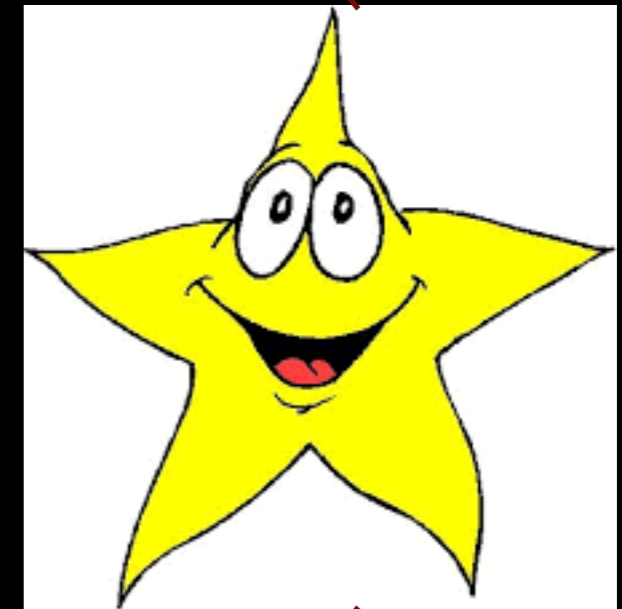


Formation of merging black holes through isolated binary evolution via the common envelope phase

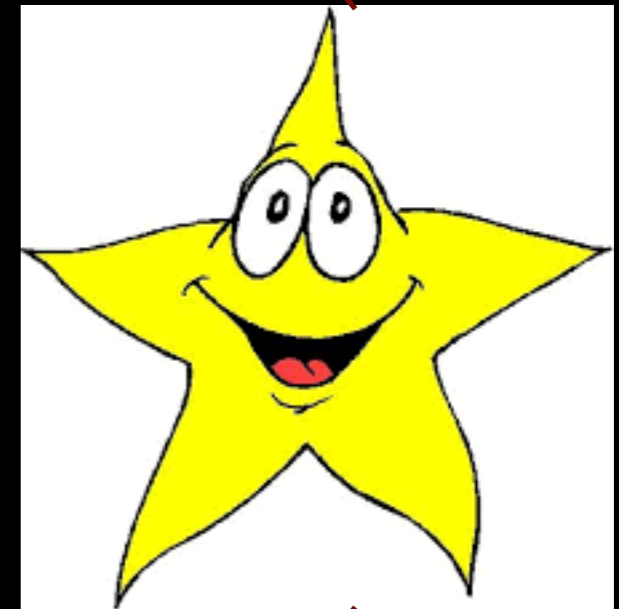


Ilya Mandel

It's easy, right?



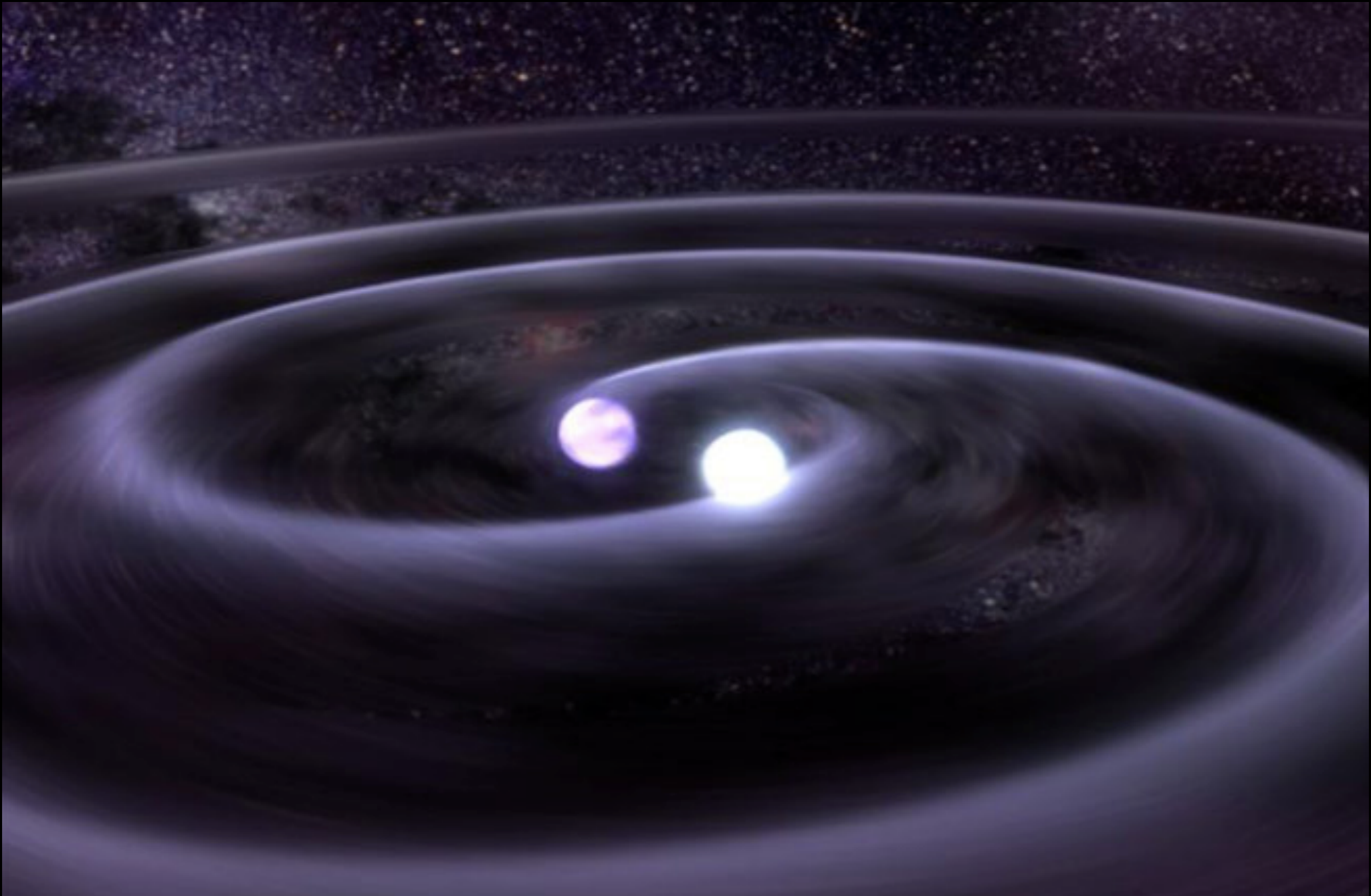
It's easy, right?



It's easy, right?



It's easy, right?

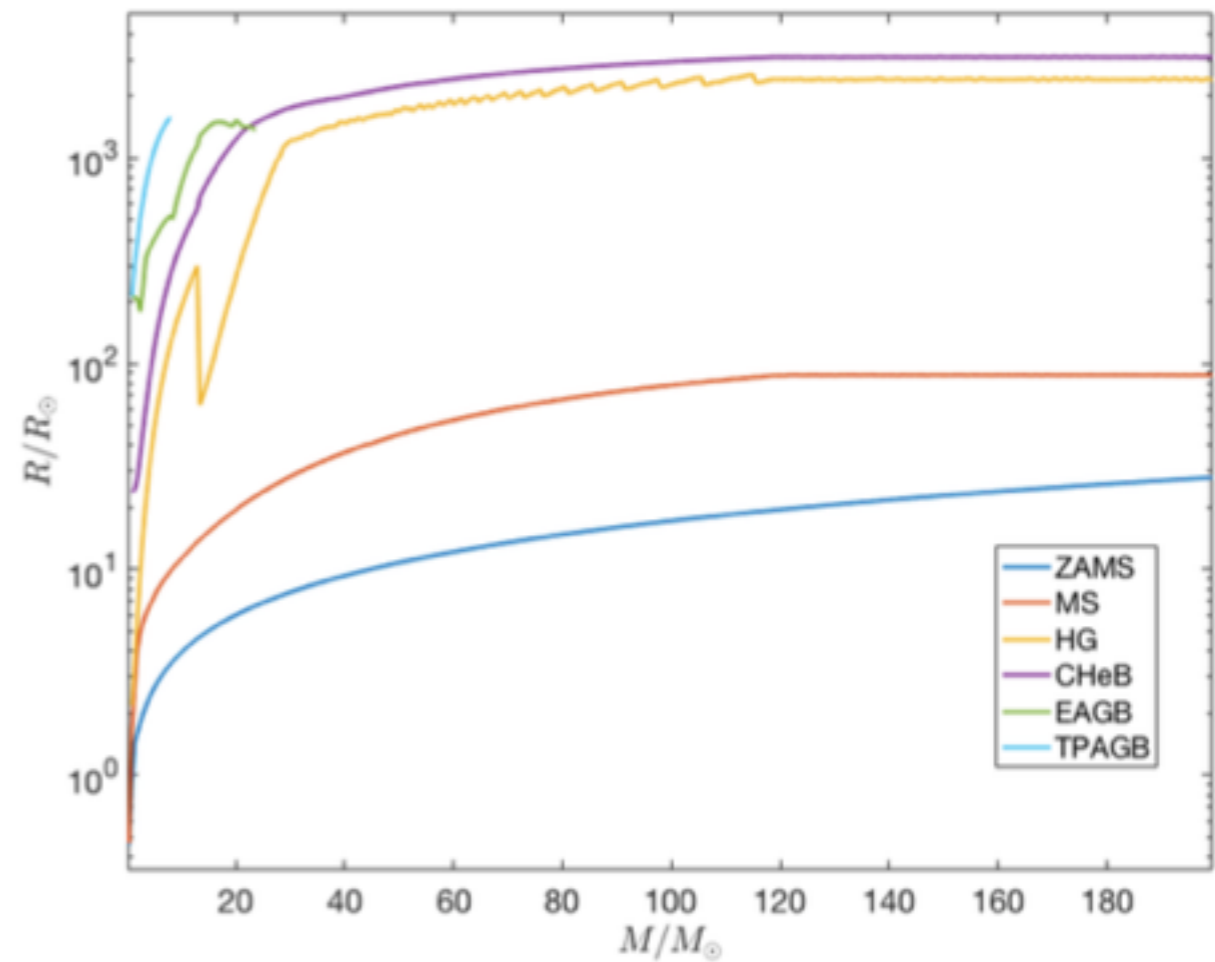
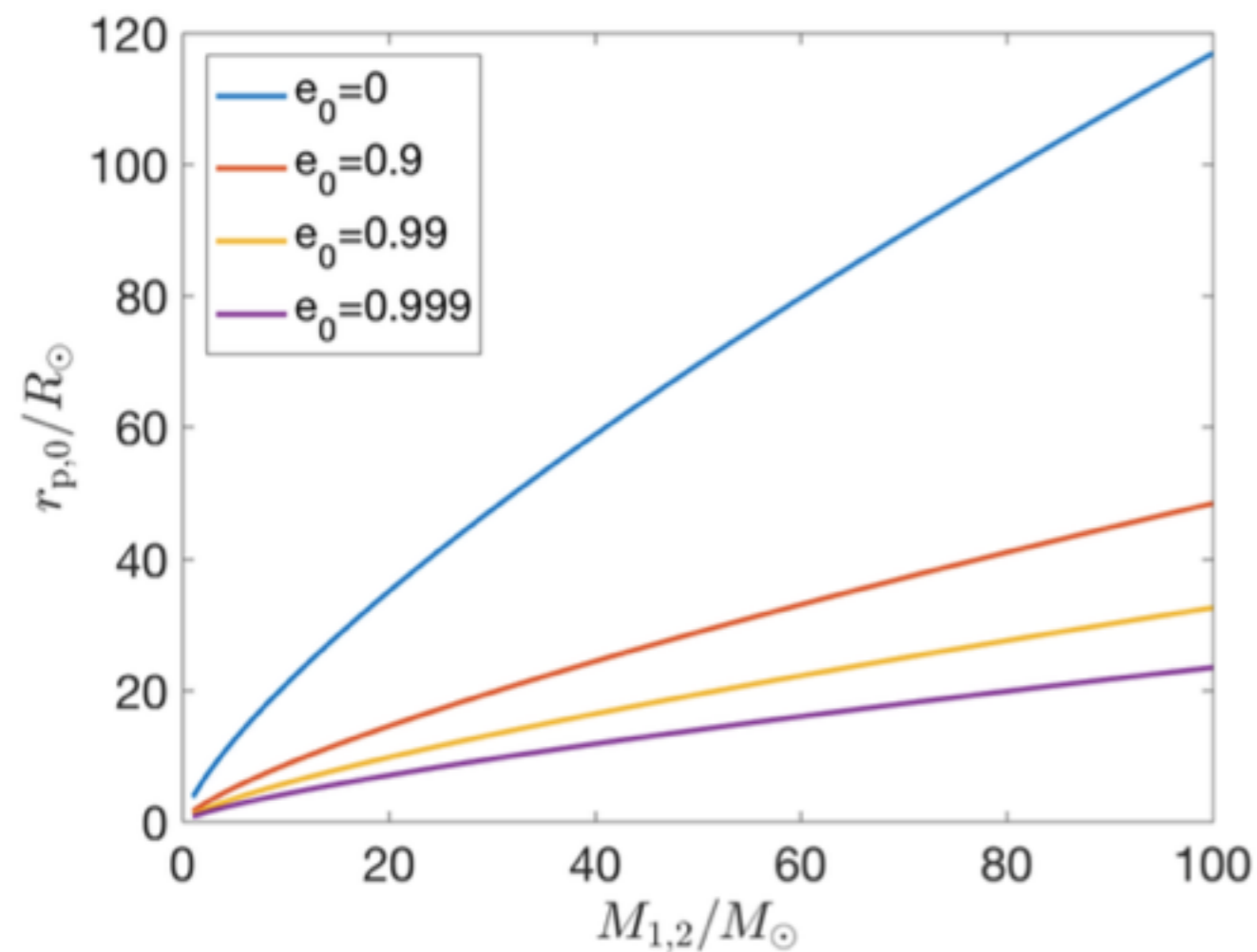


It's easy, right?

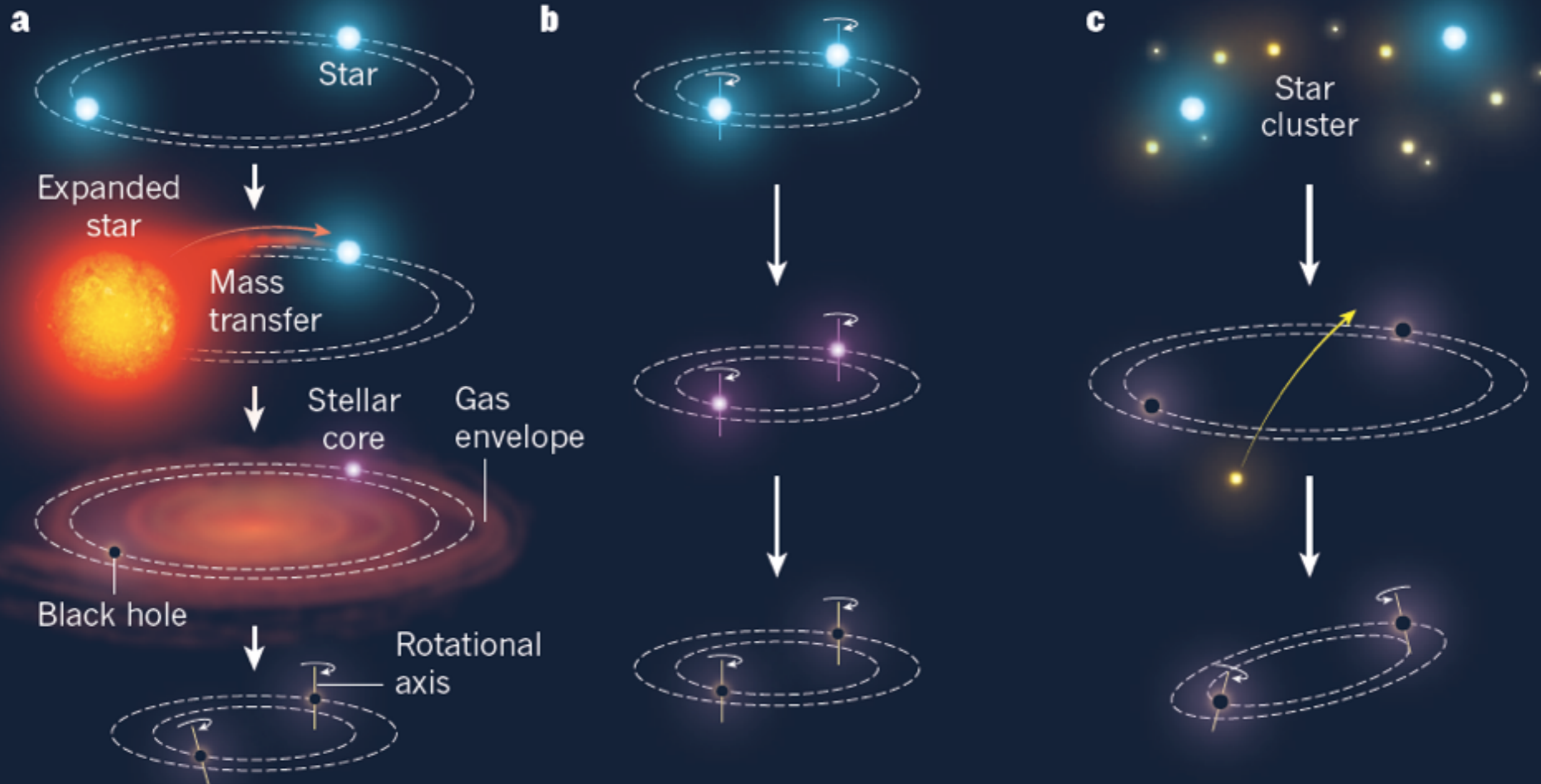


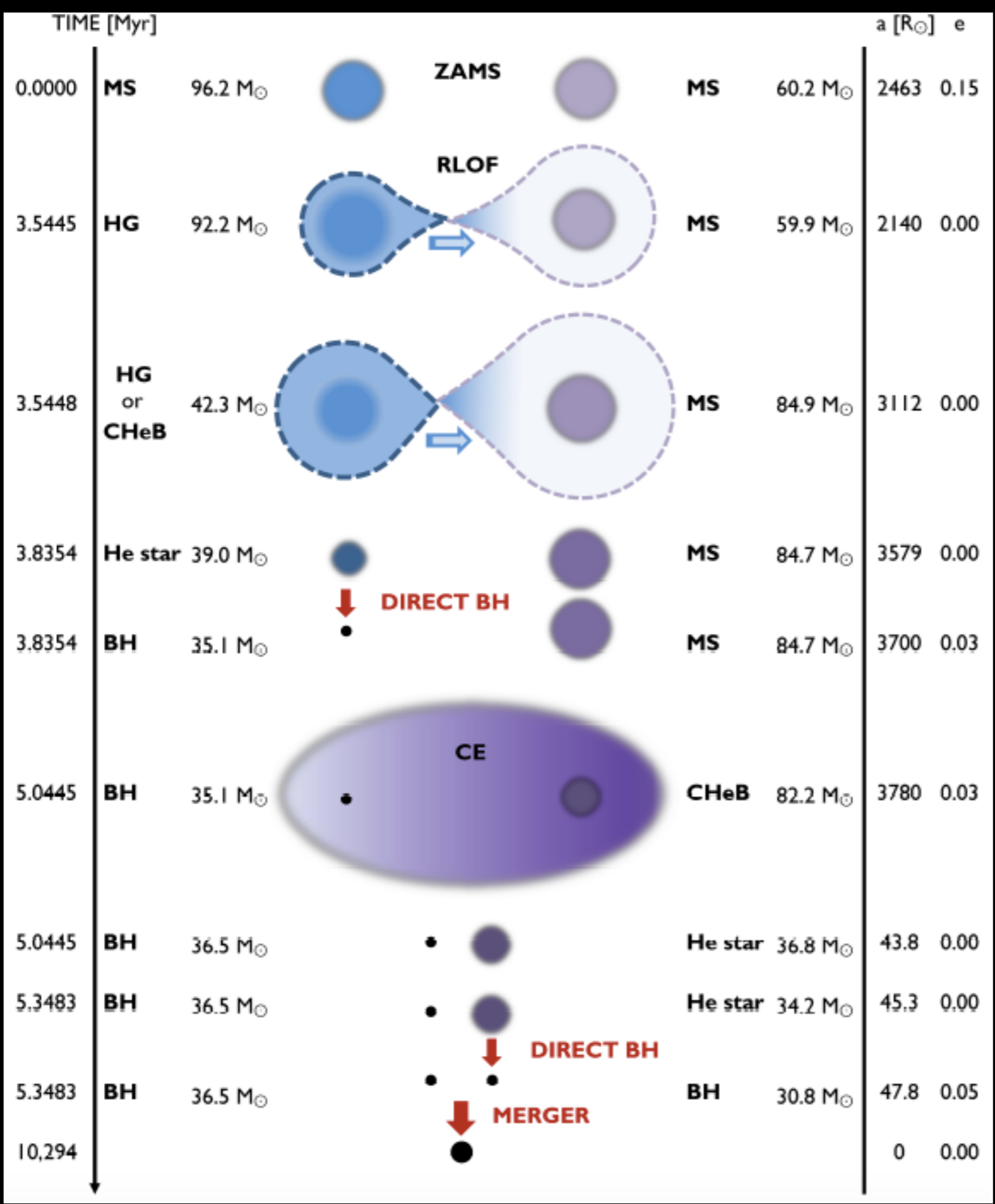
Fundamental theorem of GW astrophysics

It's challenging to bring compact objects to merge within the age of the Universe!



Merging binary black holes





Belczynski et al., 2016

Tutukov & Yungelson 1973, 1993; Lipunov, Postnov & Prokhorov (1997), Bethe & Brown (1998), Bloom, Sigurdsson & Pols (1999), De Donder & Vanbeveren (2004), Grishchuk et al. (2001), Nelemans (2003), Voss & Tauris (2003), Pfahl, Podsiadlowski & Rappaport (2005), Dewi, Podsiadlowski & Sena (2006), Kalogera et al. 2007; O’Shaughnessy et al. (2008), Mennekens & Vanbeveren (2014), Dominik et al. (2012, 2013, 2015), Belczynski et al. 2016, Eldridge & Stanway (2016), Lipunov+ (2016), Stevenson et al. (2017)

...





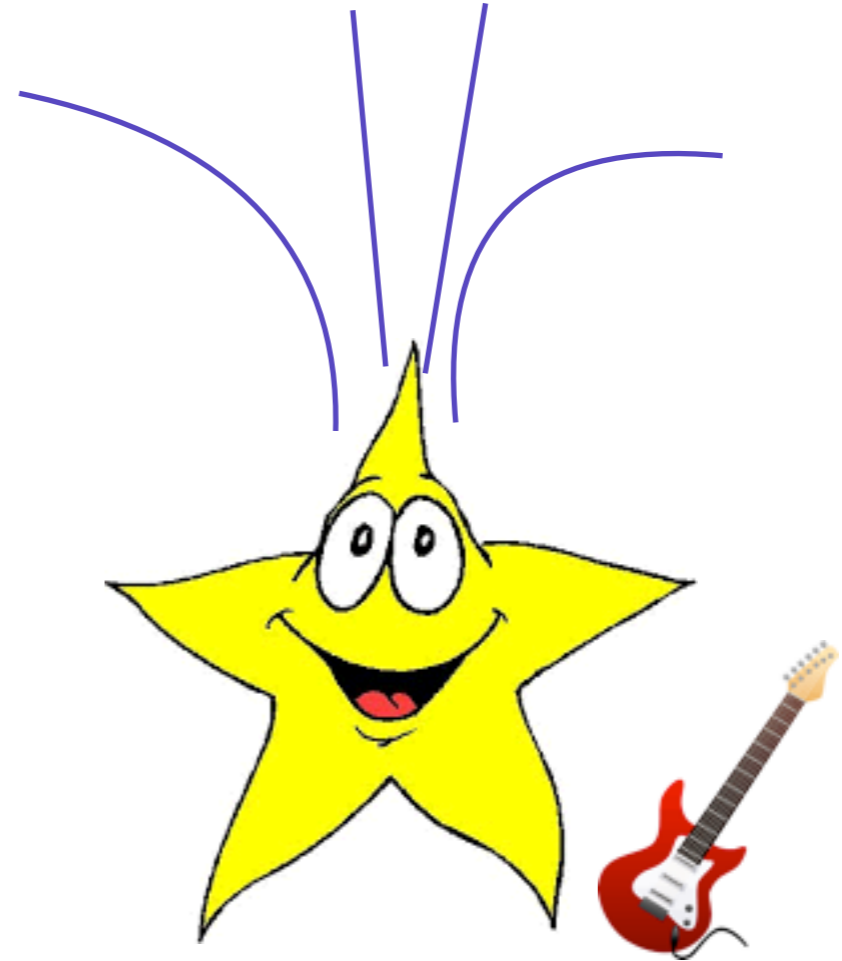
Stella



Estelle



Stella



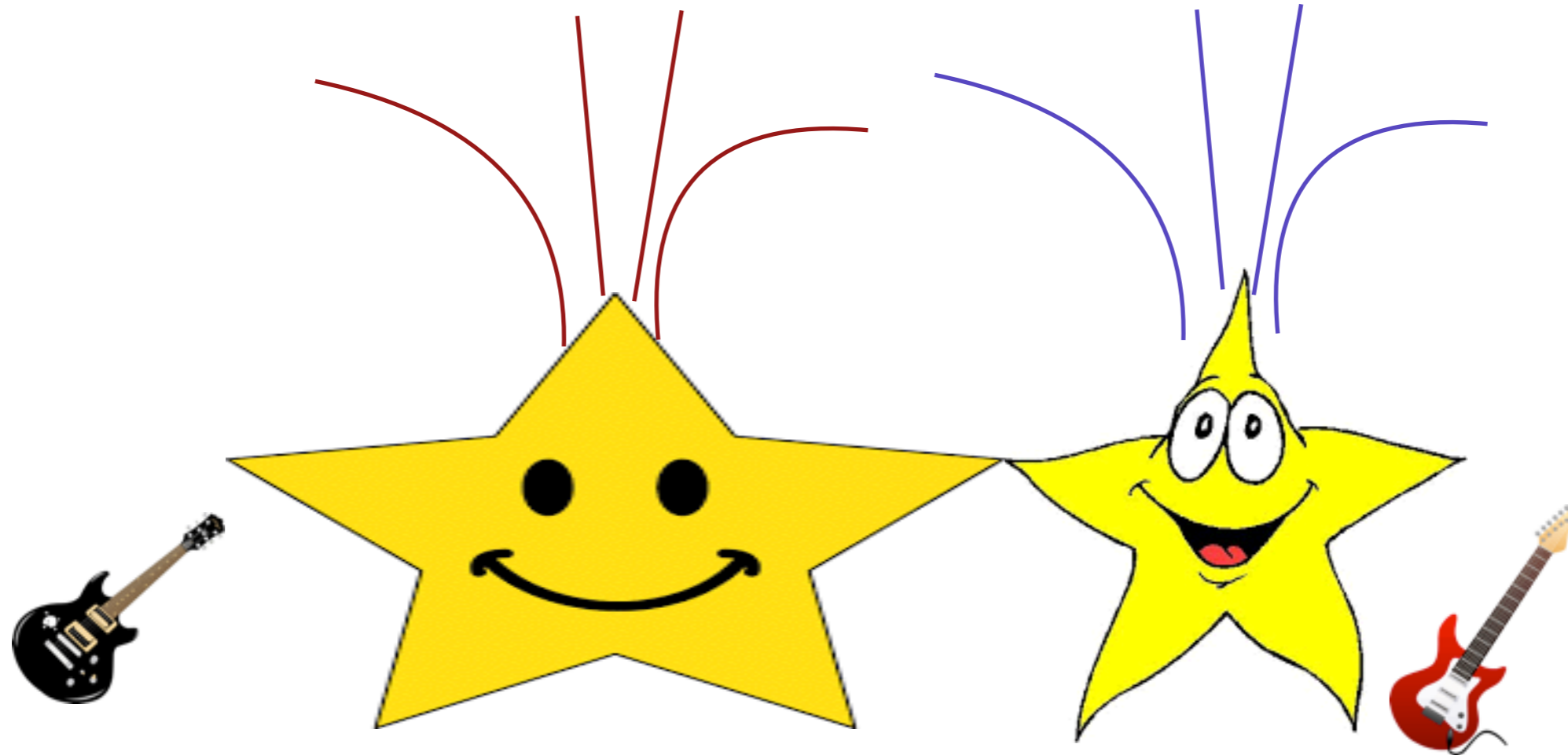
Estelle



Stella

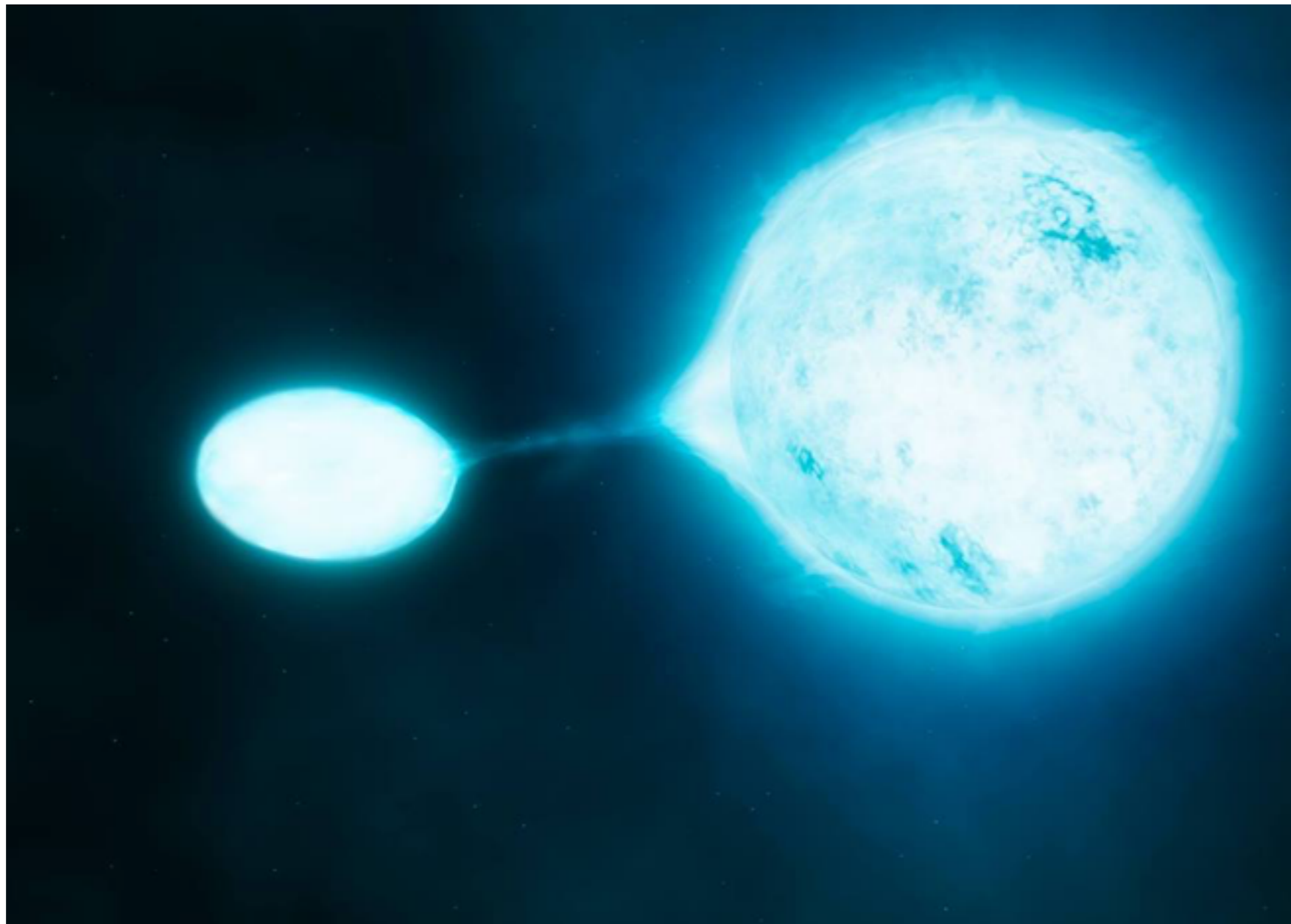


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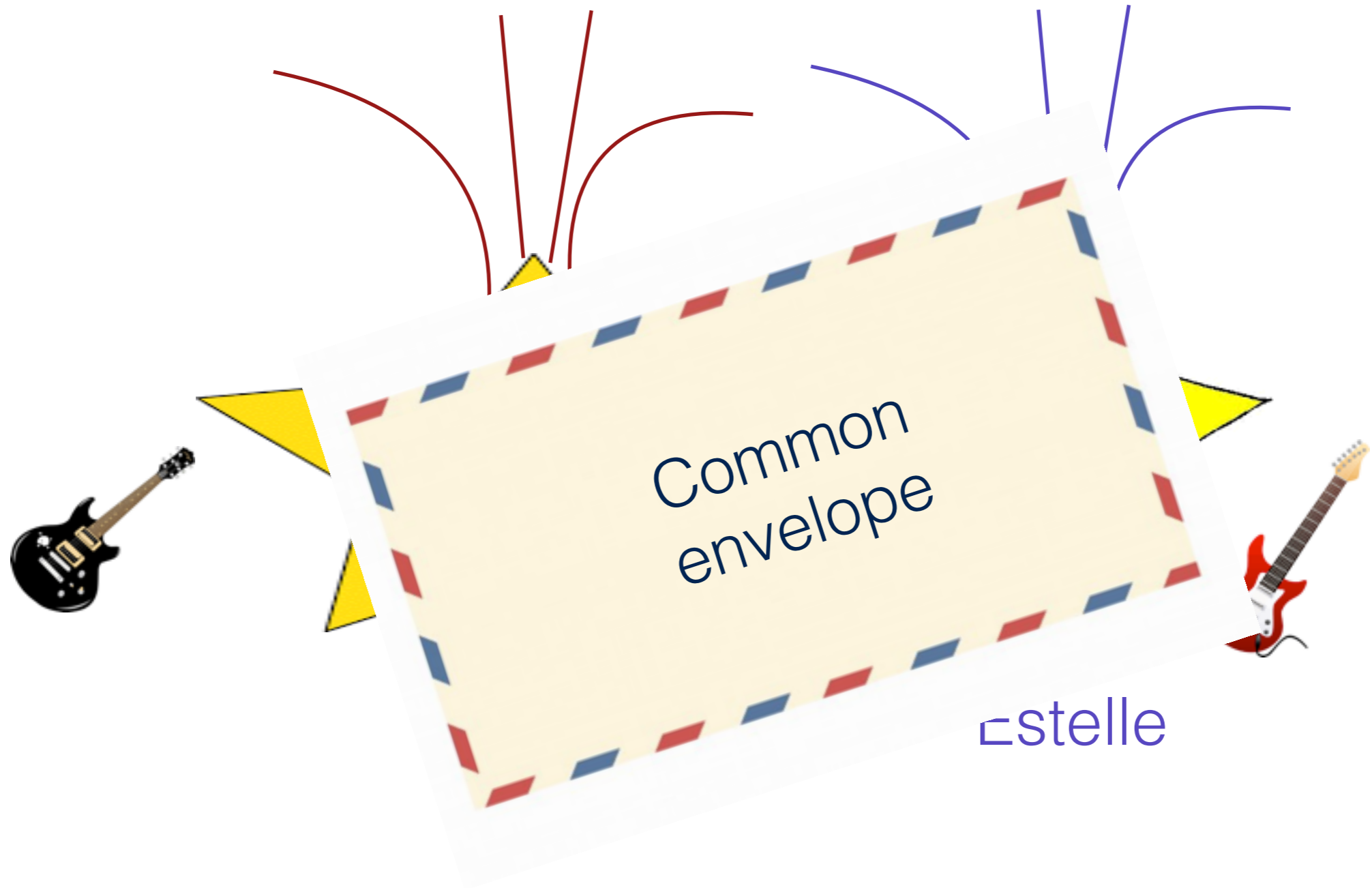


Stella

Estelle



Credit: ESO Kornmesser/de Mink

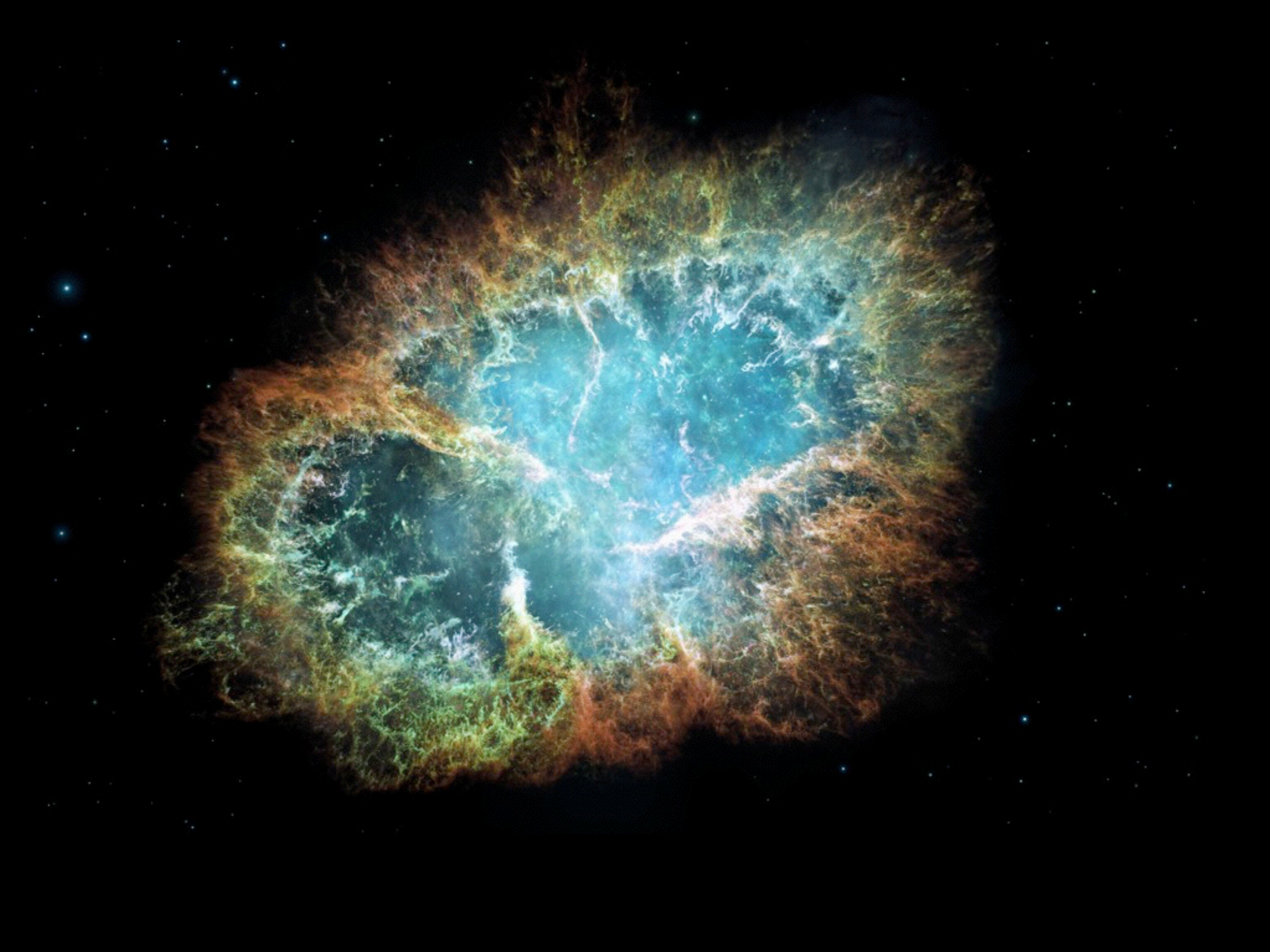


Common
envelope

stelle



Stella

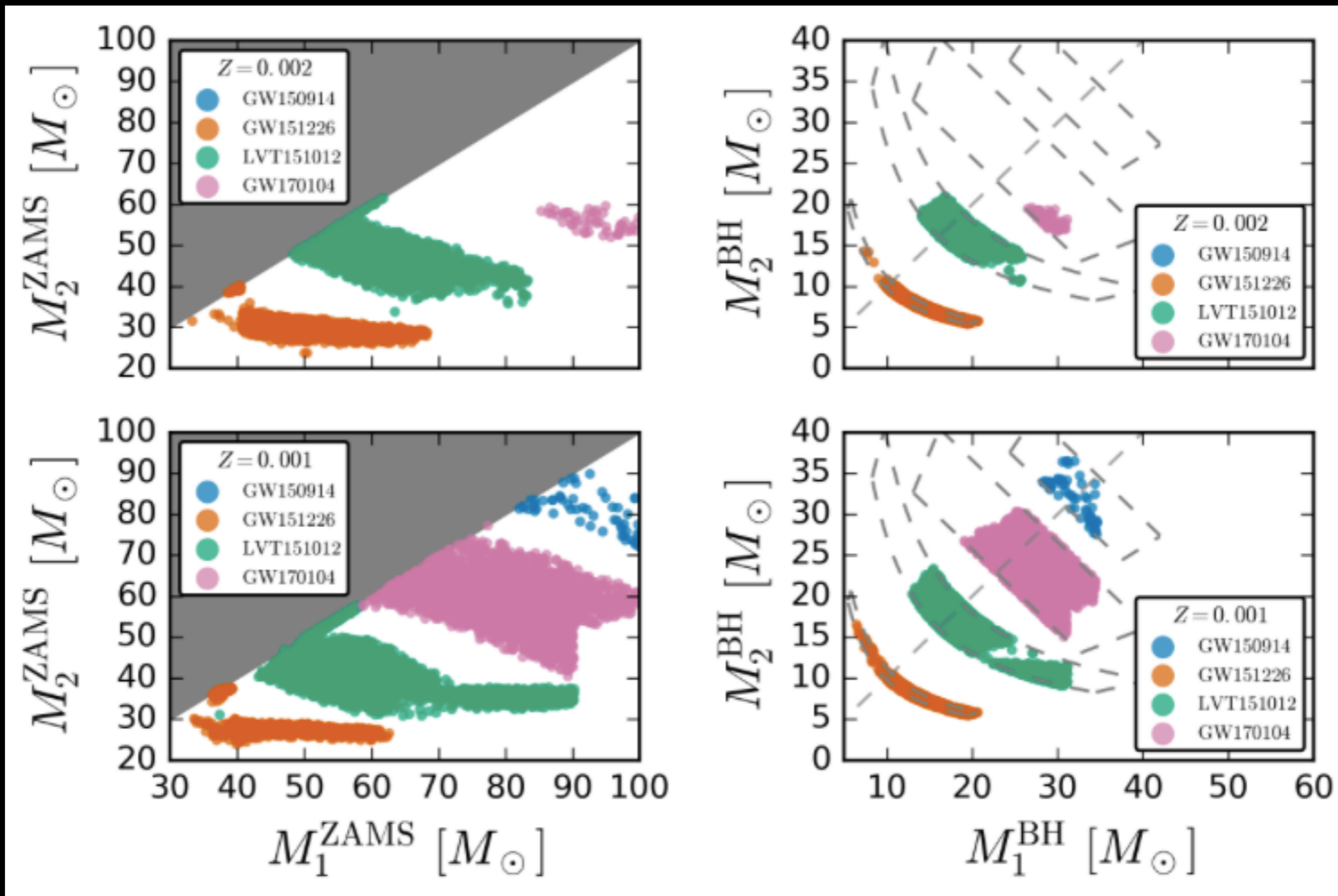




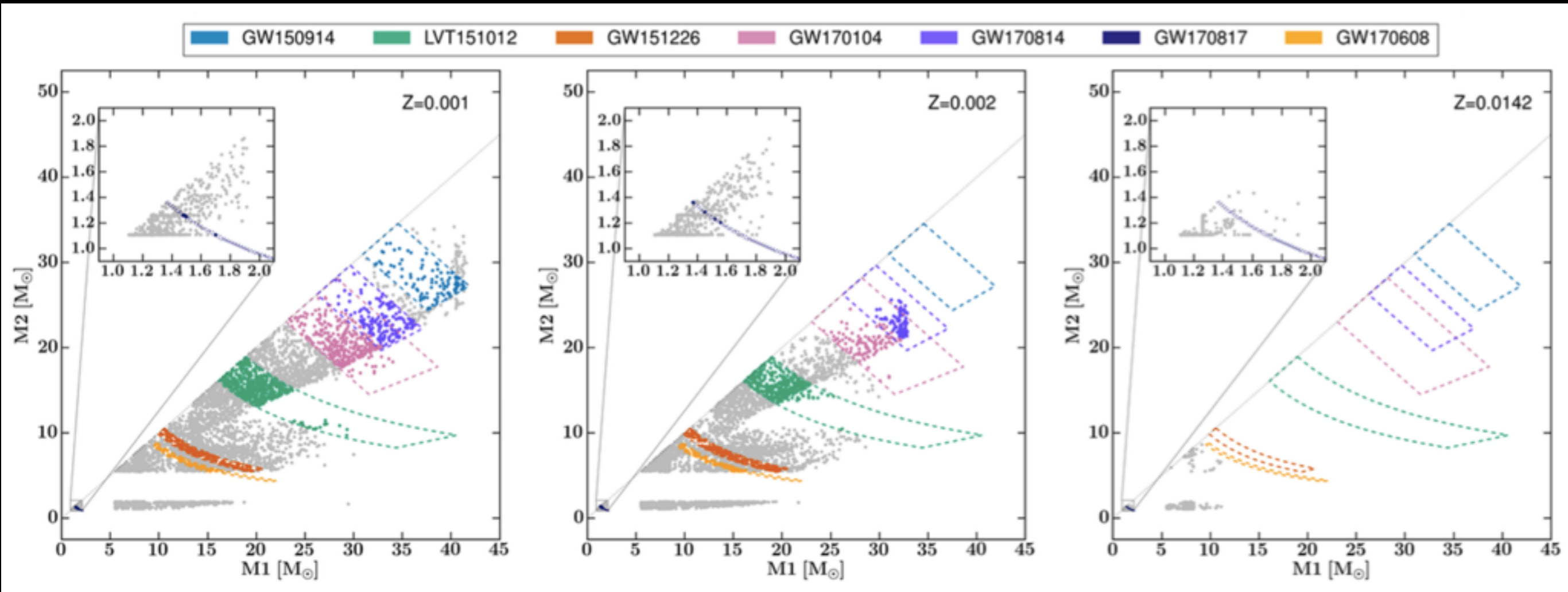
| Time (Myr) | $M_1 (M_\odot)$ | ST ₁ | | ST ₂ | $M_2 (M_\odot)$ | $a (R_\odot)$ |
|------------|-----------------|-----------------|--|-----------------|-----------------|---------------|
| 0.0 | 63.6 | MS | | MS | 27.8 | 729.93 |
| 4.1 | 60.4 | HG | | MS | 27.7 | 757.5 |
| 4.12 | 24.6 | HeMS | | MS | 30.6 | 622.07 |
| 4.49 | 19.1 | BH | | MS | 30.6 | 692.7 |
| 7.21 | 19.1 | BH | | CHeB | 30.3 | 697.48 |
| 7.42 | 19.1 | BH | | CHeB | 29.7 | 706.33 |
| 7.42 | 19.1 | BH | | HeMS | 10.6 | 5.18 |
| 7.88 | 19.1 | BH | | BH | 5.7 | 8.82 |

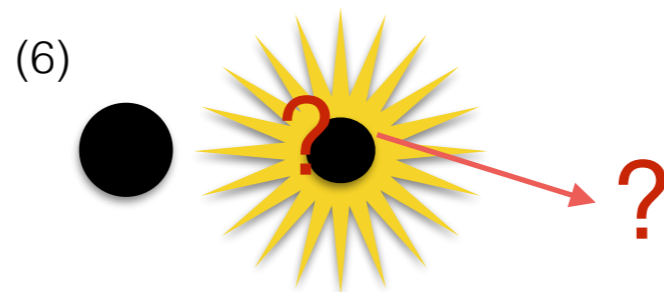
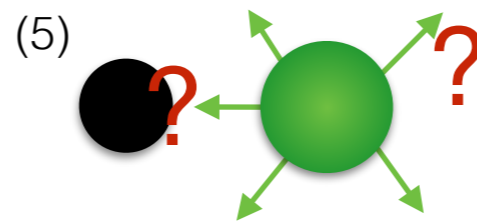
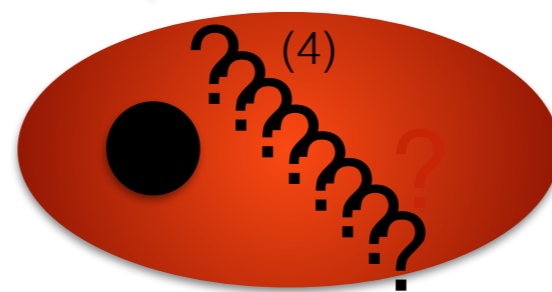
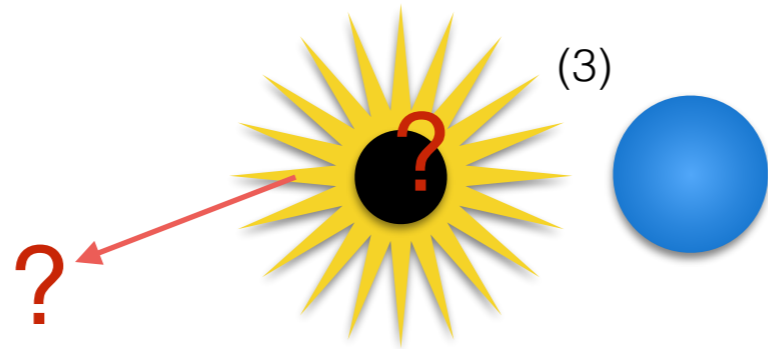
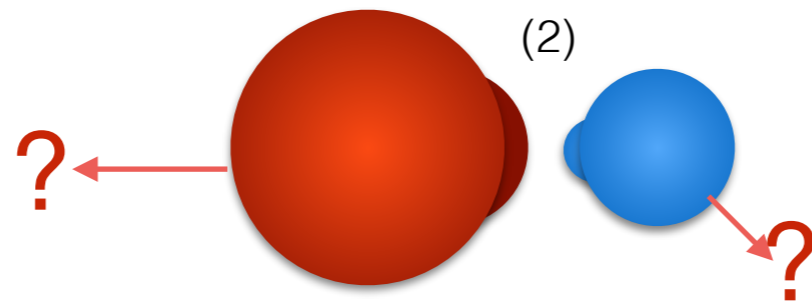
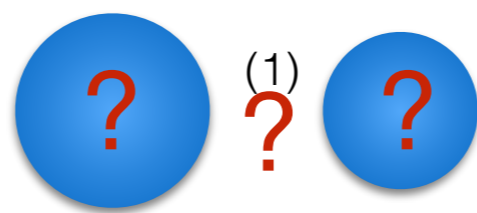
Figure 3 | Formation of GW151226. Typical formation of GW151226 at 10% solar metallicity in our model, as described in the Results. The columns

Could all observed events come from this channel?

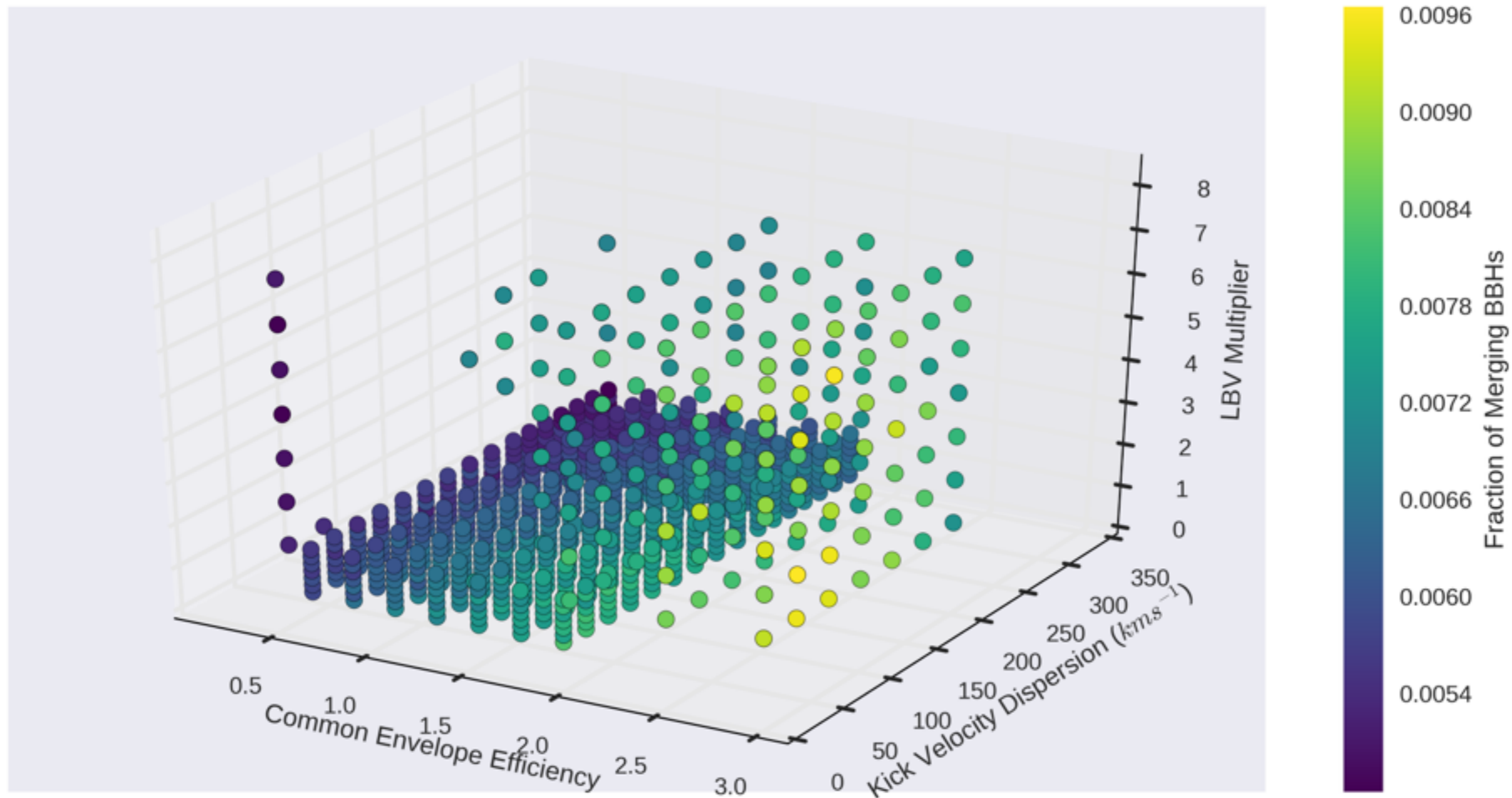


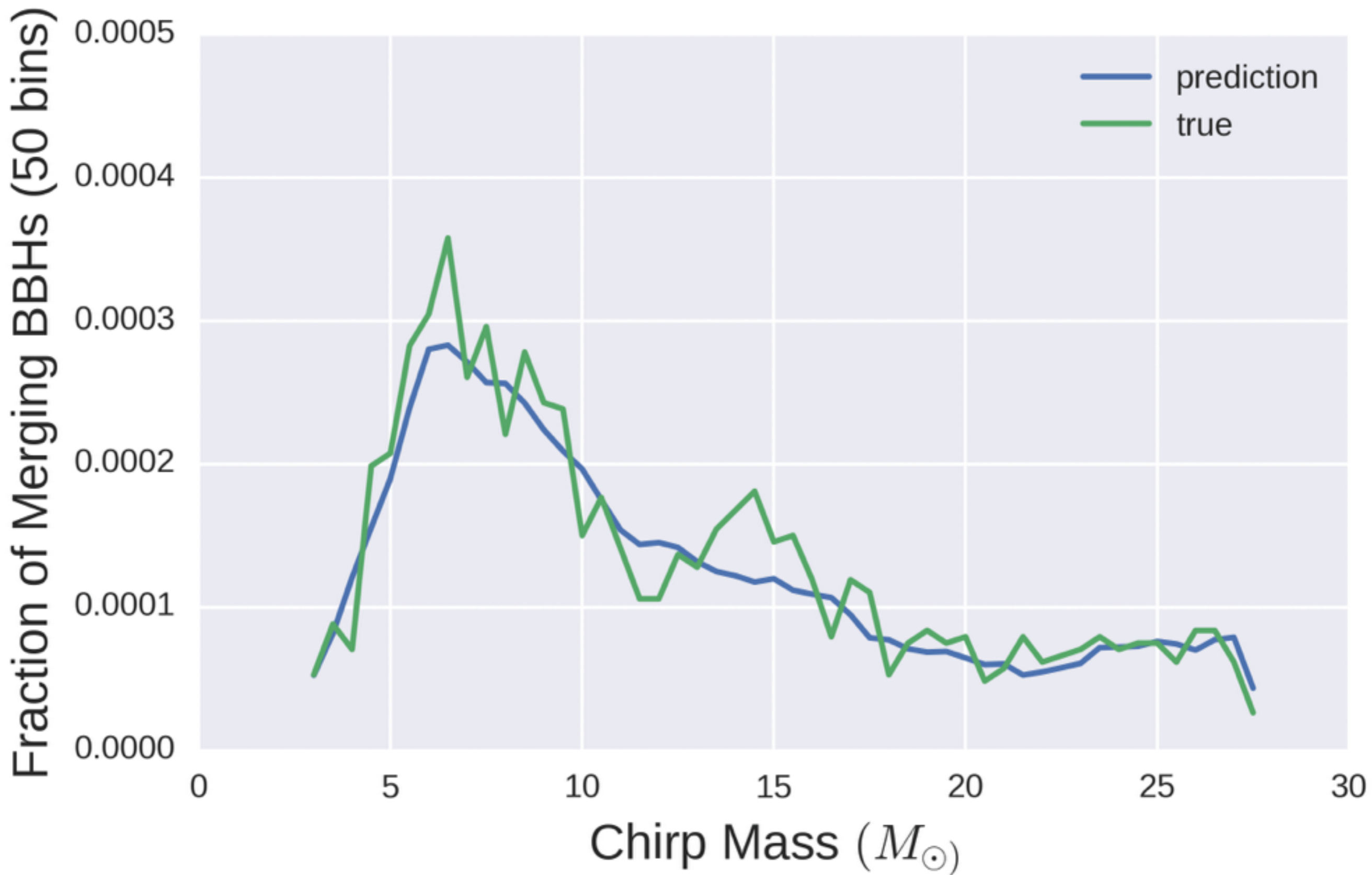
Population Synthesis



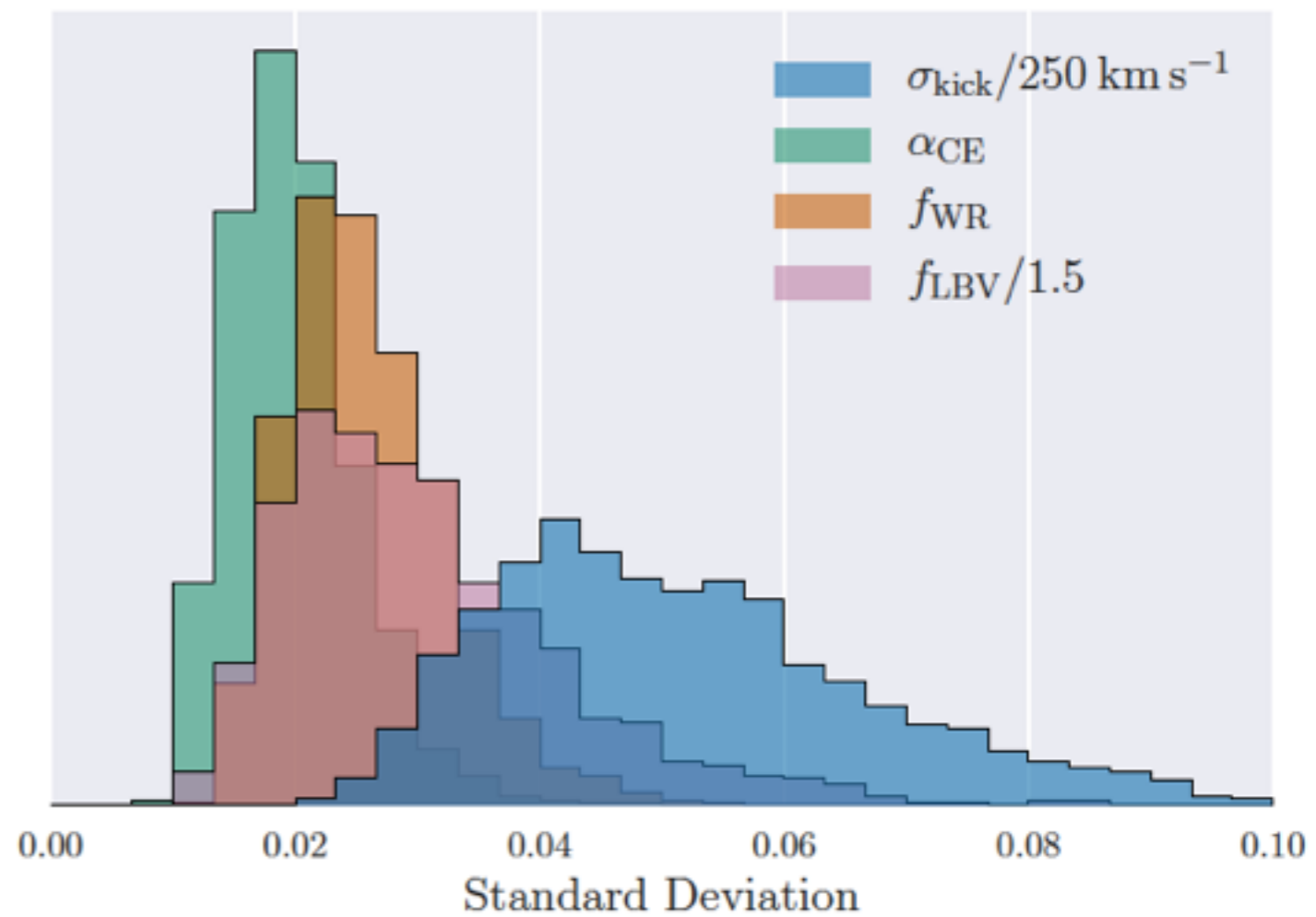
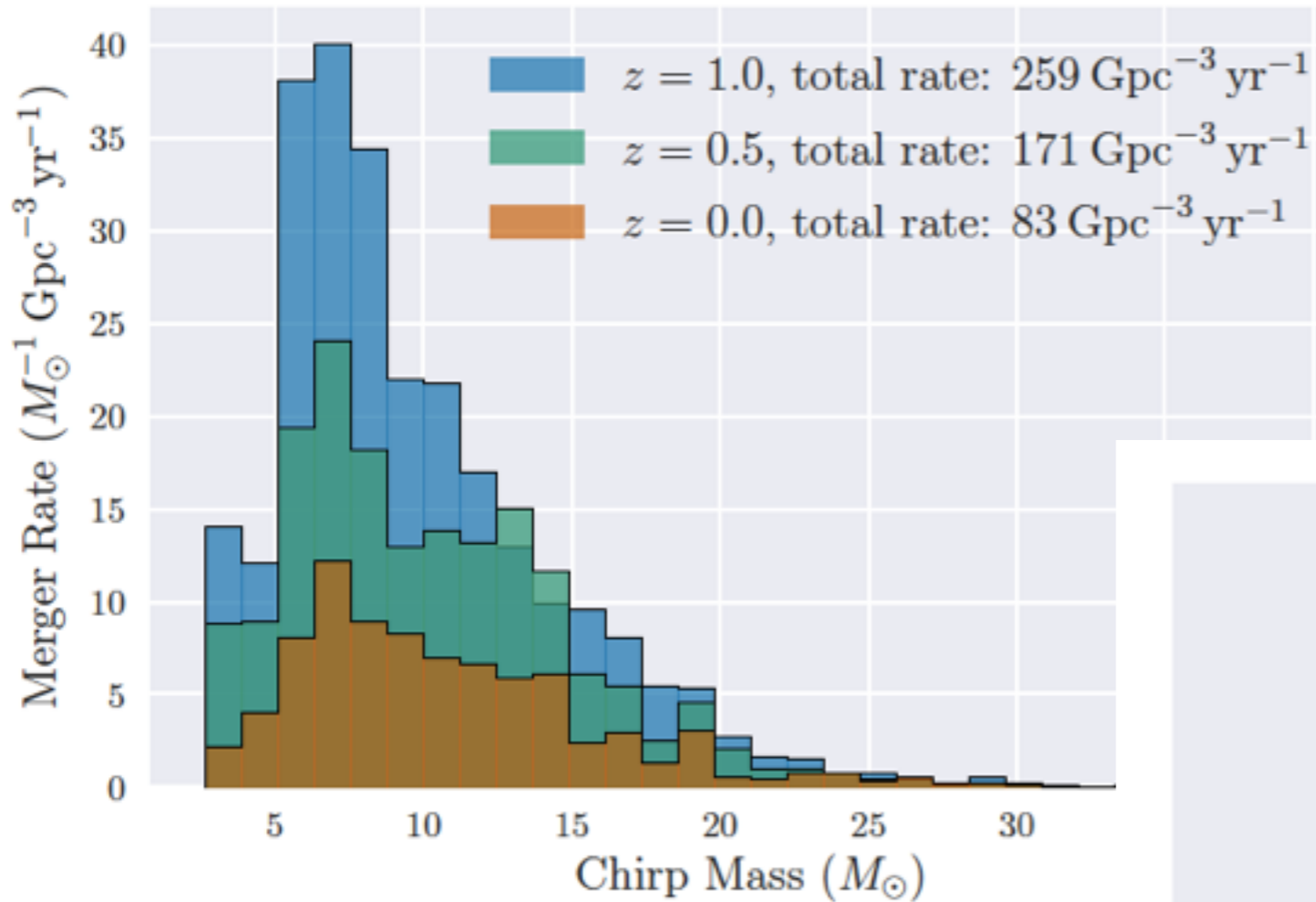


Model interpolation



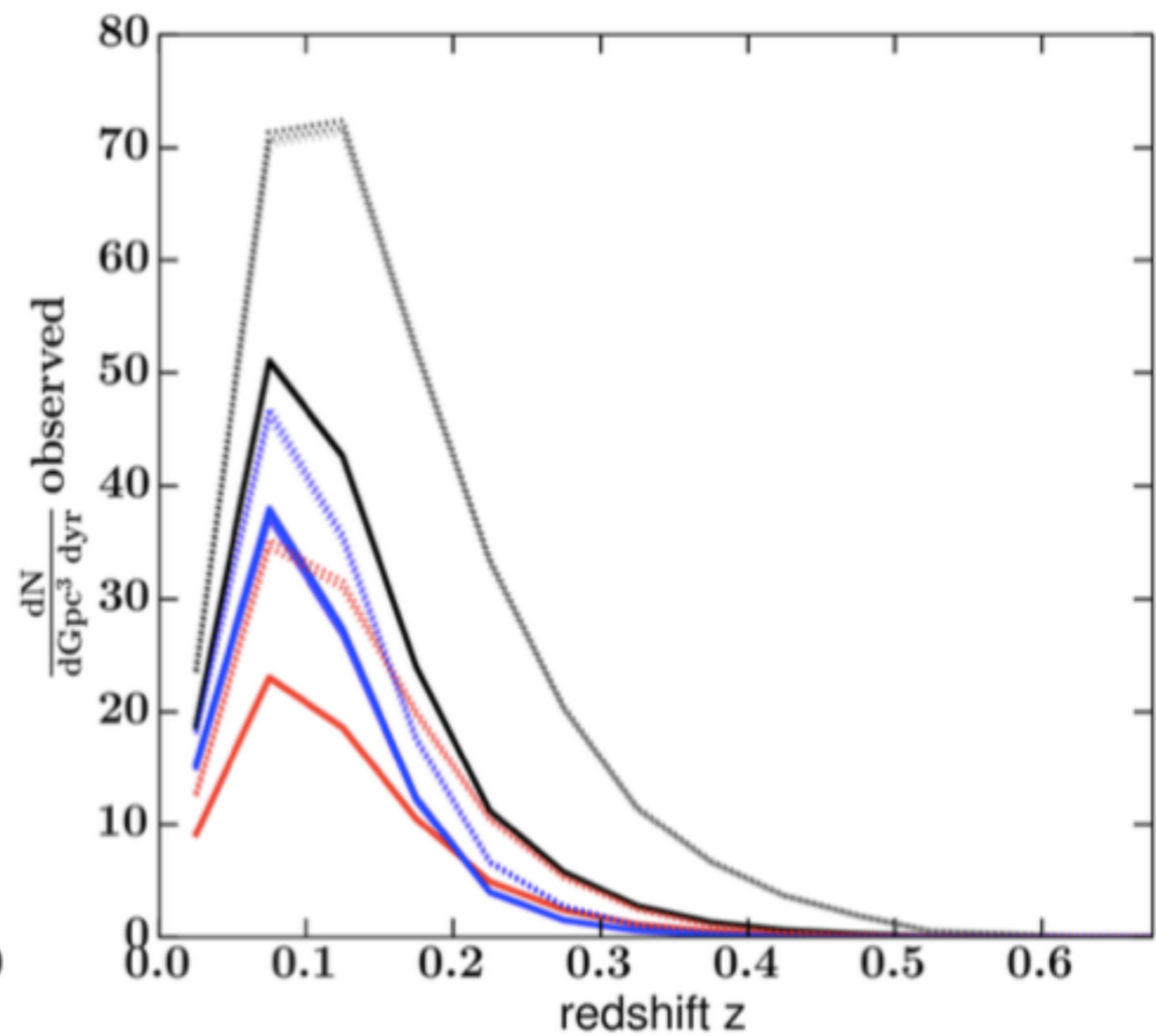
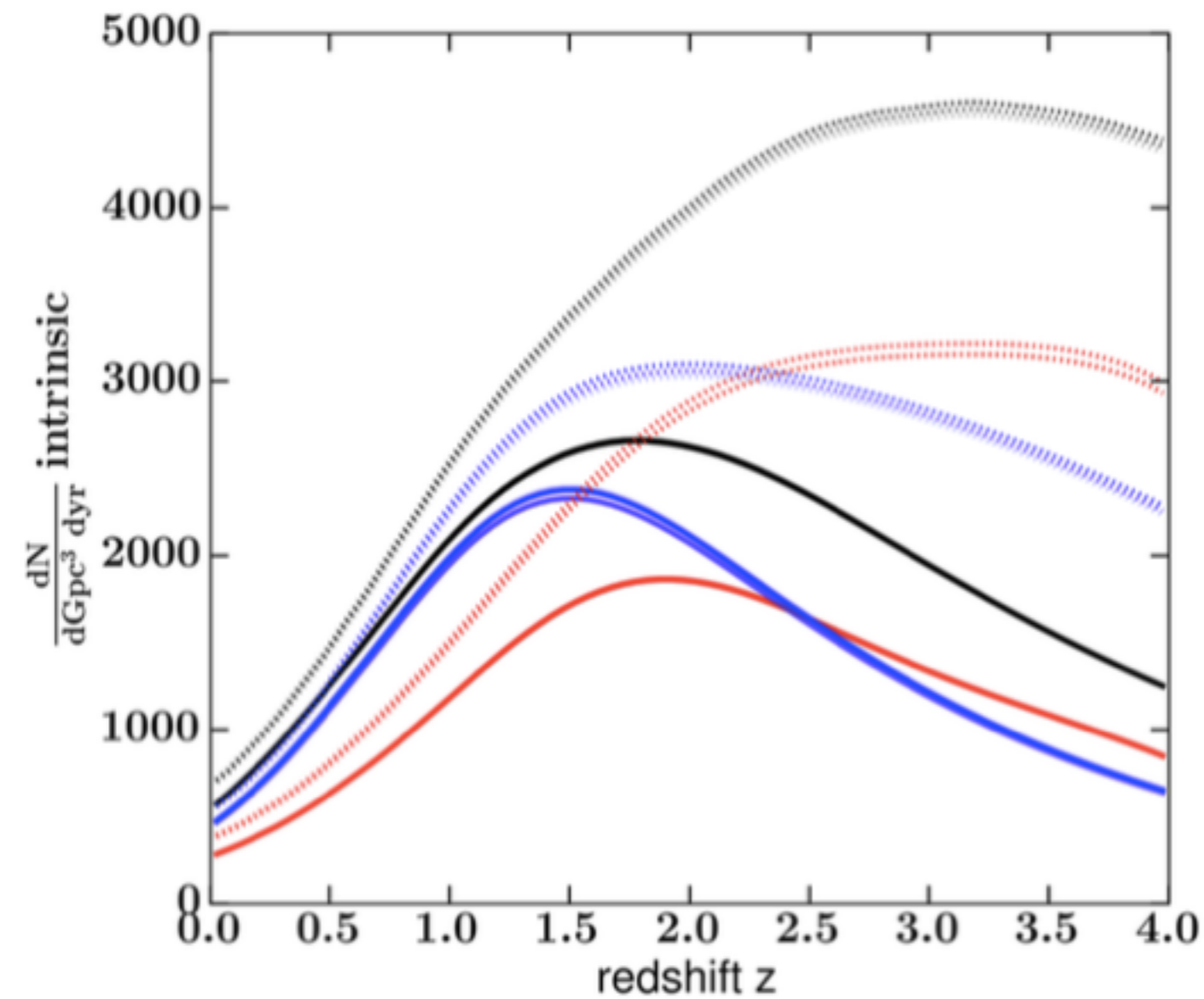


Predictions

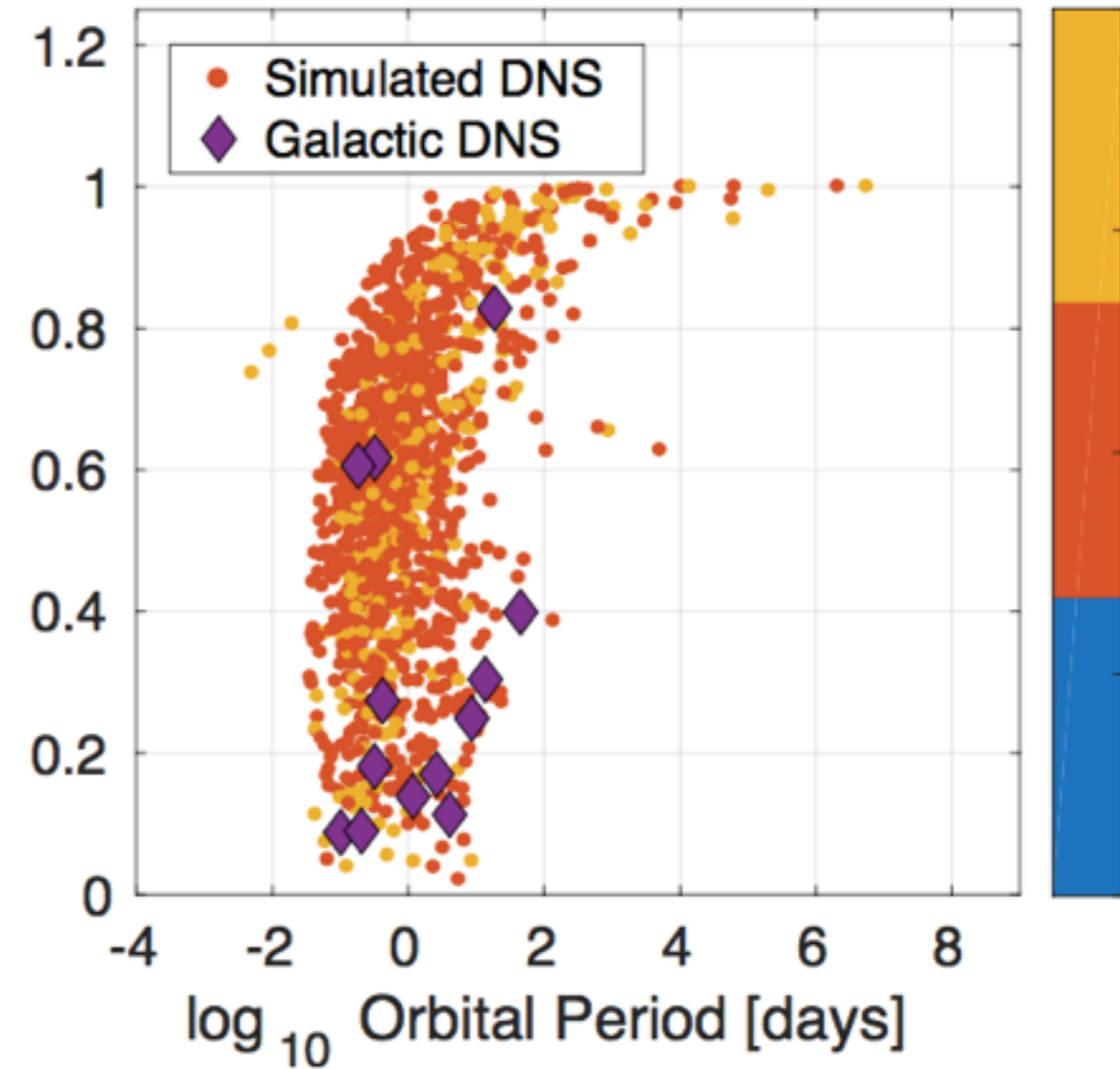
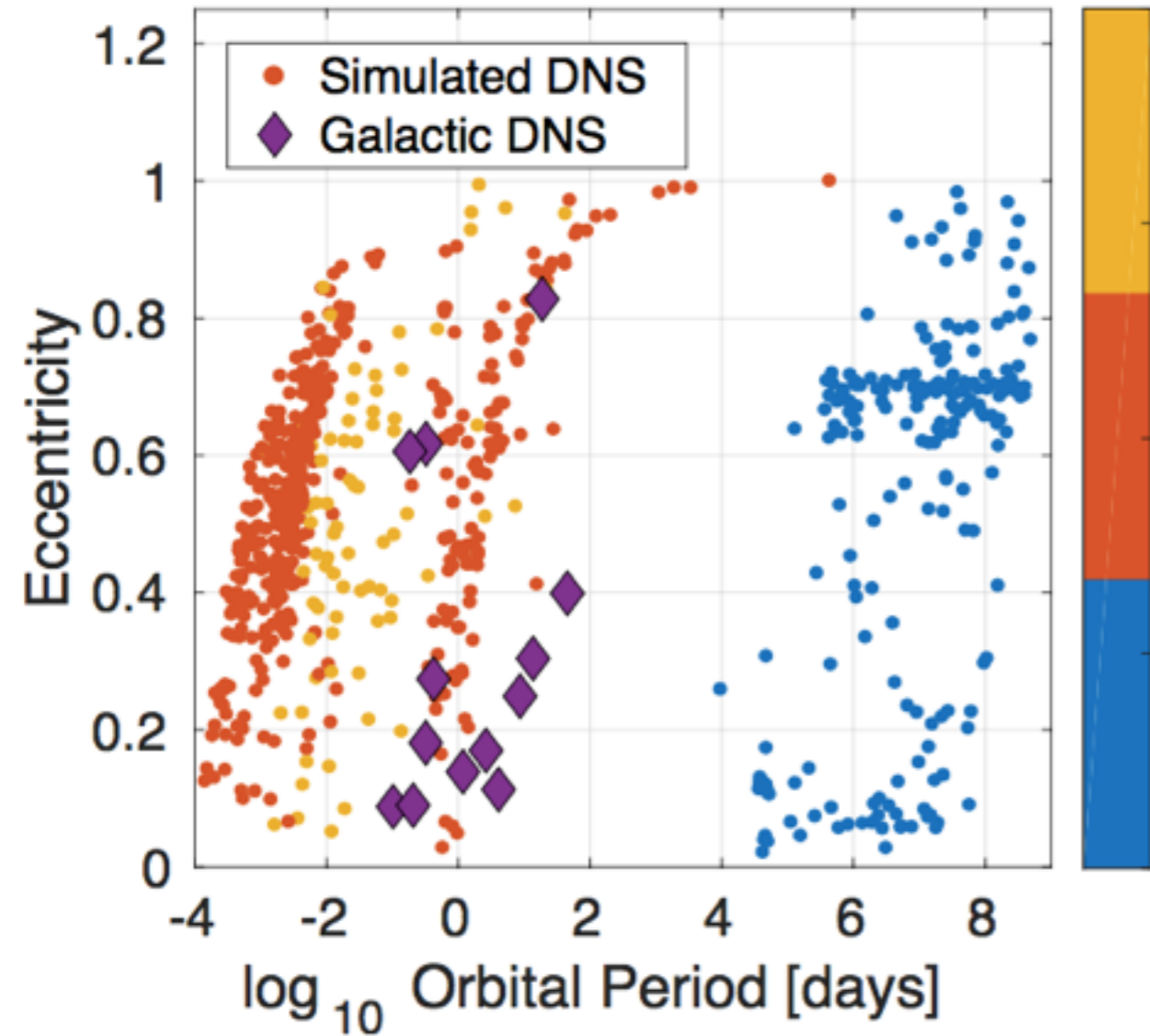


Barrett et al., 2018

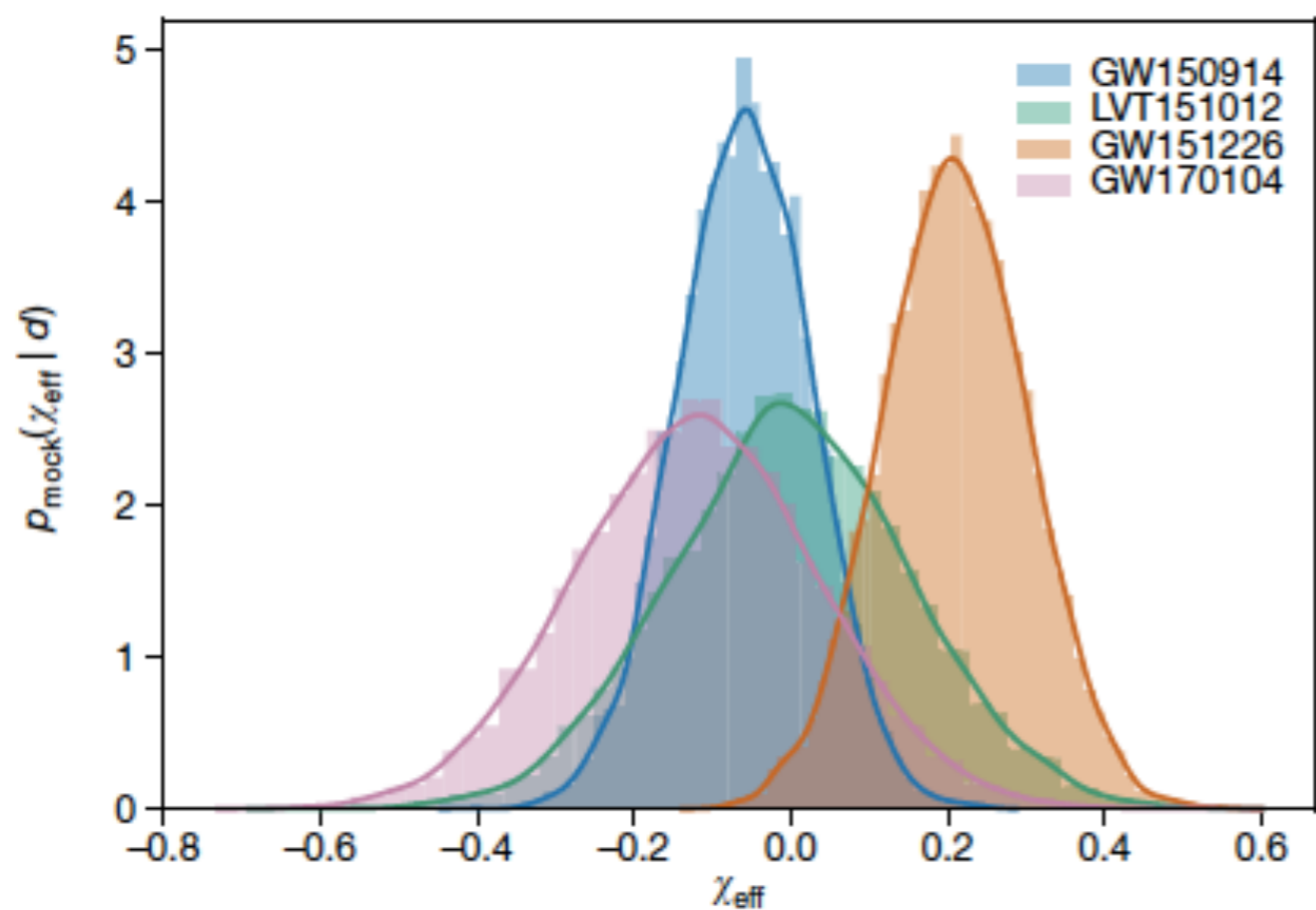
SFR and metallicity



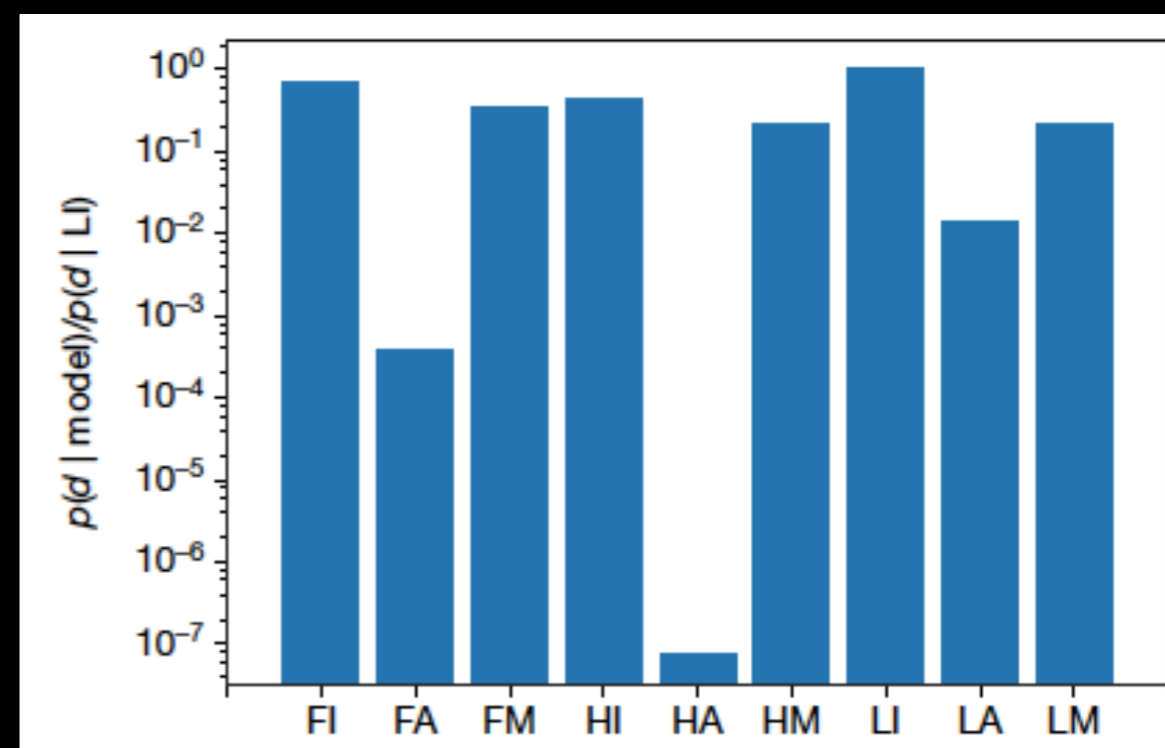
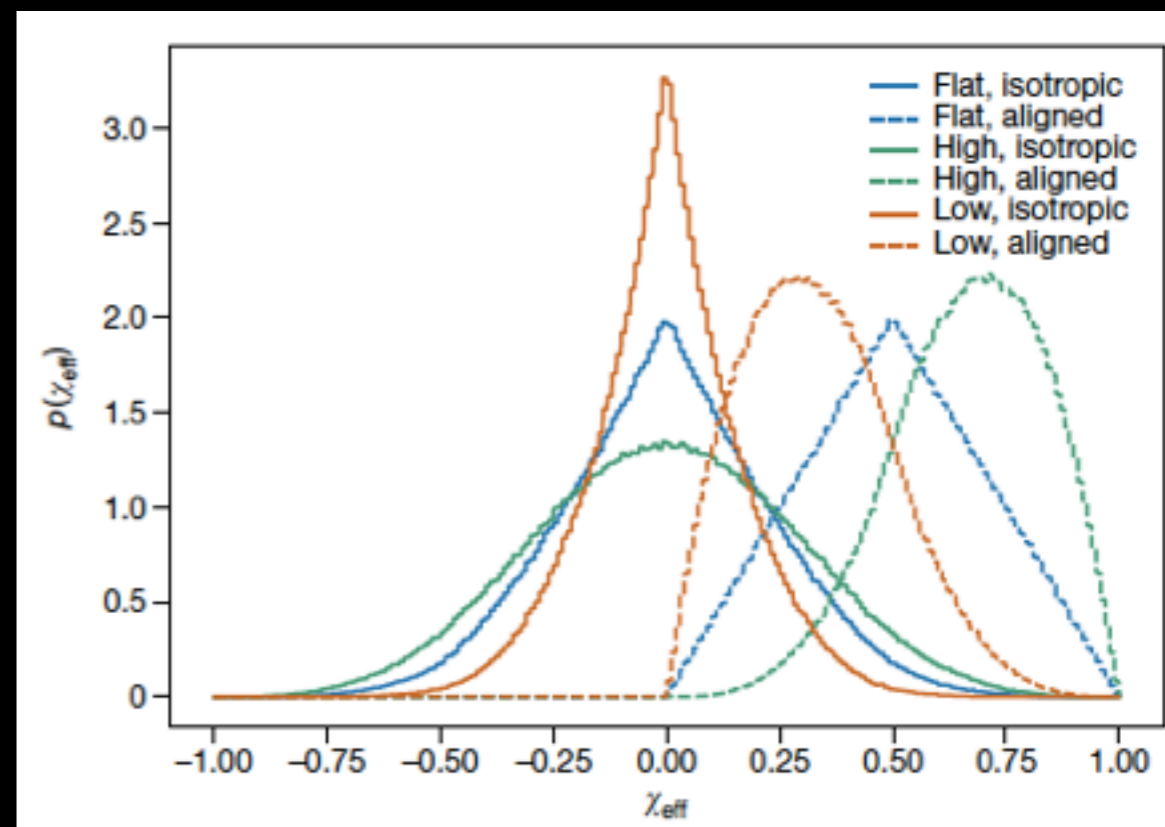
Learning from detections



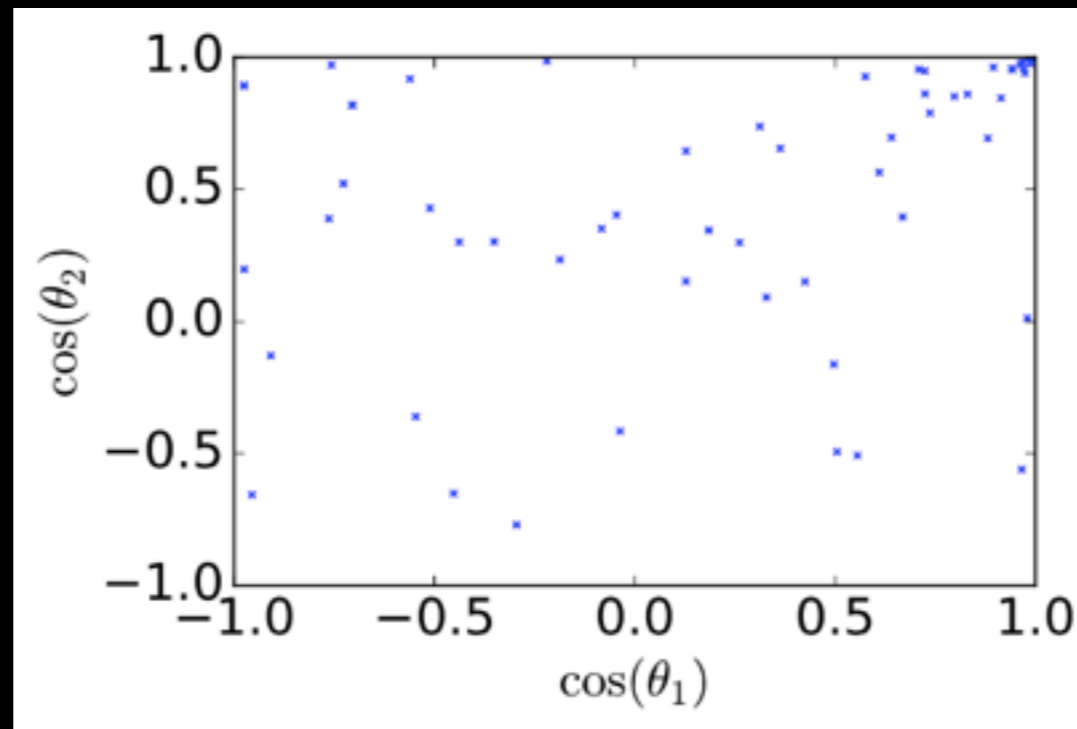
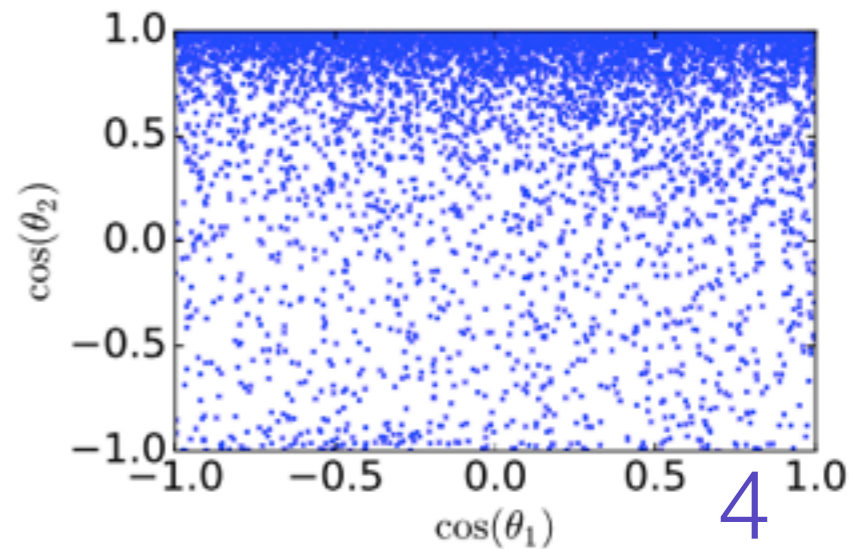
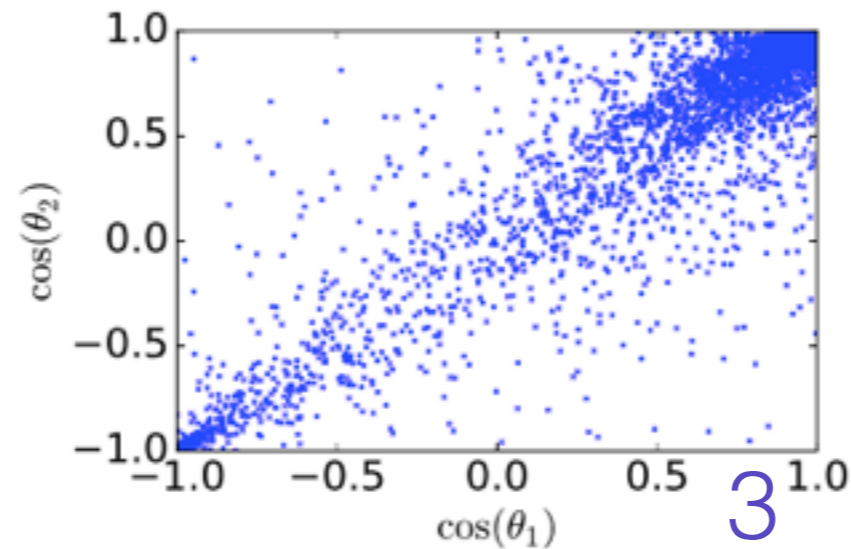
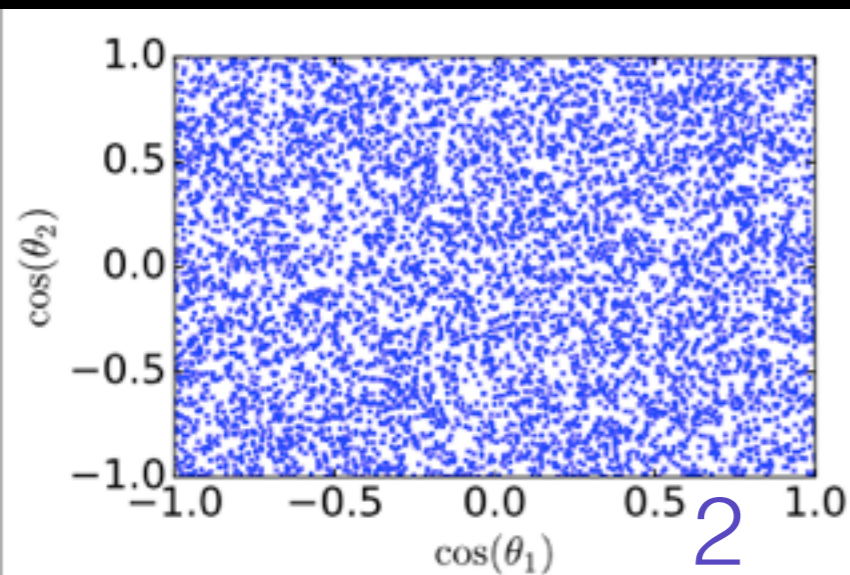
Learning from detections



Farr+, 2017

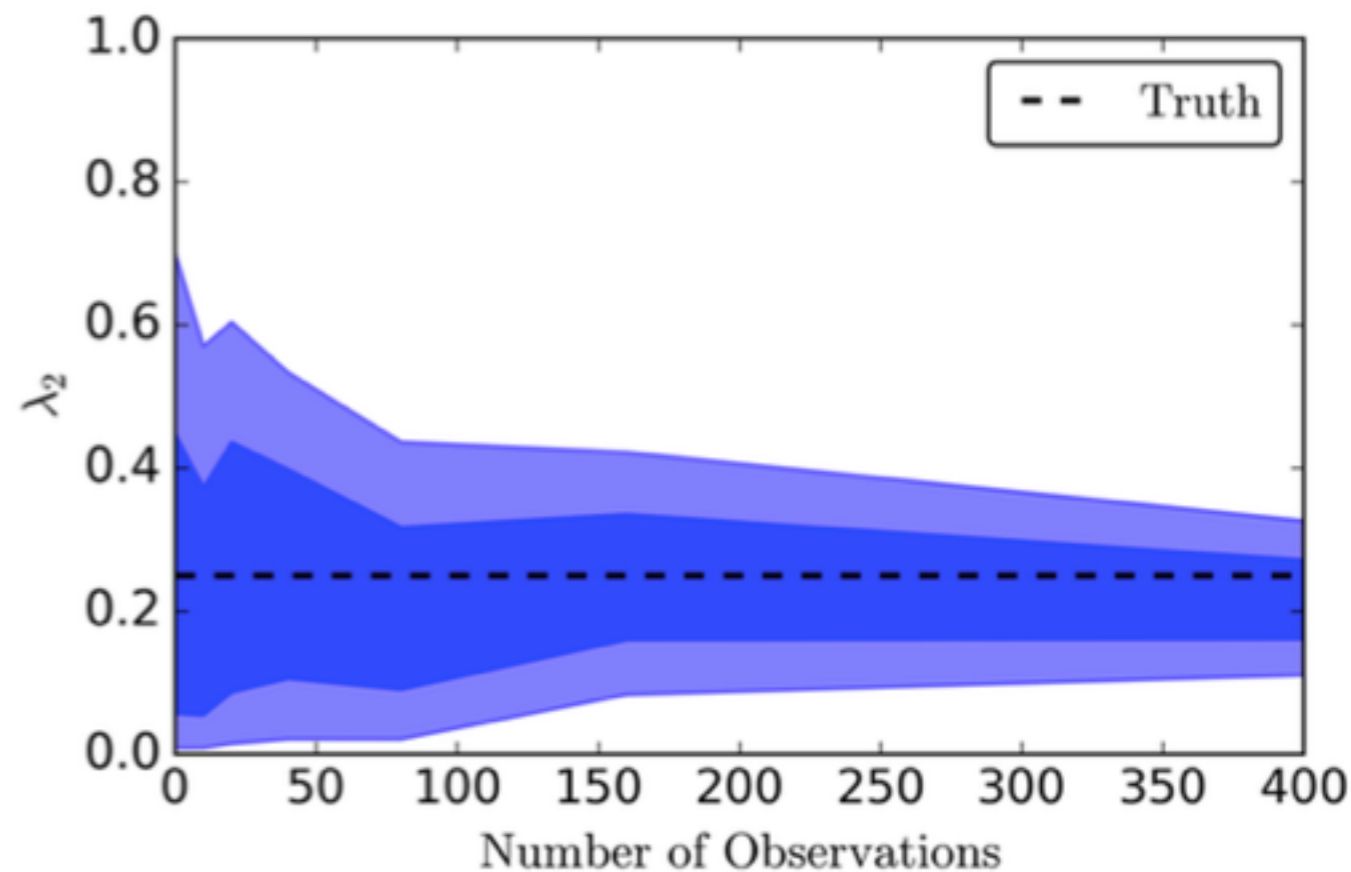
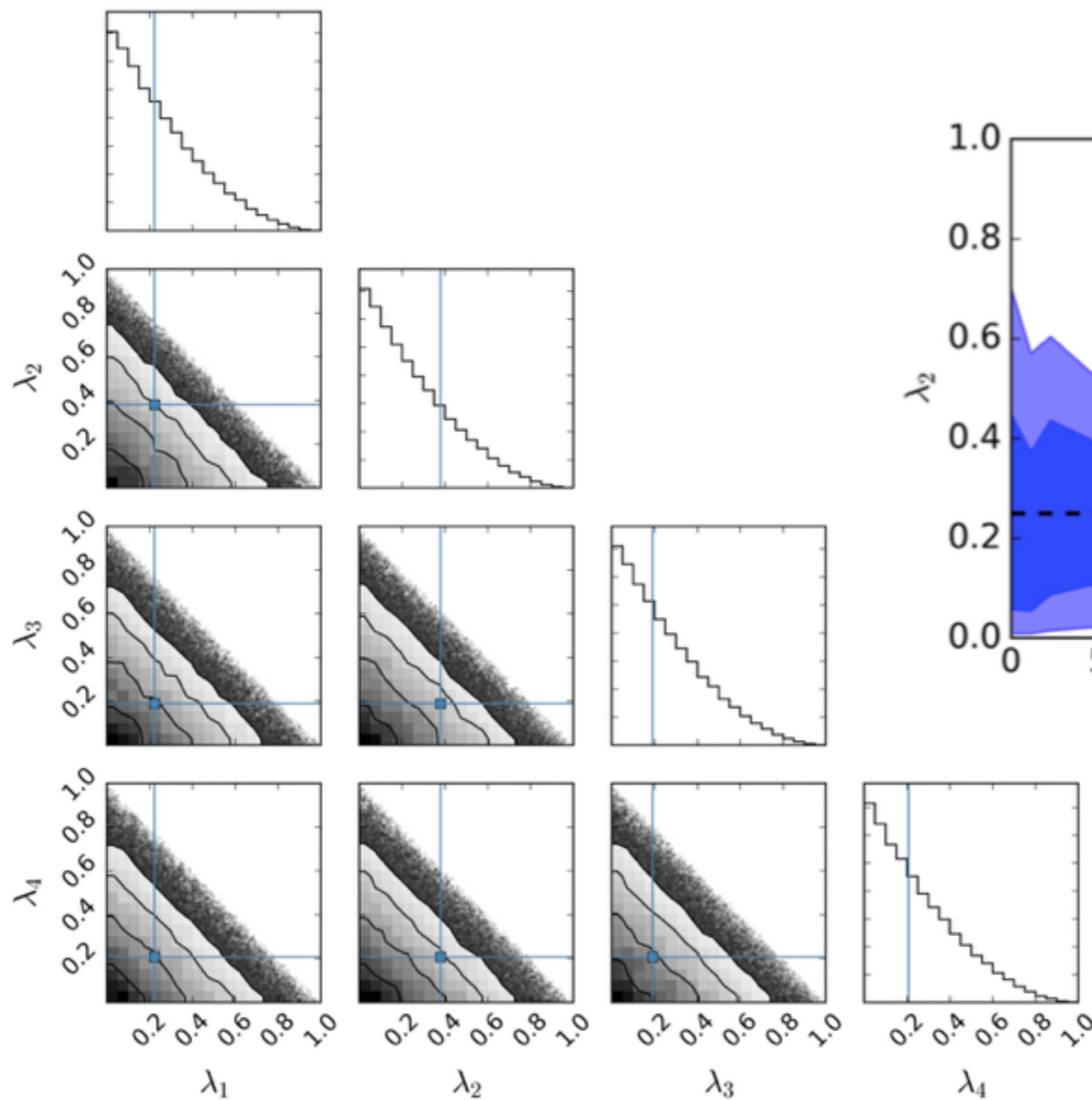


Multiple populations



Stevenson, Berry, Mandel, 2017

Hierarchical modeling



The future

- Bring together observations, modelling and astrostatistics
- Figure out what questions we can realistically answer... and answer them!
- Use full observation set — concordance binary evolution?

