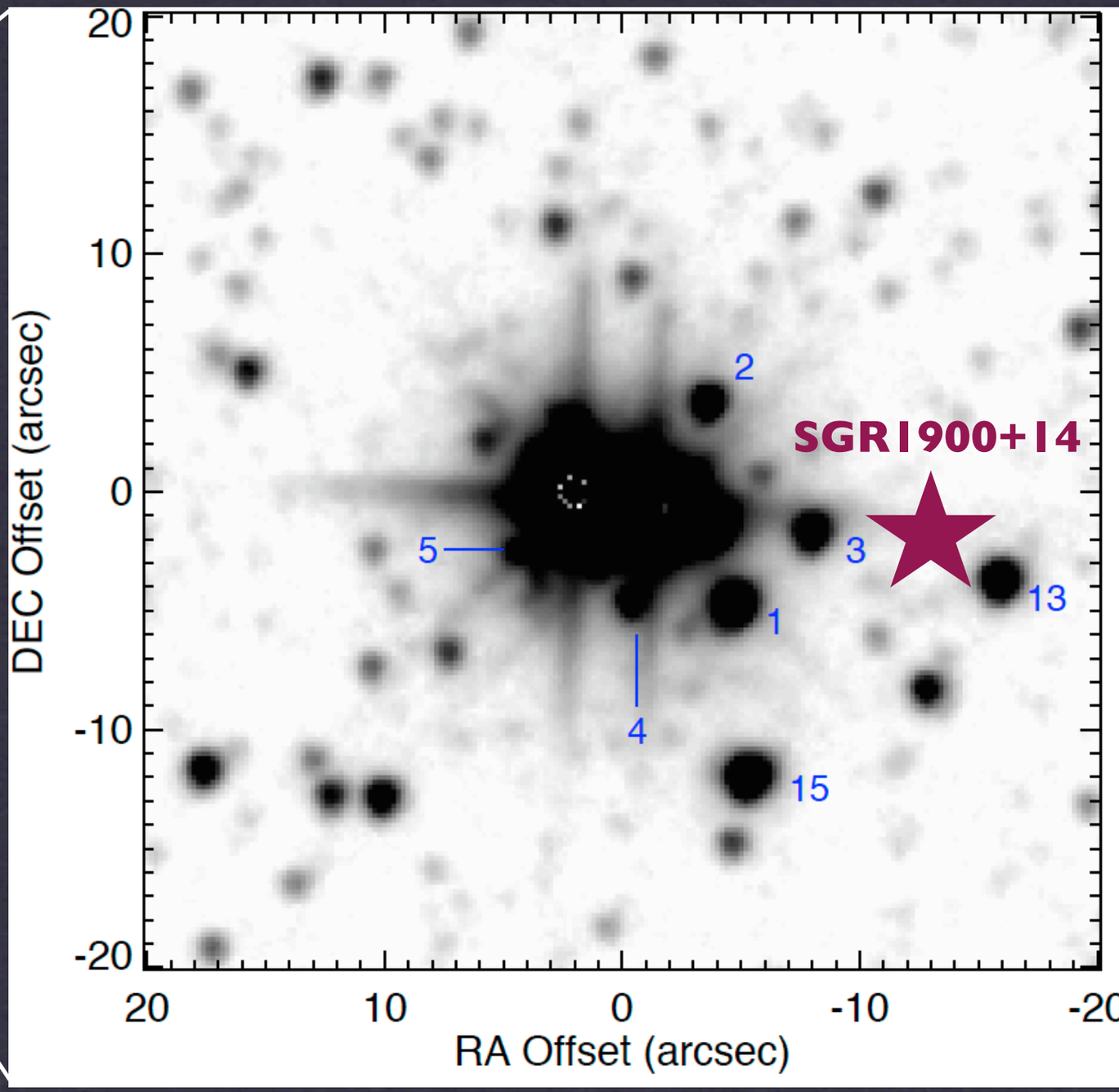

UKIDSS H-band

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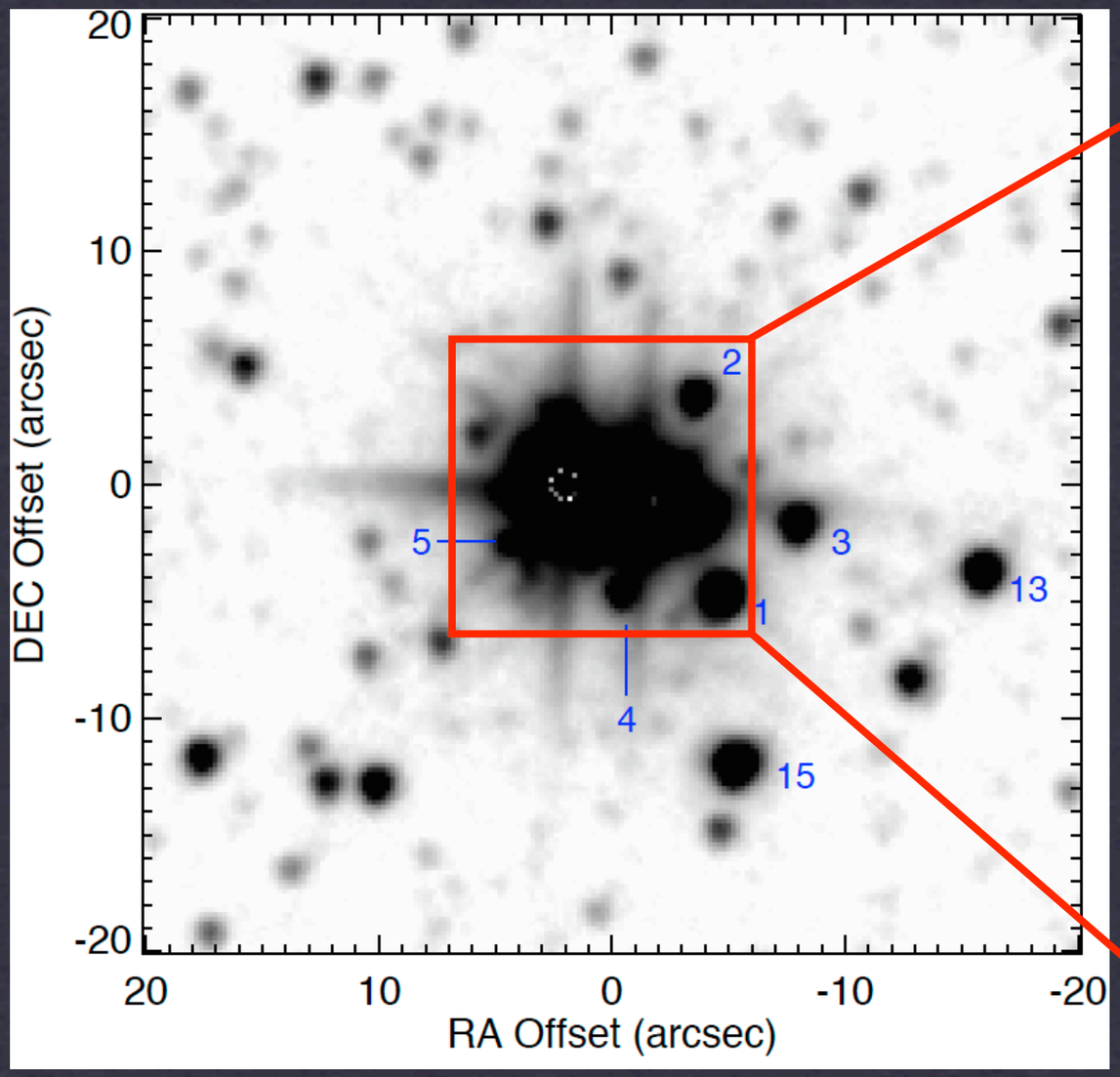

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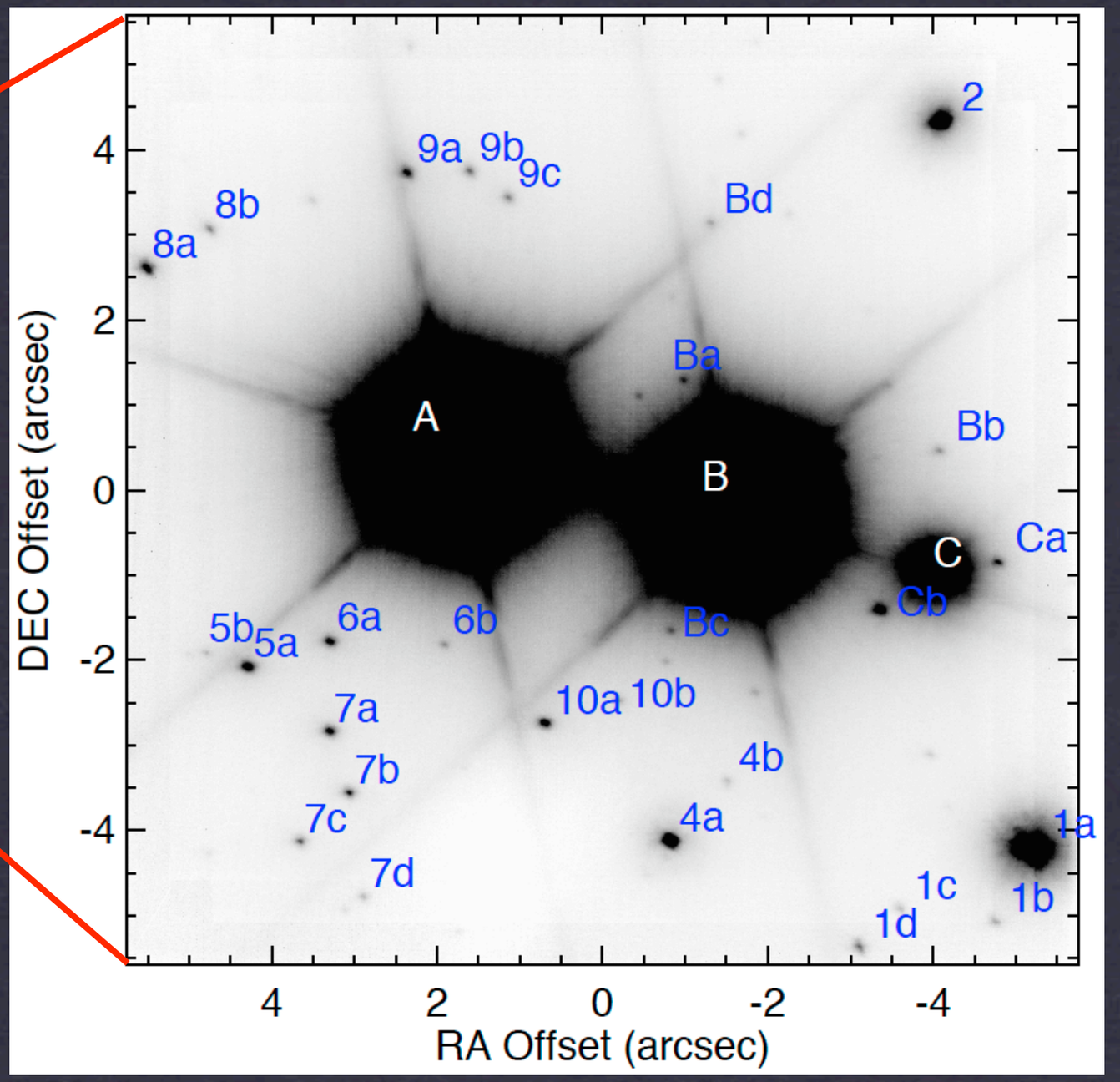

Keck/NIRC2 (AO-assisted) H-band

Davies et al 2009, ApJ 707, 844

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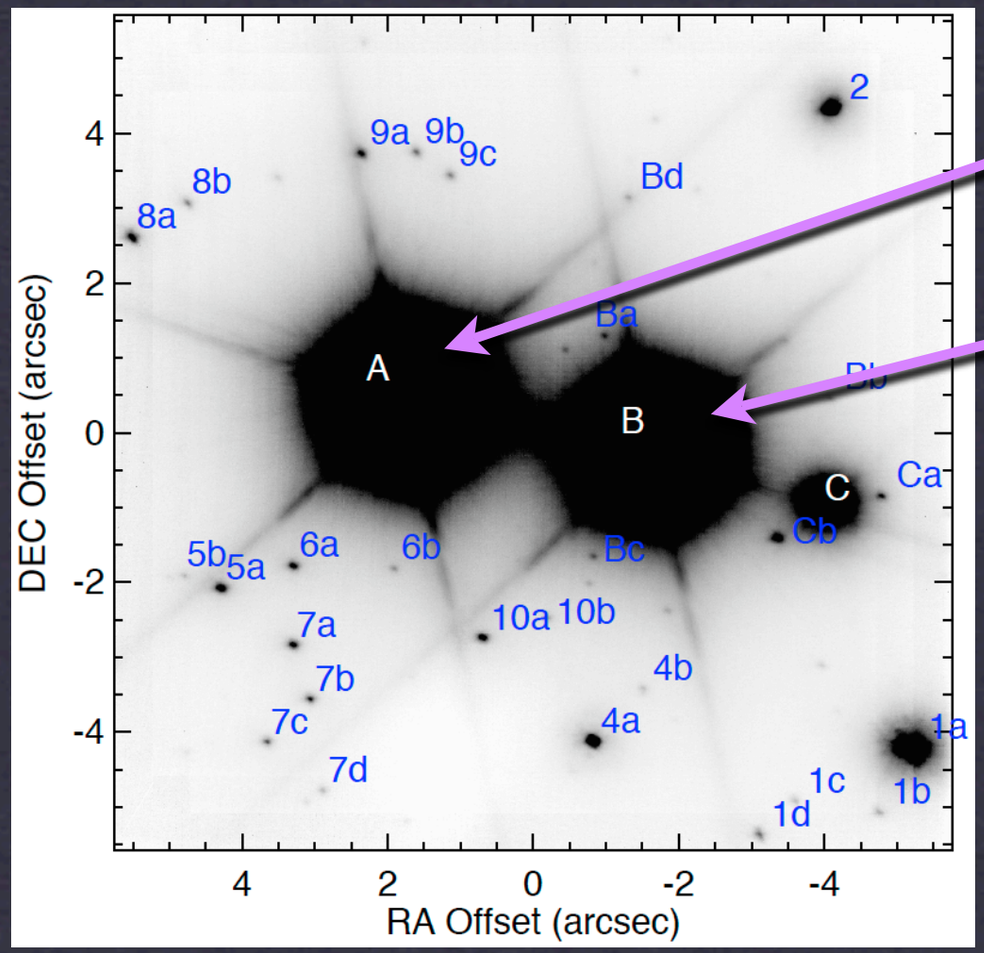

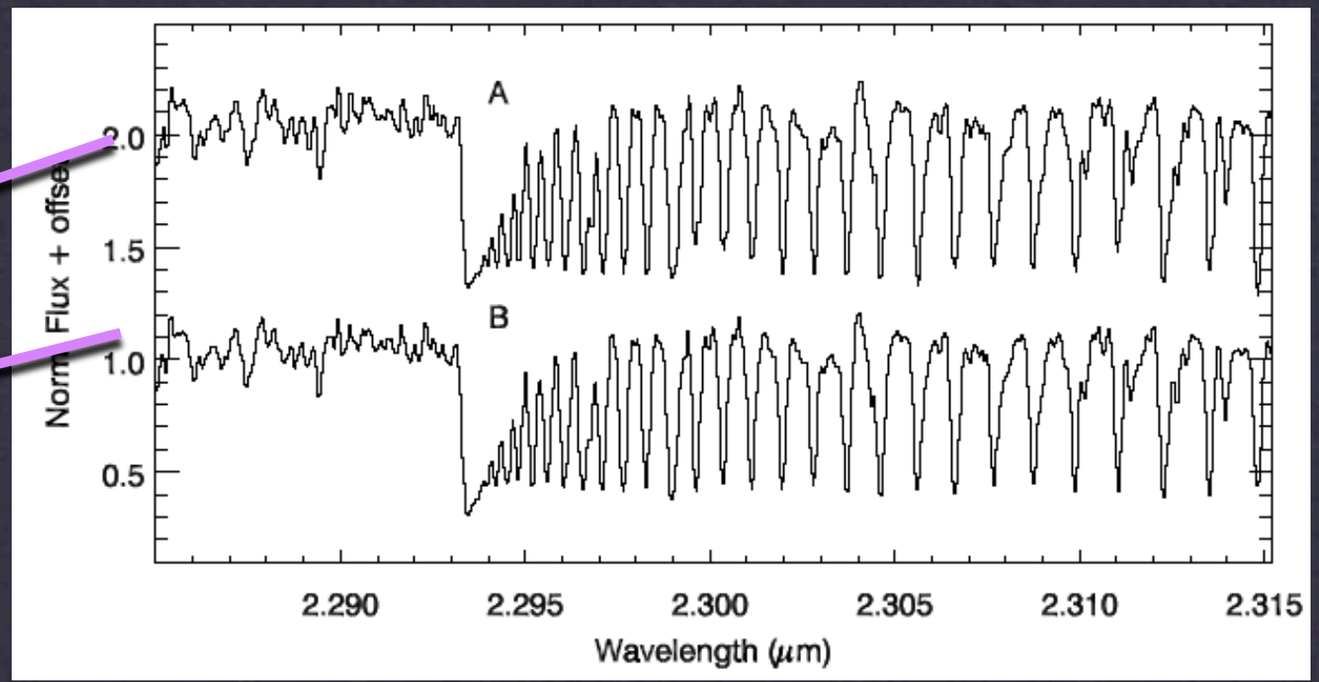

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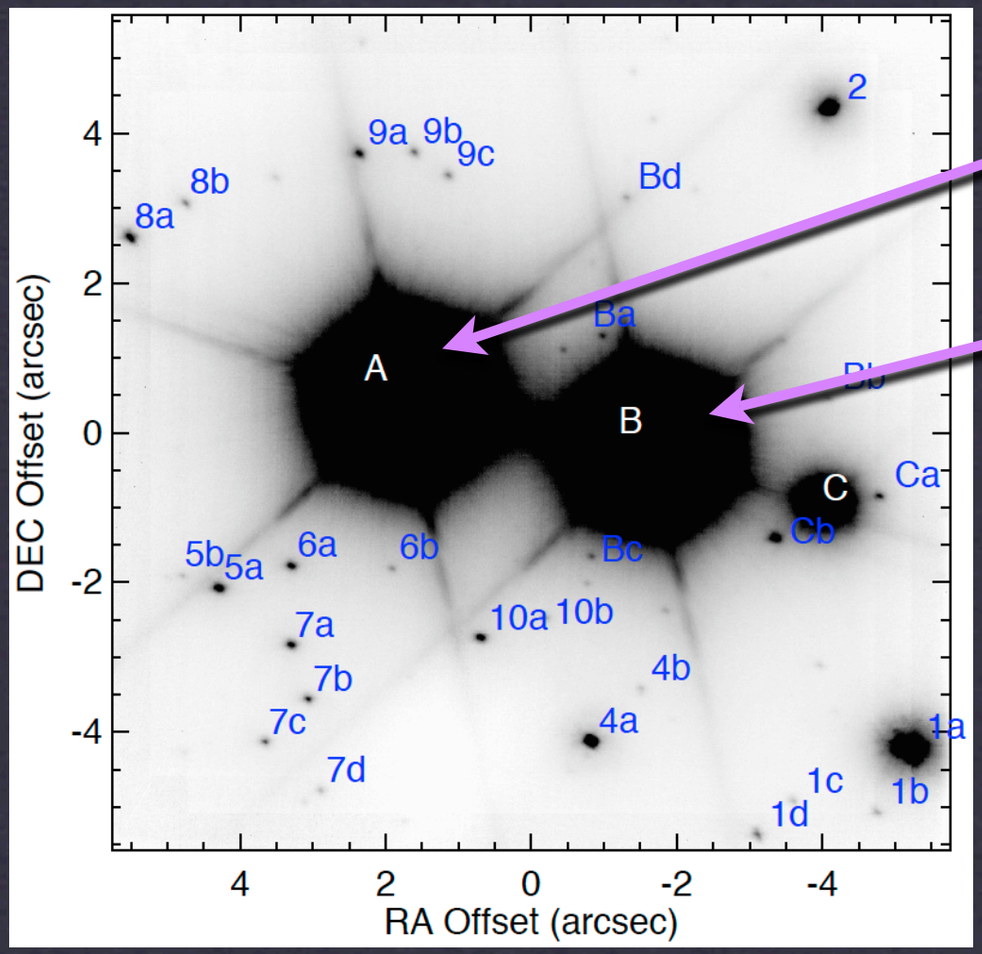

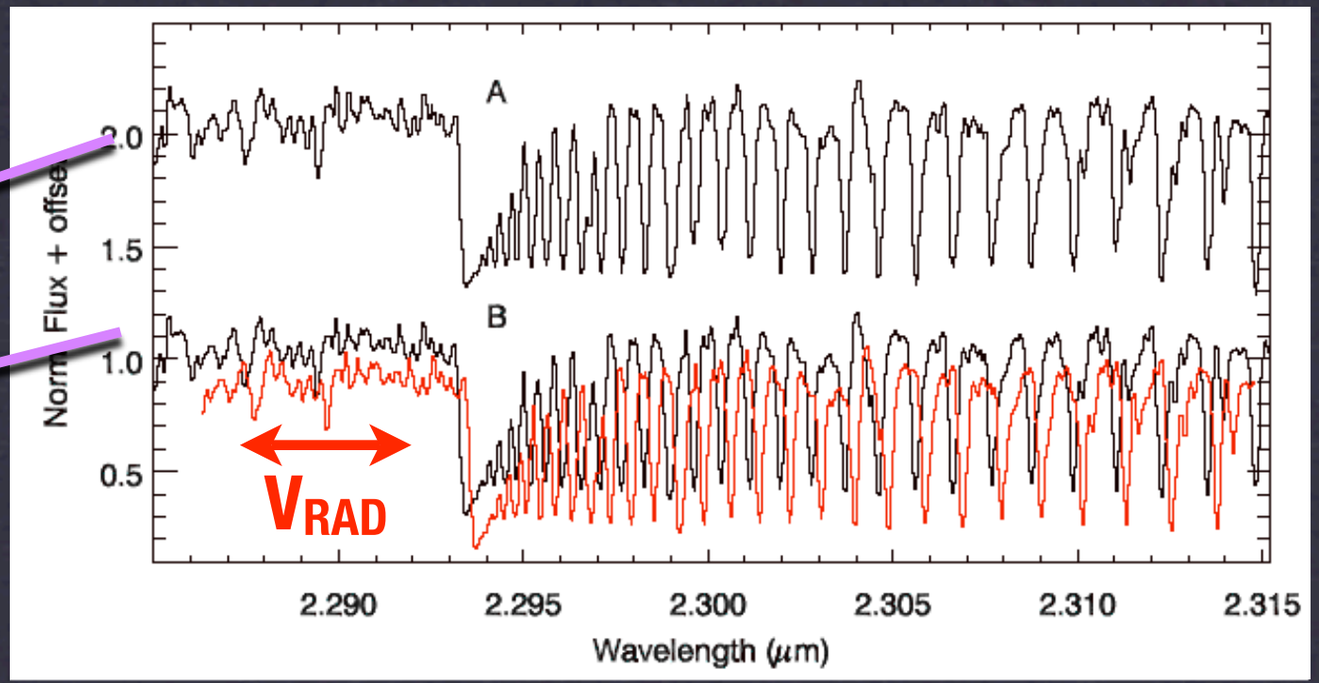

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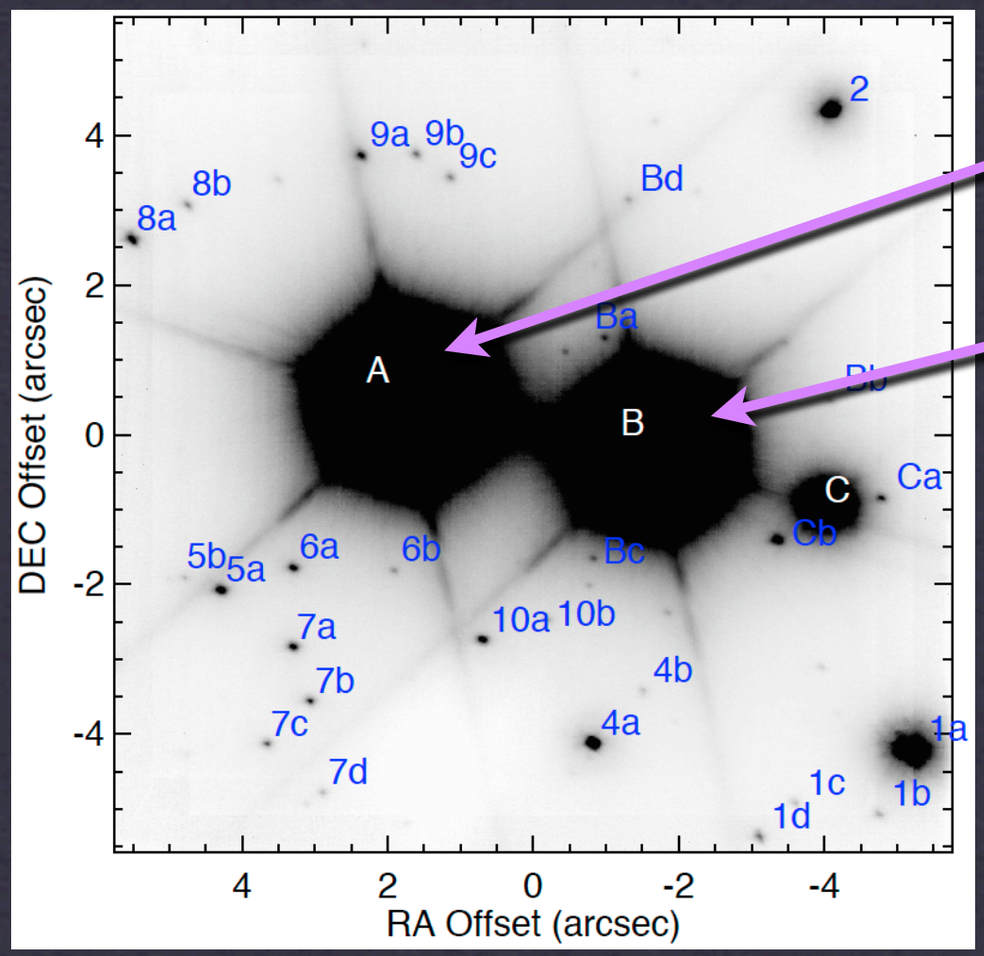

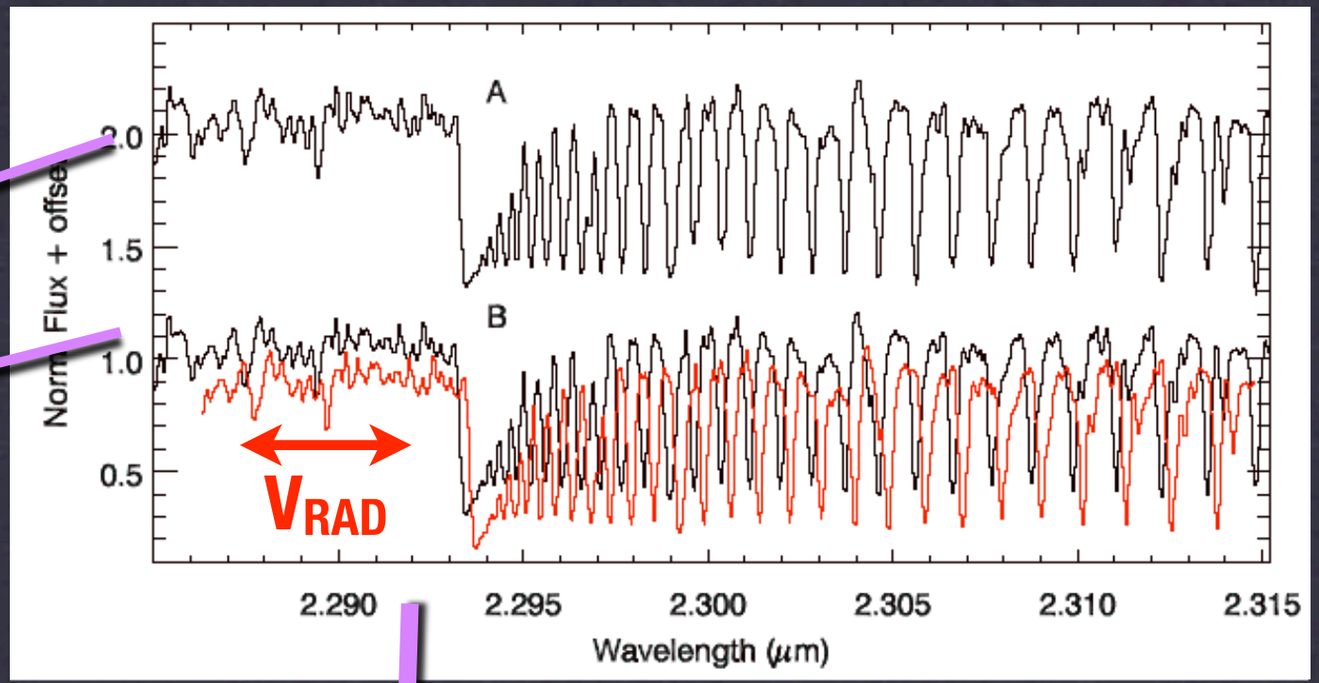

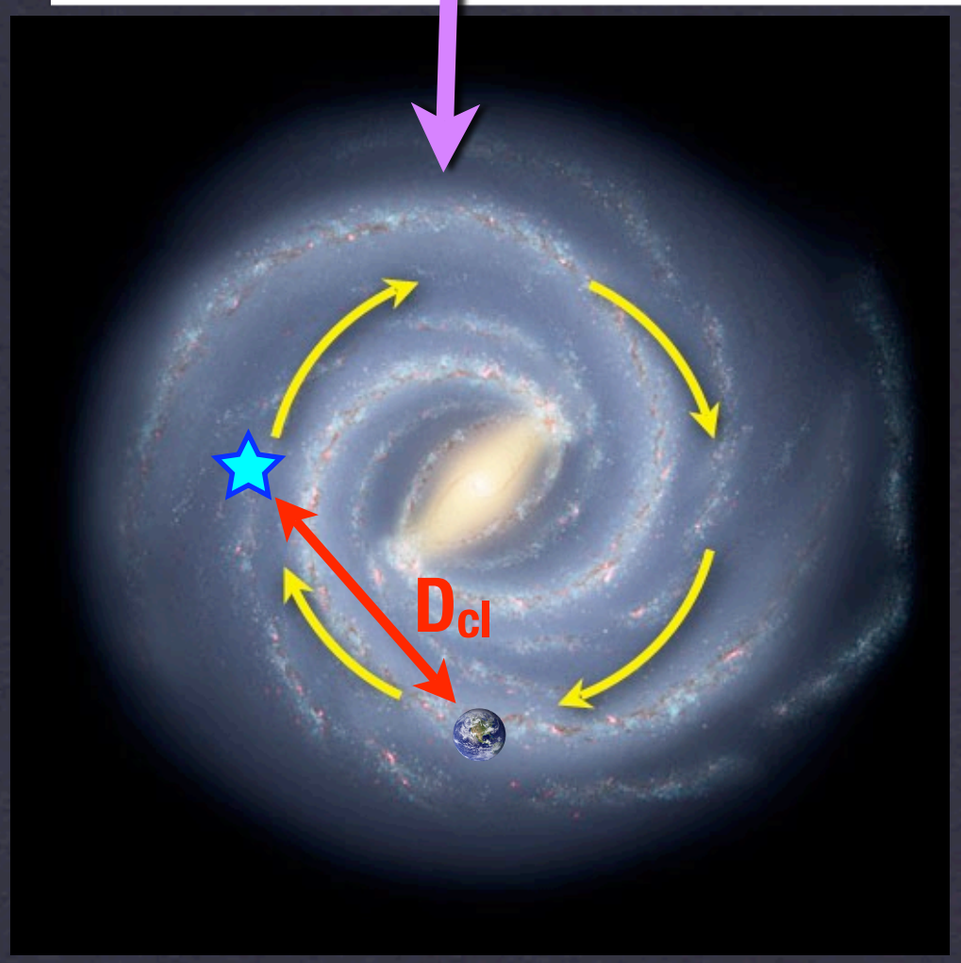

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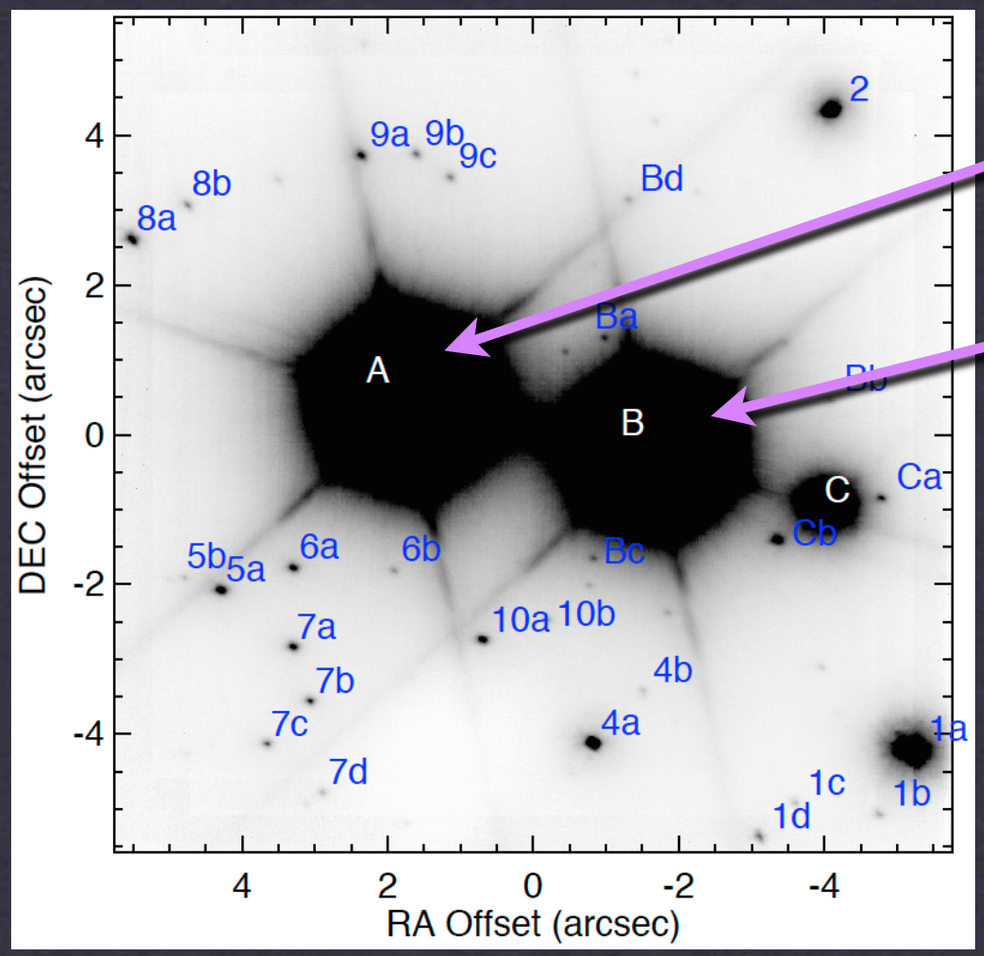

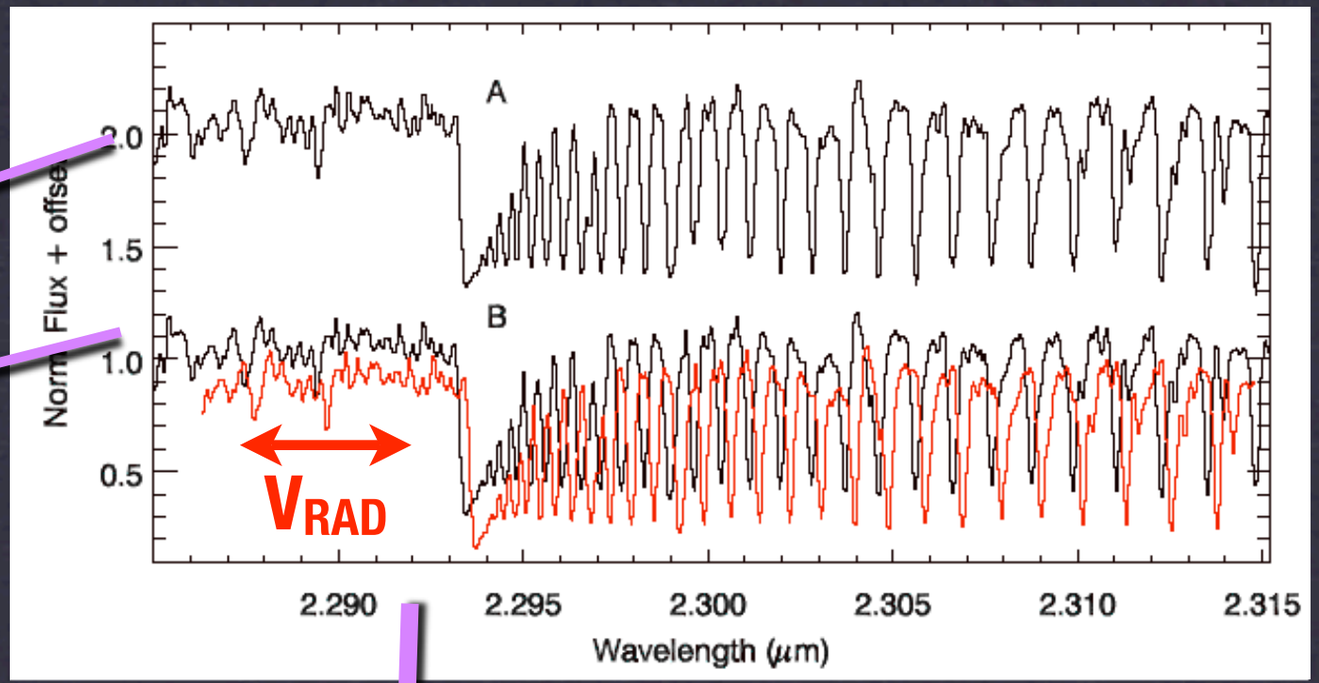

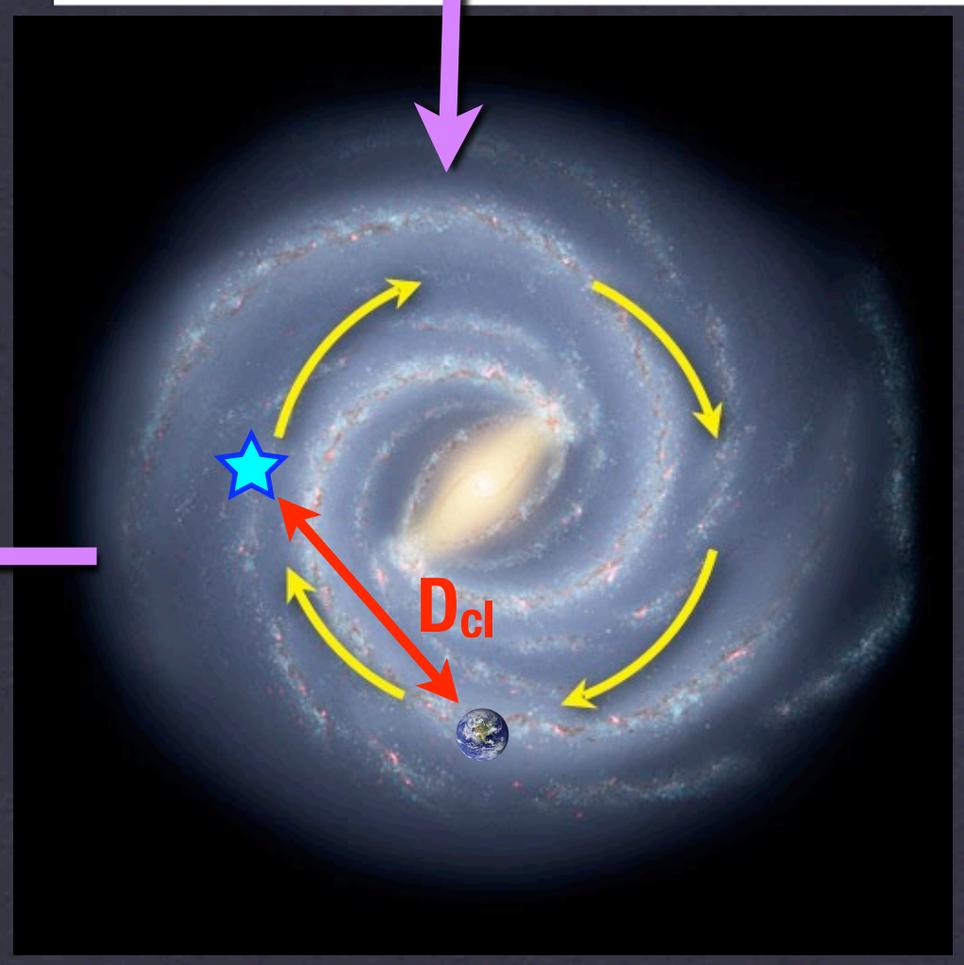

- RSG Luminosities
- Cluster age
- Mass of magnetar progenitor

Age of cluster ➜ mass of neutron star's progenitor

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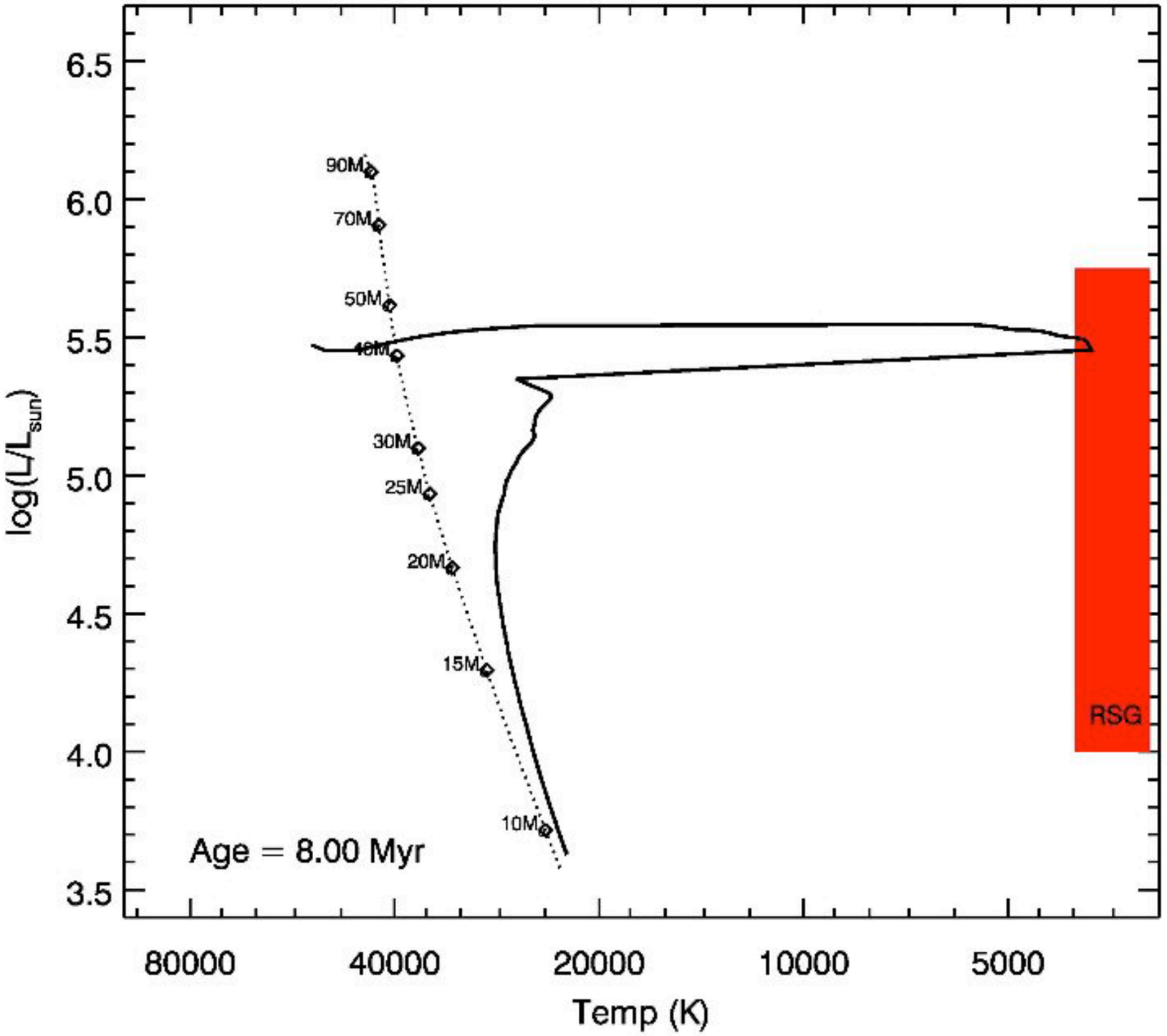

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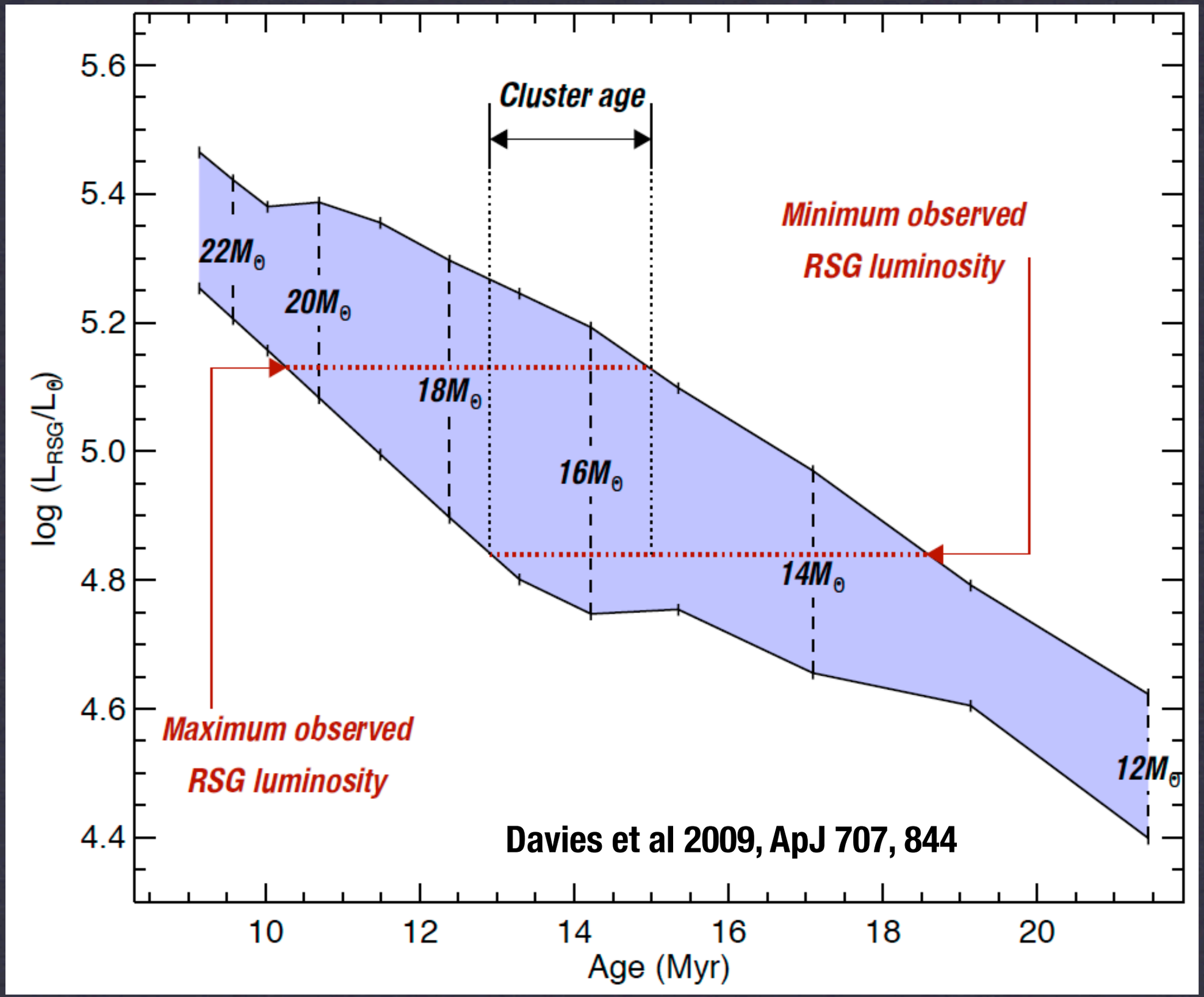

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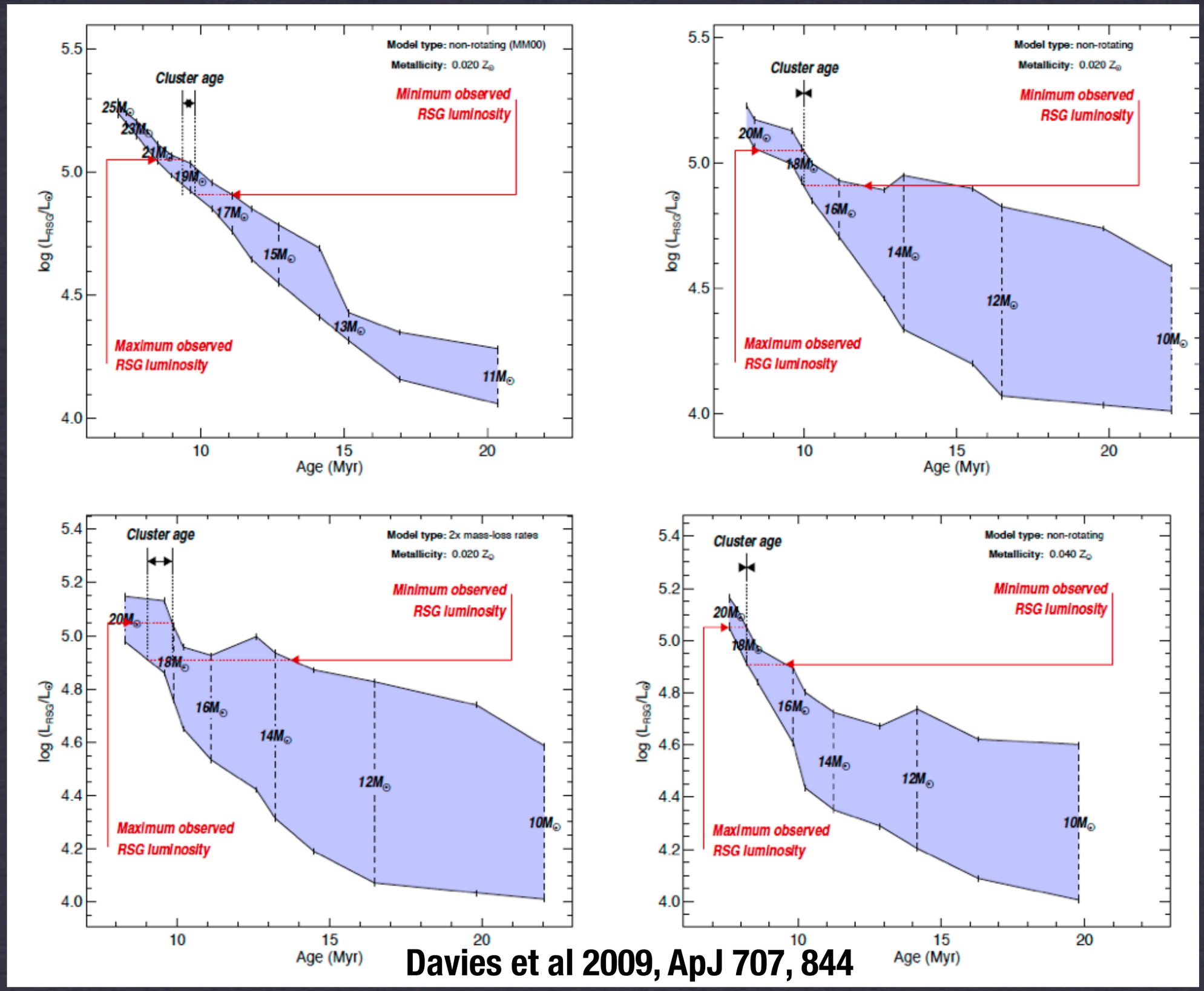

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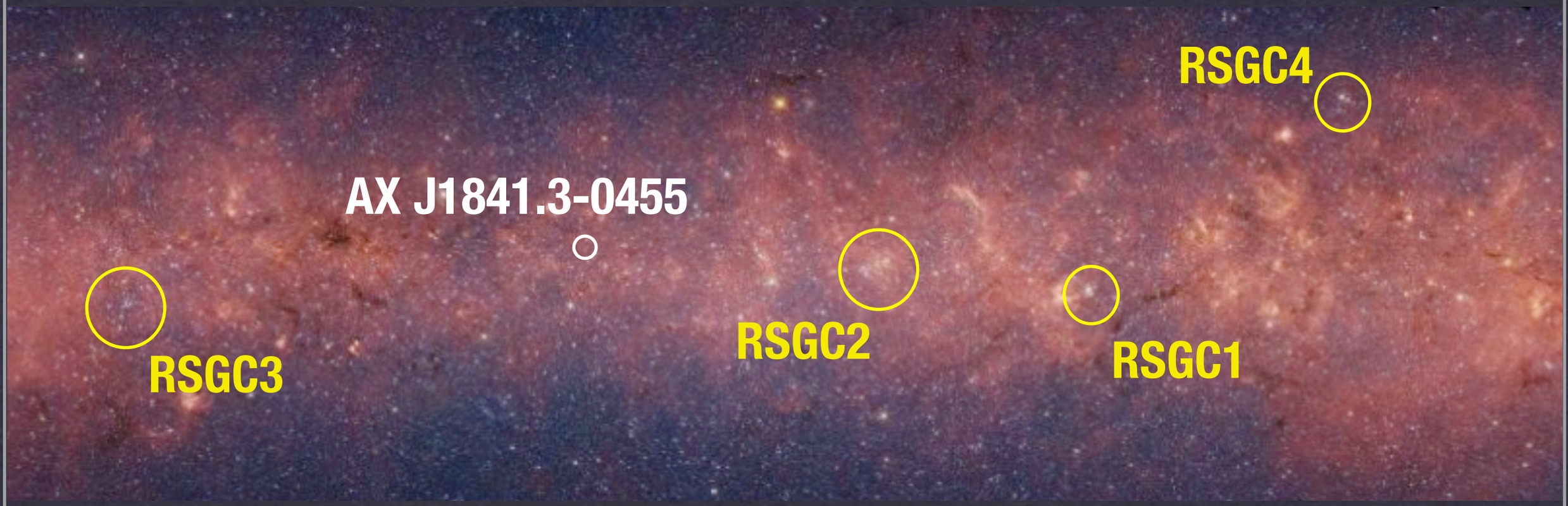
Davies et al 2009, ApJ 707, 844 (+ refs therein)

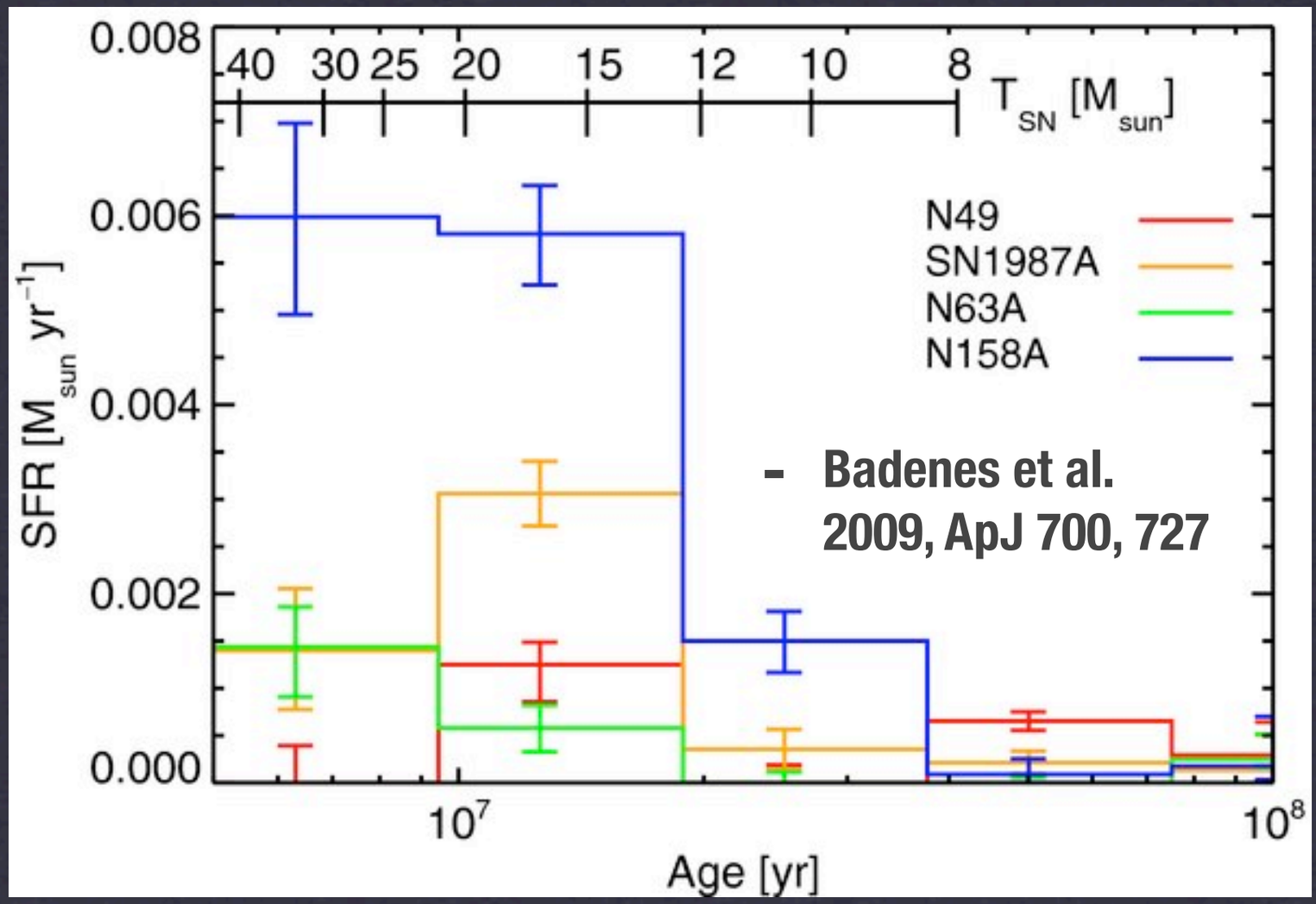
Other evidence for lower mass magnetar progenitors I: The G25 starburst region



- Region-wide starburst event ~15Myr ago.
- No evidence for any star forming activity within last ~12Myr
- If magnetar is associated, implies initial mass of $<18M_{\odot}$

- Figer et al. 2006, ApJ 643, 1166
- Davies et al. 2007, ApJ 671, 781
- Davies et al. 2008, ApJ 676, 1016
- Clark et al. 2009, A&A 504, 429
- Negueruela et al. 2010 A&A 513, 74

Other evidence for lower mass magnetar progenitors II: The N49 region in the LMC (near SGR 0526-66).



- Badenes et al. 2009, ApJ 700, 727

- Little evidence for star-forming activity within last ~10Myr around N49.
- If magnetar is associated, implies initial mass of progenitor <20$M_\odot$

The Progenitors of Neutron Stars and Magnetars - Conclusions:

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Neutron star progenitors

- Can use stellar clusters to estimate the masses of NS progenitors.
- NS B-field probably depends on more than just mass of the stellar progenitor.
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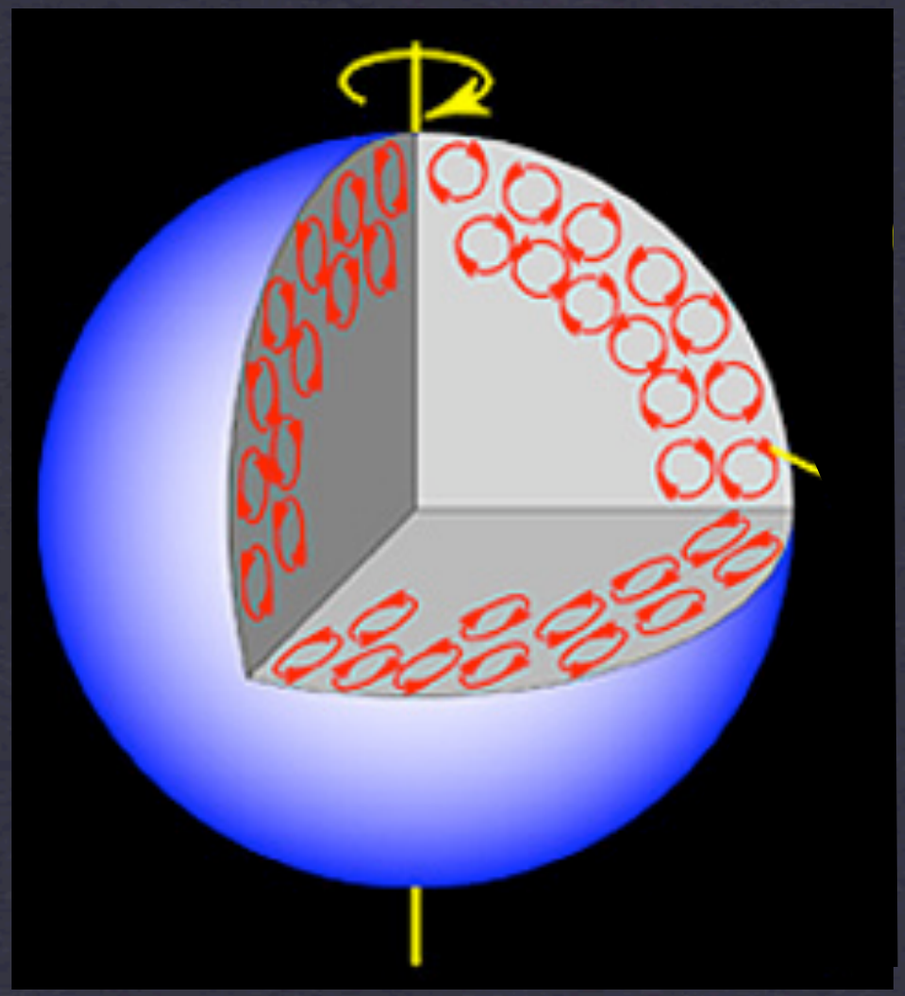
Future:

- All-plane survey for magnetars. How common are they? Birthrate similar to that of regular NSs?
- Did SN1987A leave a magnetar?

Fin.

Origin of large magnetic fields..?



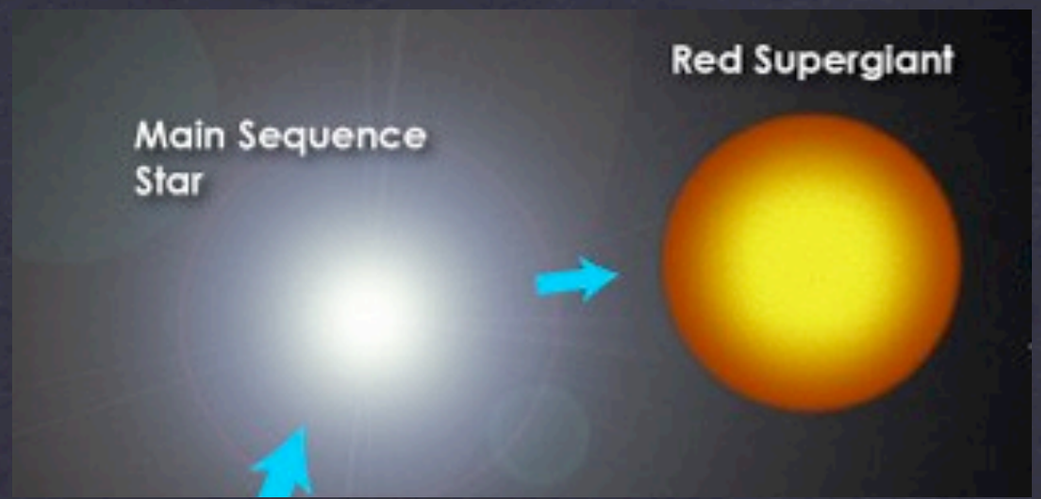
- Hot, newborn (<10sec) neutron star churns & mixes.
- Internal convection carries away heat.
- If birth period shorter than convective timescale (~1ms), super-efficient dynamo operates, boosting magnetic field.

(Duncan & Thompson 1992)

Origin of large magnetic fields..?

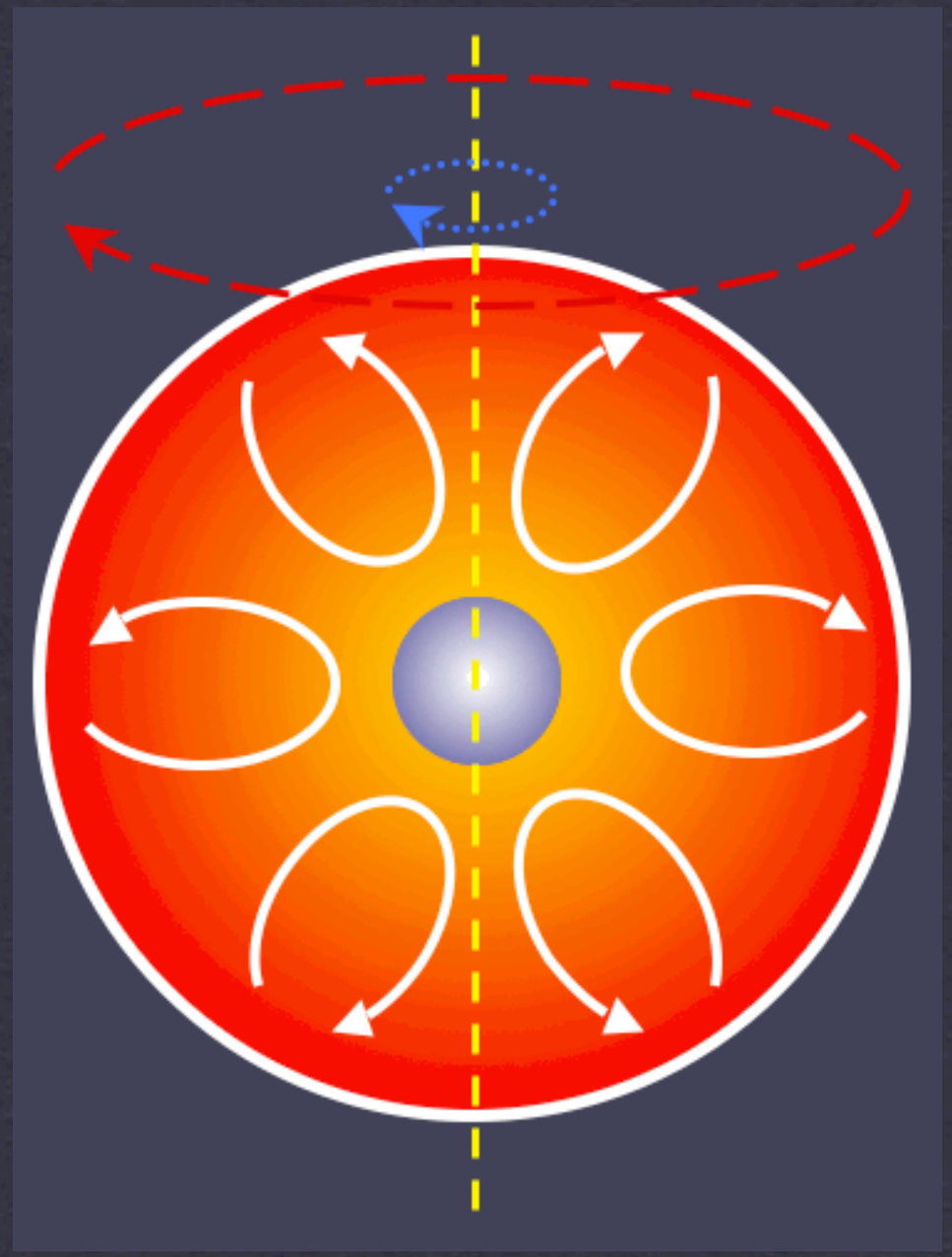
Requires neutron star to be born with a fast rotation period!

Magnetars produced by SNe of very massive stars..?



When star evolves to the RSG phase...

- Core contracts & **spins up.**
- Envelope expands & **spins down.**
- BUT: envelope and core magnetically coupled by convection zones...
- Core rotation is BRAKED.



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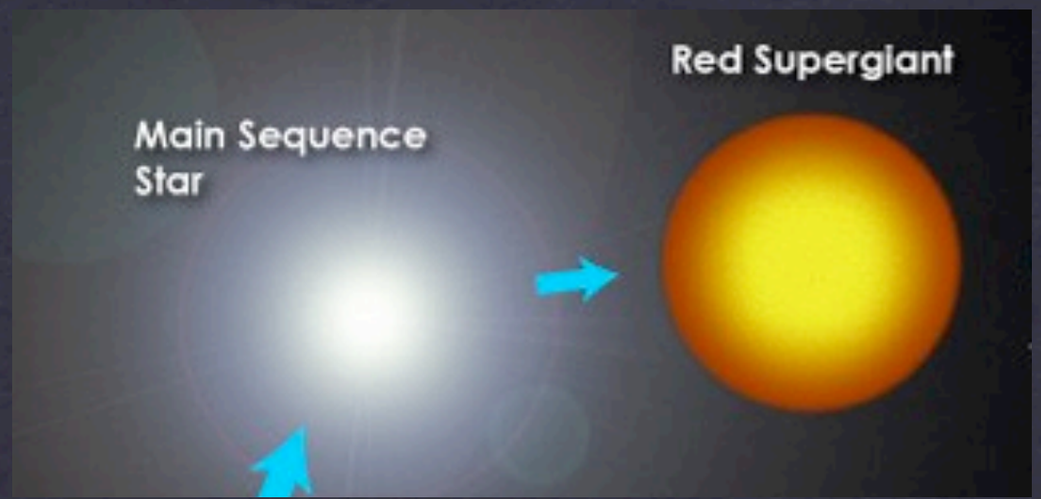
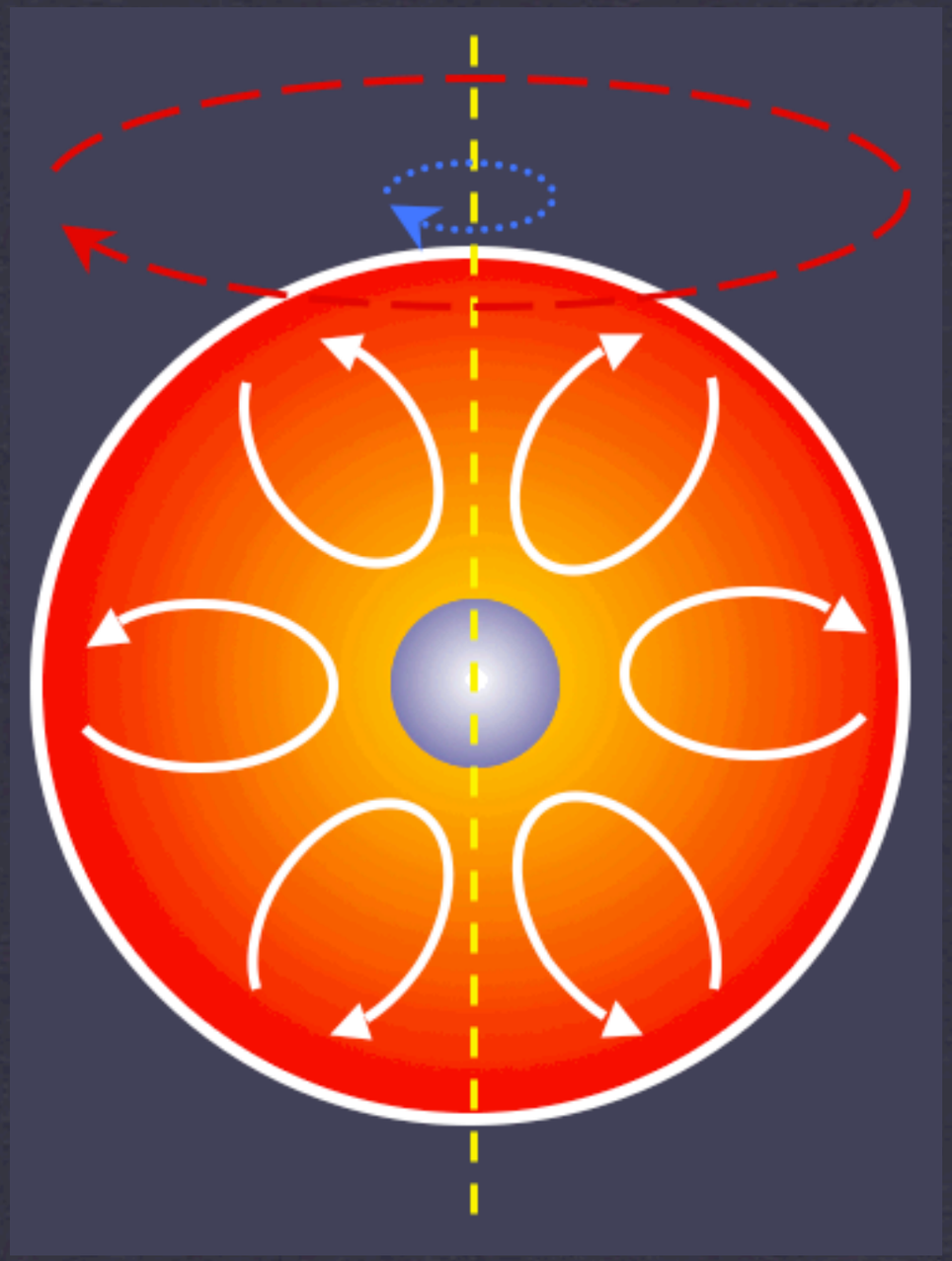


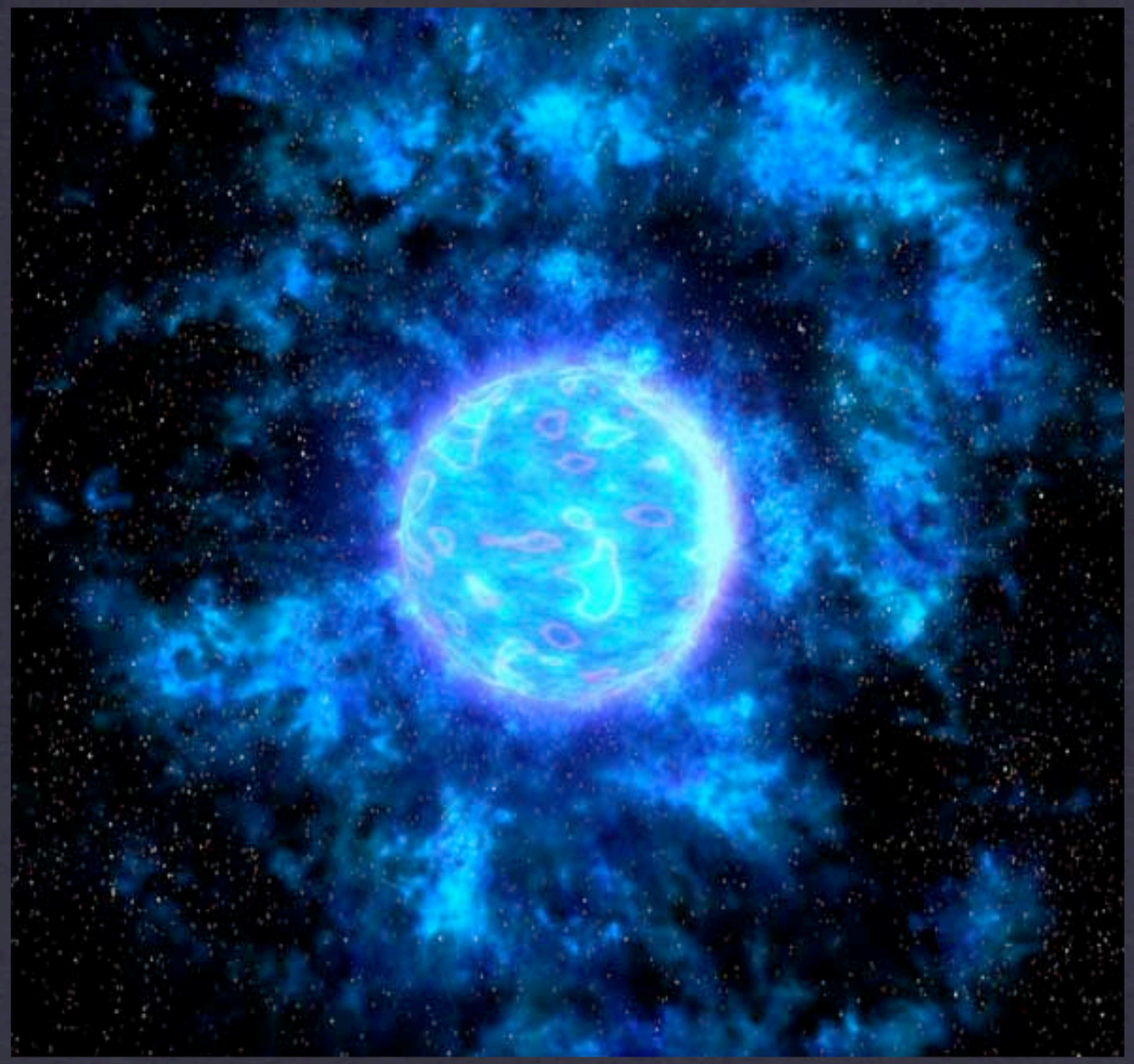
When star evolves to the RSG phase...

- Results in a highly magnetized, slowly rotating neutron star



Magnetars produced by SNe of very massive stars..?

HOWEVER: very massive stars AVOID the RSG phase, and (possibly) associated core spin-down.



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- ... but is favoured explanation for SN1987A.
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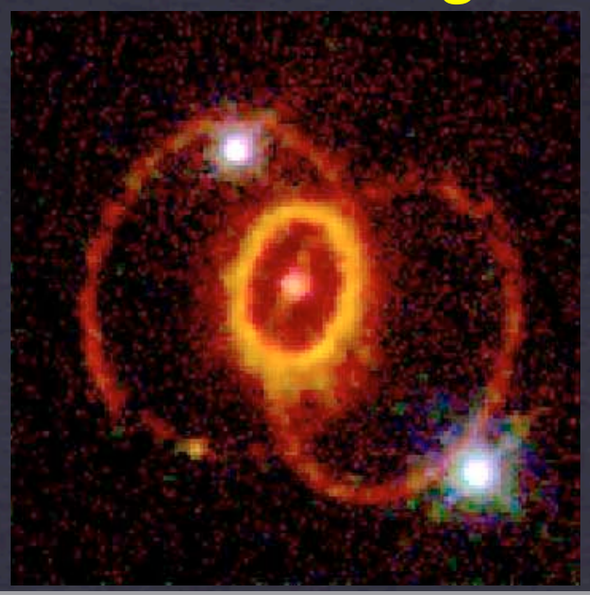

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Stellar mass ↔ post-SN remnant