

The impossible GW190521

Dorottya Szécsi

6. Oct. 2020 – Köln

Gravitational wave event GW190521 (George)


- *LIGO/Virgo interferometry*

- *Abbott et al. (2020a,b)*

- [arXiv2009.01075] [arXiv2009.01190]*

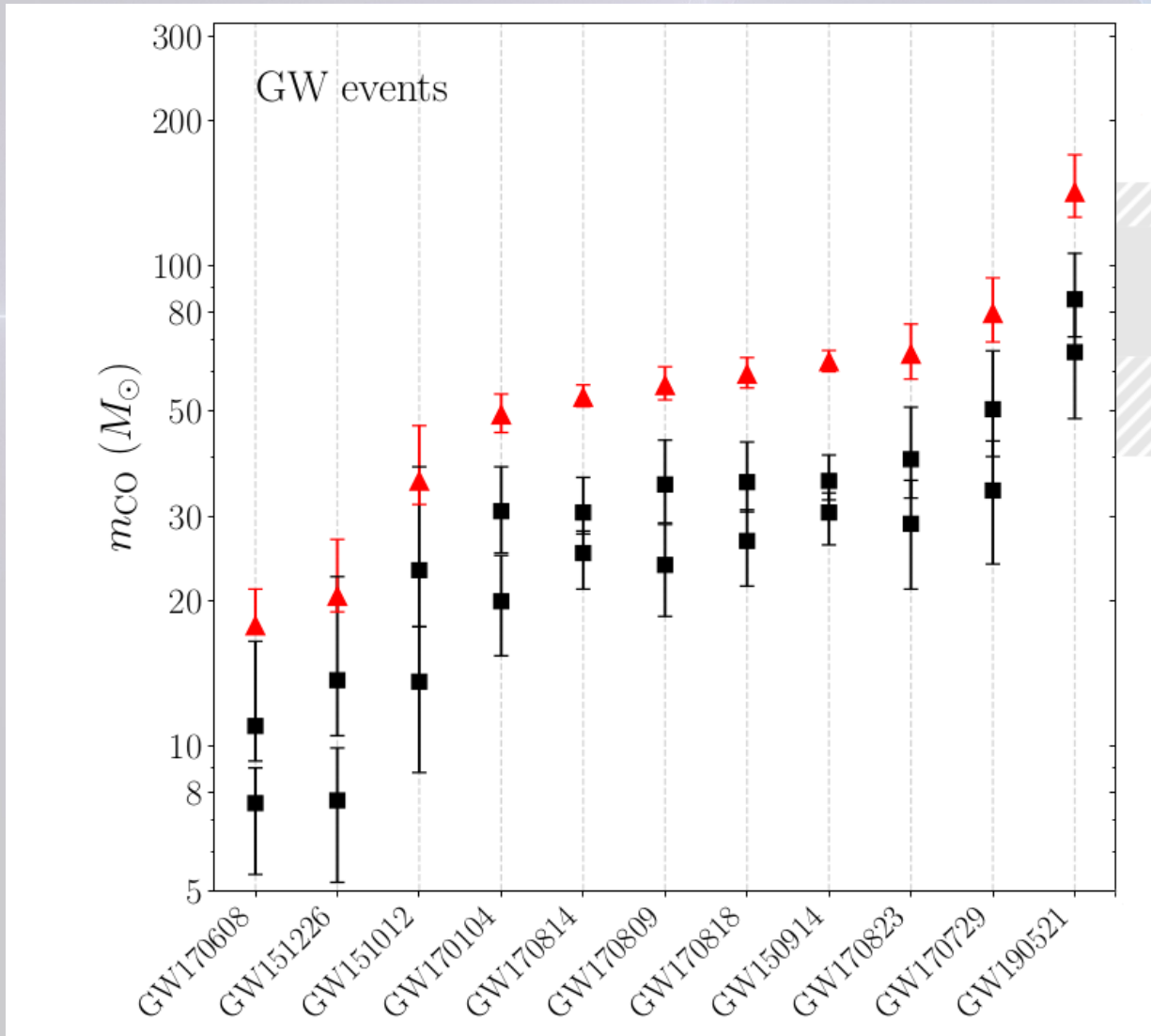
- $m_1 = 85 (+21/-14) \text{ Msun}$

- $m_2 = 66 (+17/-18) \text{ Msun}$



Nobel Prize
on BHs...

The problem... these BHs shouldn't exist!



BH no go zone

Why?

- Reason of the BH no go zone:

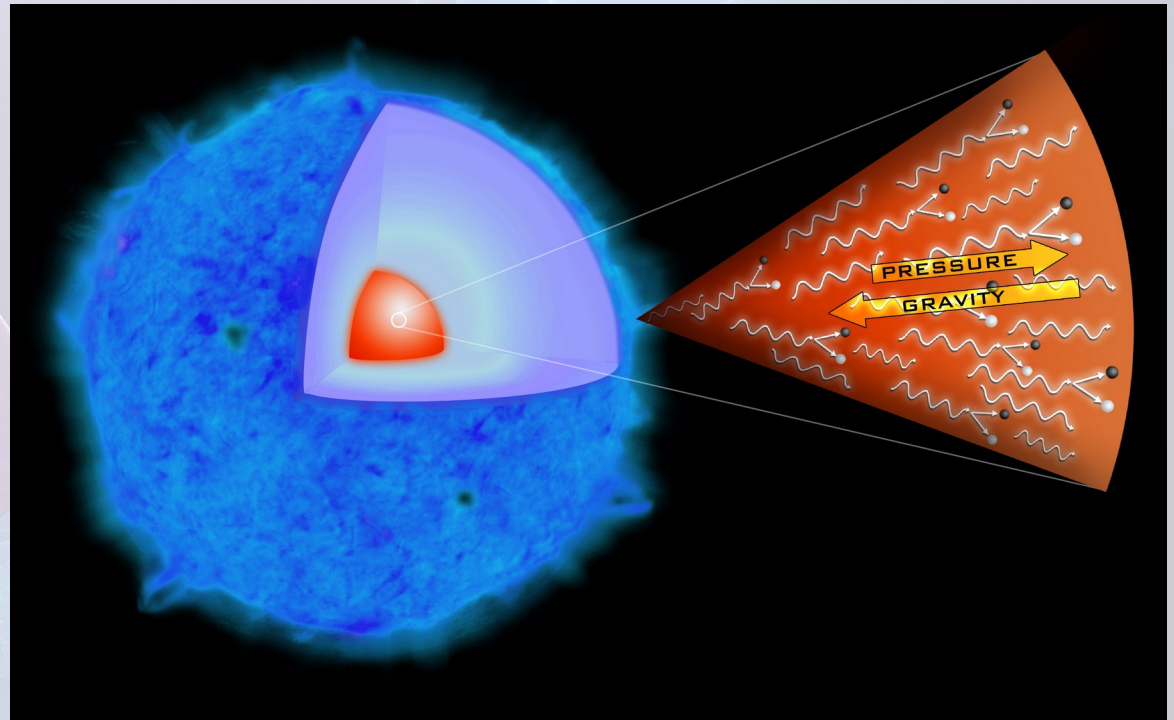
Pair Instability

Photon pressure
drops due to
 $\gamma\gamma \rightarrow e^- \text{ \& \ } e^+$

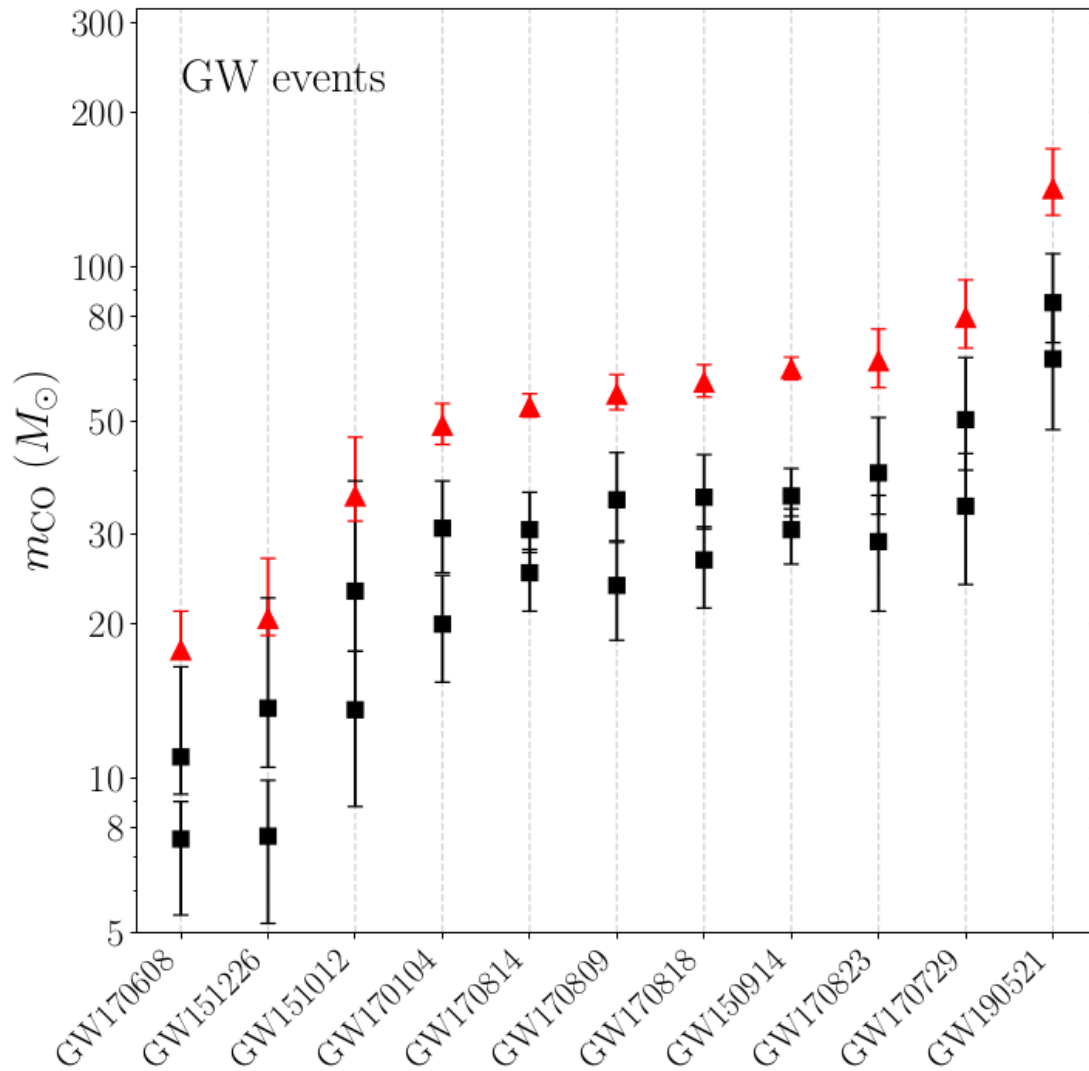
Collapse

Explosive O-burning
→ SN

No remnant!



Yet...



GW190521 (George)

$m_1 = 85 (+21/-14)$

M_{sun}

$m_2 = 66 (+17/-18)$

M_{sun}

Ziegler & Freese (2020) [arXiv2010.00254]

(1st Oct. 2020)

Filling the Black Hole Mass Gap: Avoiding Pair Instability in Massive Stars through Addition of Non-Nuclear Energy

- an energy source is added to the star in addition to nuclear fusion
- example of an extra energy source is *dark matter annihilation* within the star
- or something else.

Belczynski (2020) [arXiv2009.13526]

(28th Sept. 2020)

THE MOST ORDINARY FORMATION OF THE MOST UNUSUAL DOUBLE BLACK HOLE MERGER

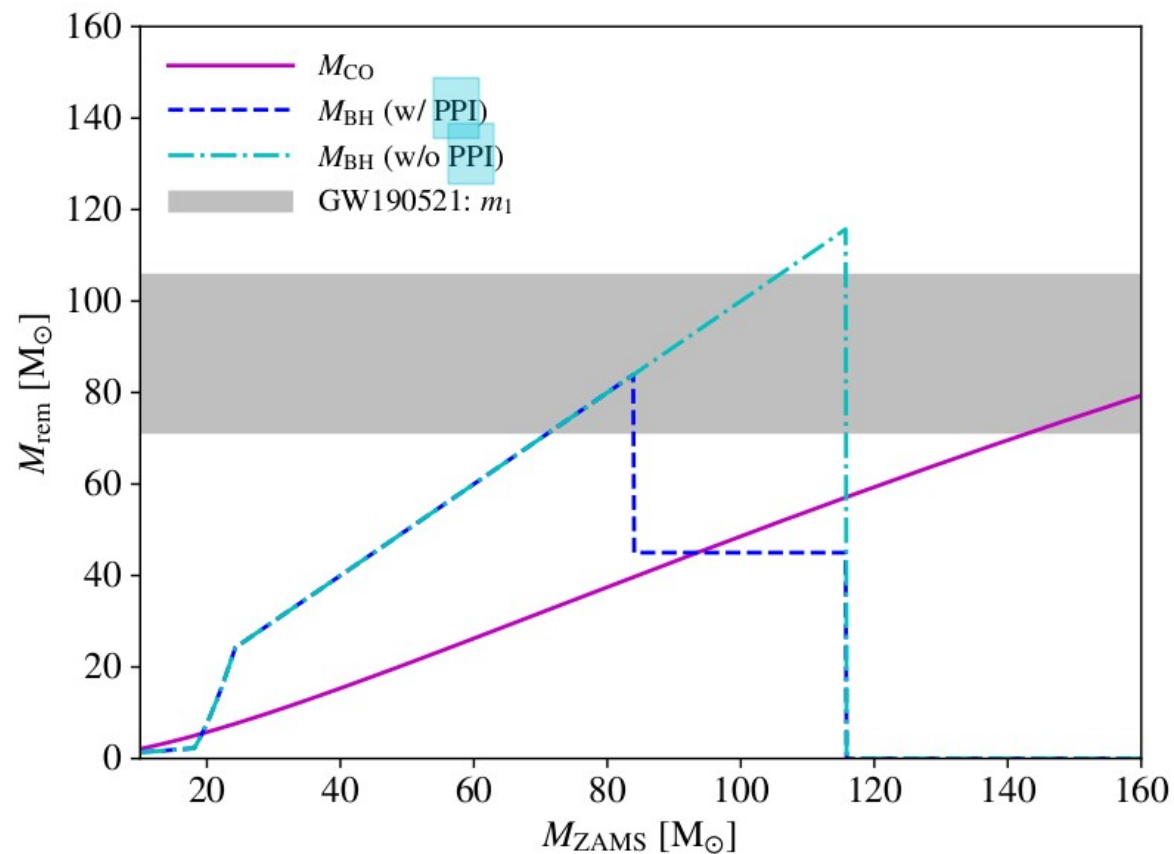
- model* “with standard assumptions about input physics”
*population synthesis
- employing newly estimated uncertainties** on pulsational pair-instability mass-loss
**see later slide
 - possibility of forming BHs with mass up to $\sim 90 M_{\text{sun}}$

Liu & Bromm (2020) [arXiv2009.11447]

(24th Sept. 2020)

The Population III origin of GW190521

- no real models, just statistics w/ and w/o PI



Farrell et al. (2020) [arXiv2009.06585]

(14th Sept. 2020)

Is GW190521 the merger of black holes from the first stellar generations?

- Proper models!! ;)
 - crappy figures...
- “H-He interactions” modifying the core mass during He-burn.

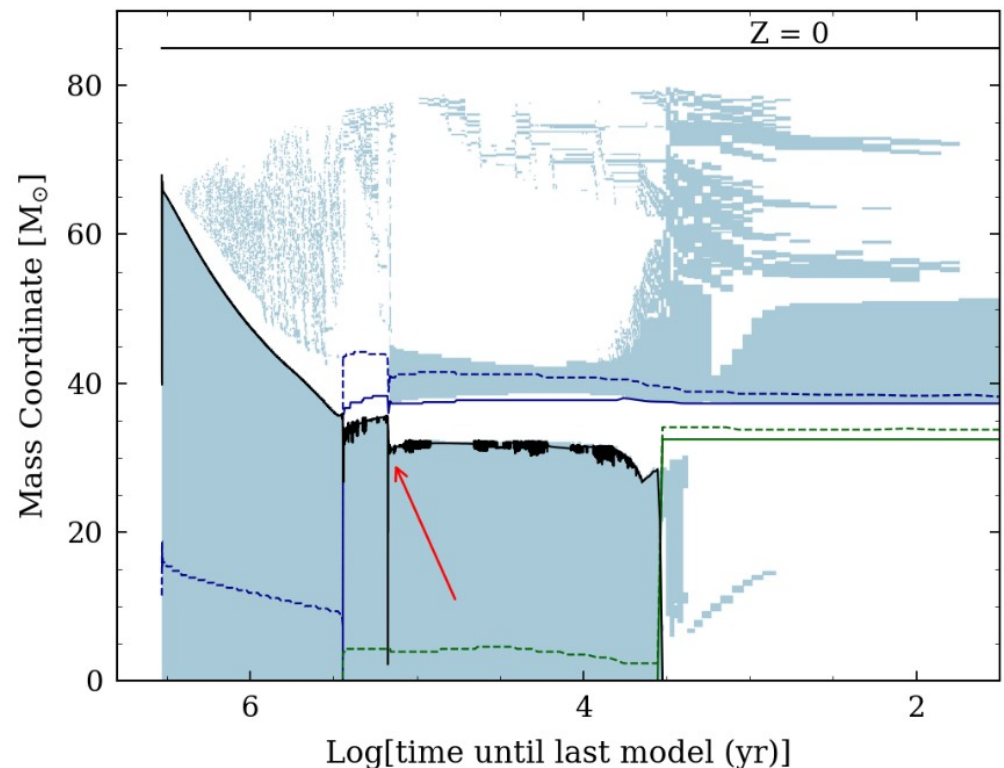


Figure 2. Kippenhahn diagram of a GENEC non-rotating 85 M_{\odot} model at $Z = 0$. The red arrow indicates the H-He shell interaction.

Clarkson & Herwig (2020) [arXiv2005.07748]

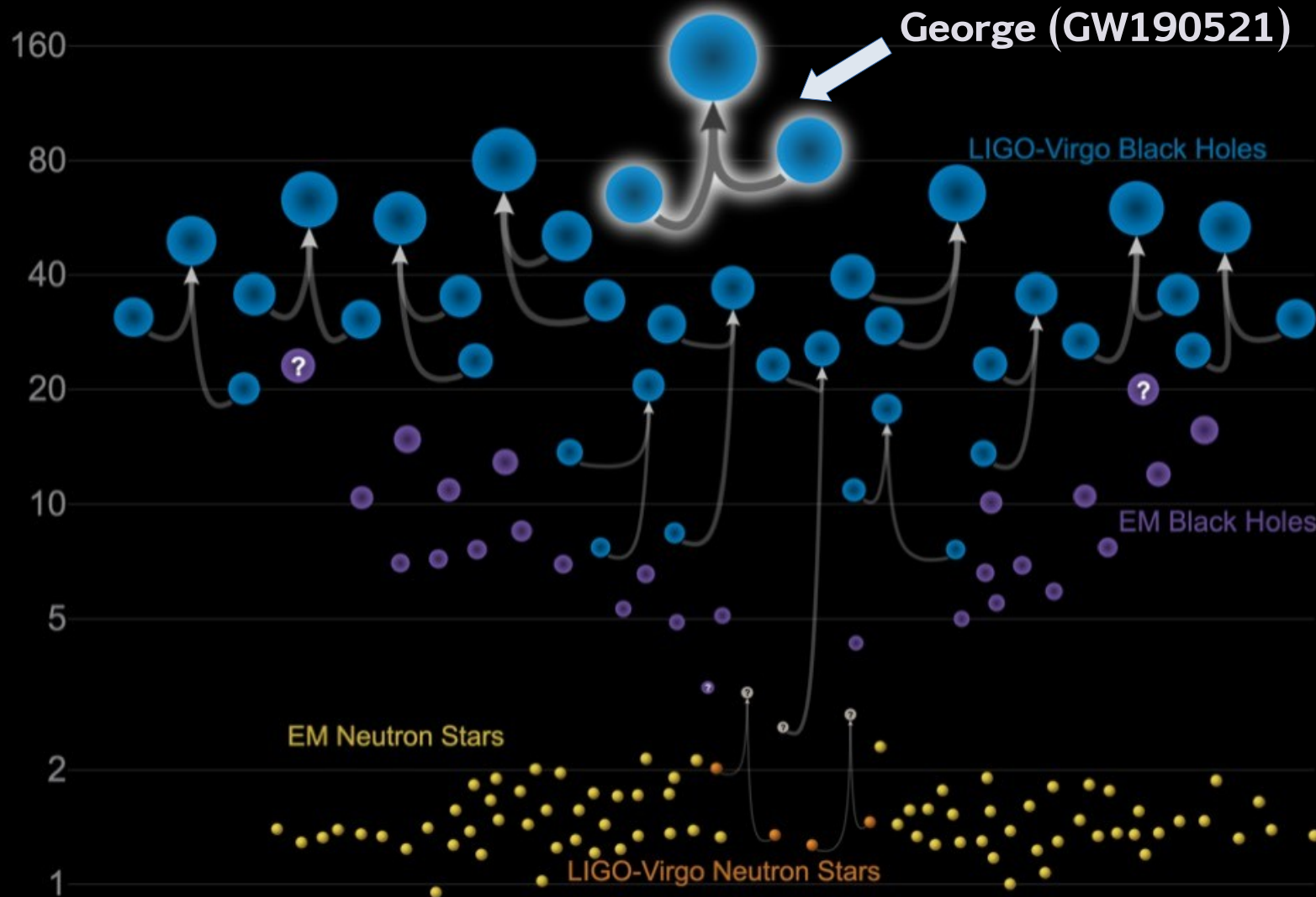
(15th May. 2020)

Convective H-He Interactions in Massive Population III Stellar Evolution Models

- “newly estimated uncertainties” in *Belczynski’20*
- Extra mixing* → “H-He interactions”** → local nuclear energy release
- 3D is needed
 - *five sets of mixing assumptions (1D magic?!)
 - **extra fuel (H) for burning

Masses in the Stellar Graveyard

in Solar Masses



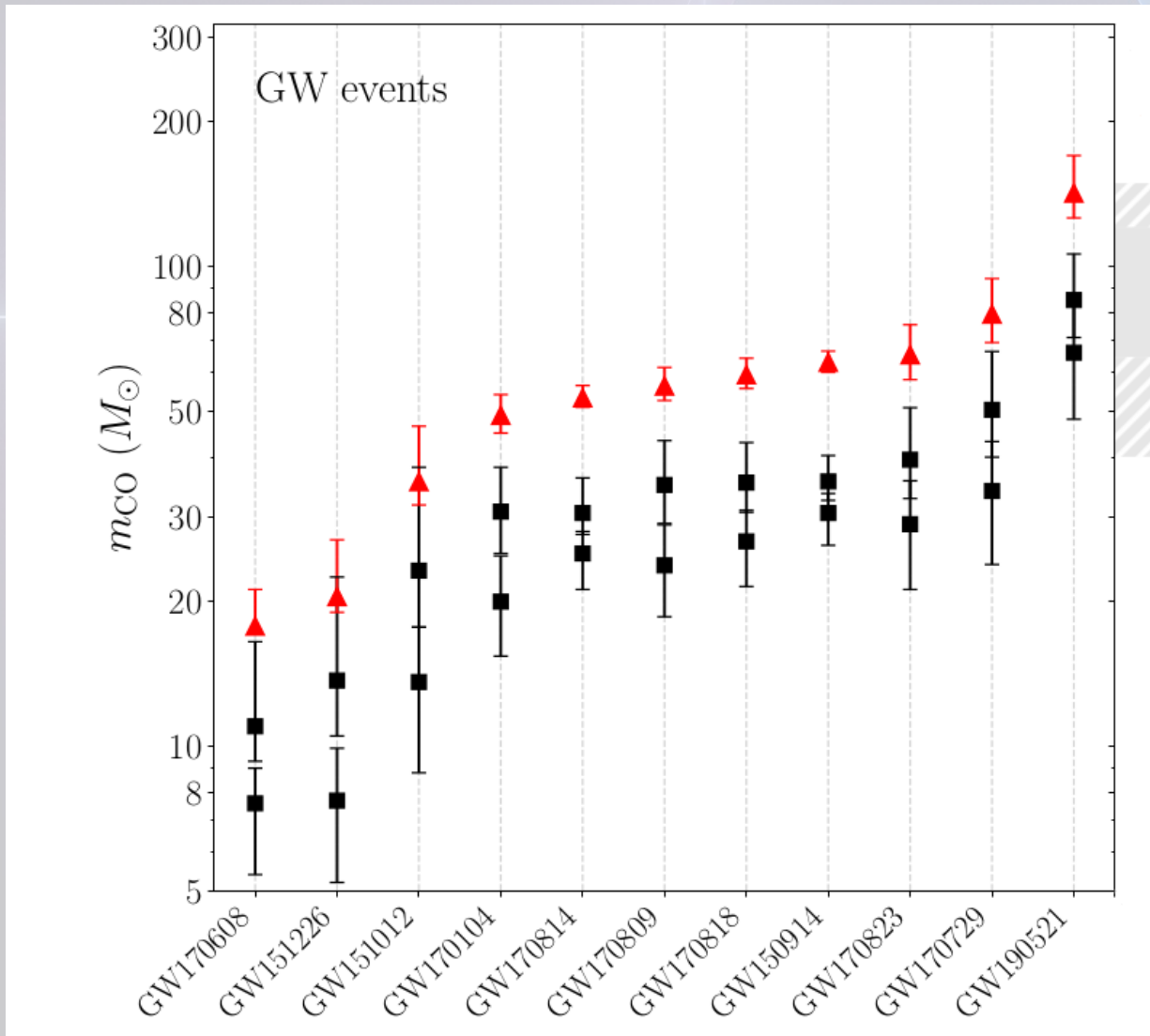
Updated 2020-09-02

Another trial to solve the case of
“the impossible GW190521” (George)

Dorottya Szécsi

19. Jan. 2021 – Köln

The BHs of GW190521 shouldn't exist...



BH no go zone

Why?

- Reason of the BH no go zone:

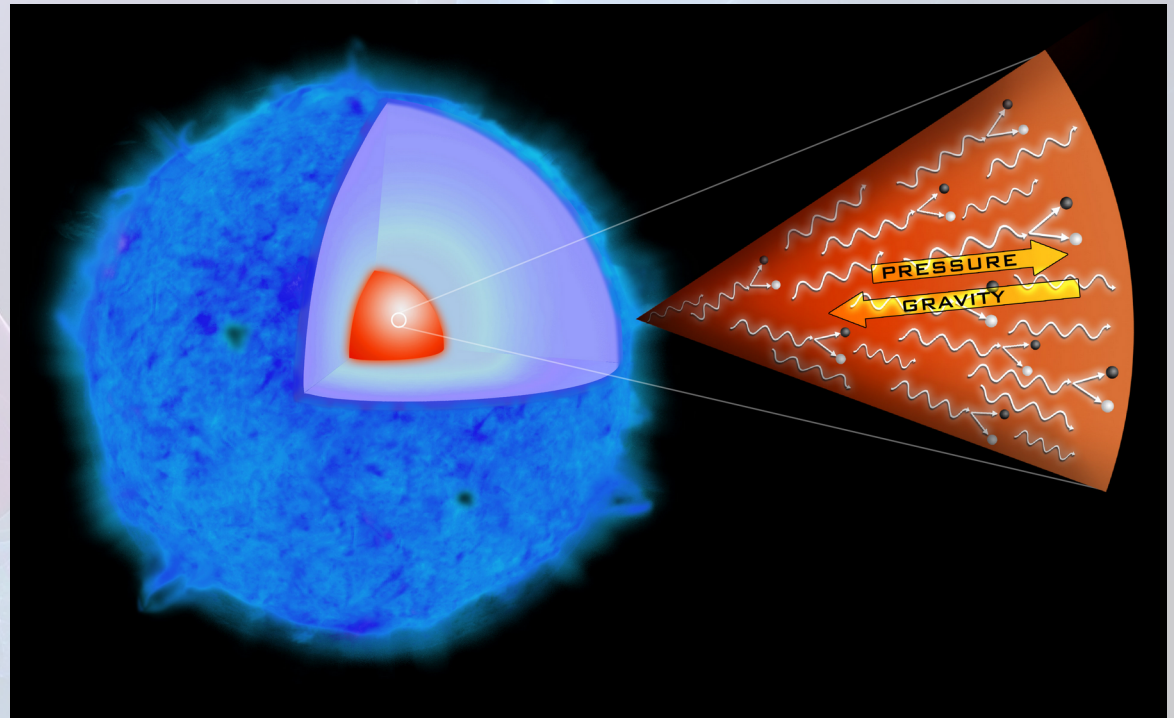
Pair Instability

Photon pressure
drops due to
 $\gamma\gamma \rightarrow e^- \text{ \& \ } e^+$

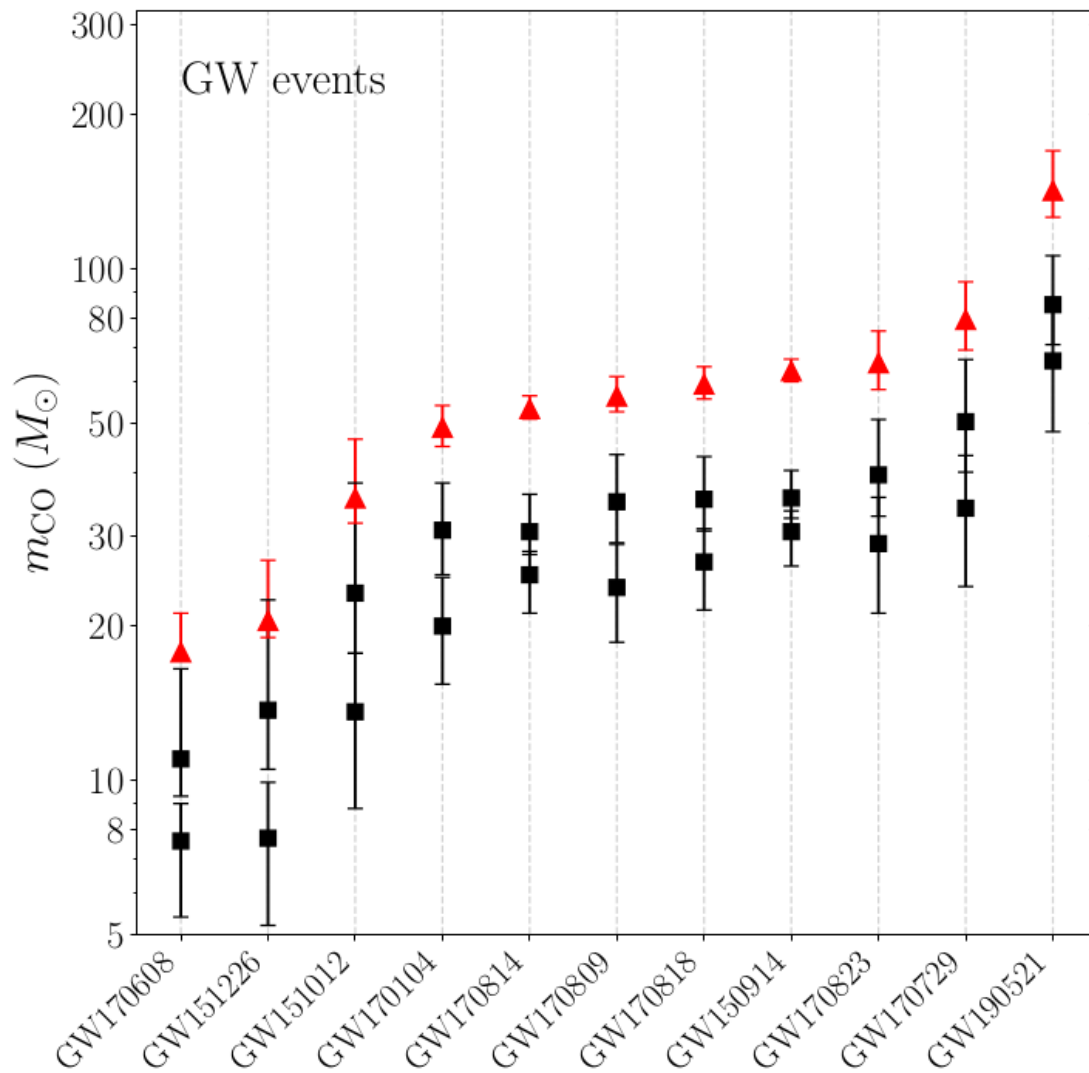
Collapse

Explosive O-burning
→ SN

No remnant!



Yet...



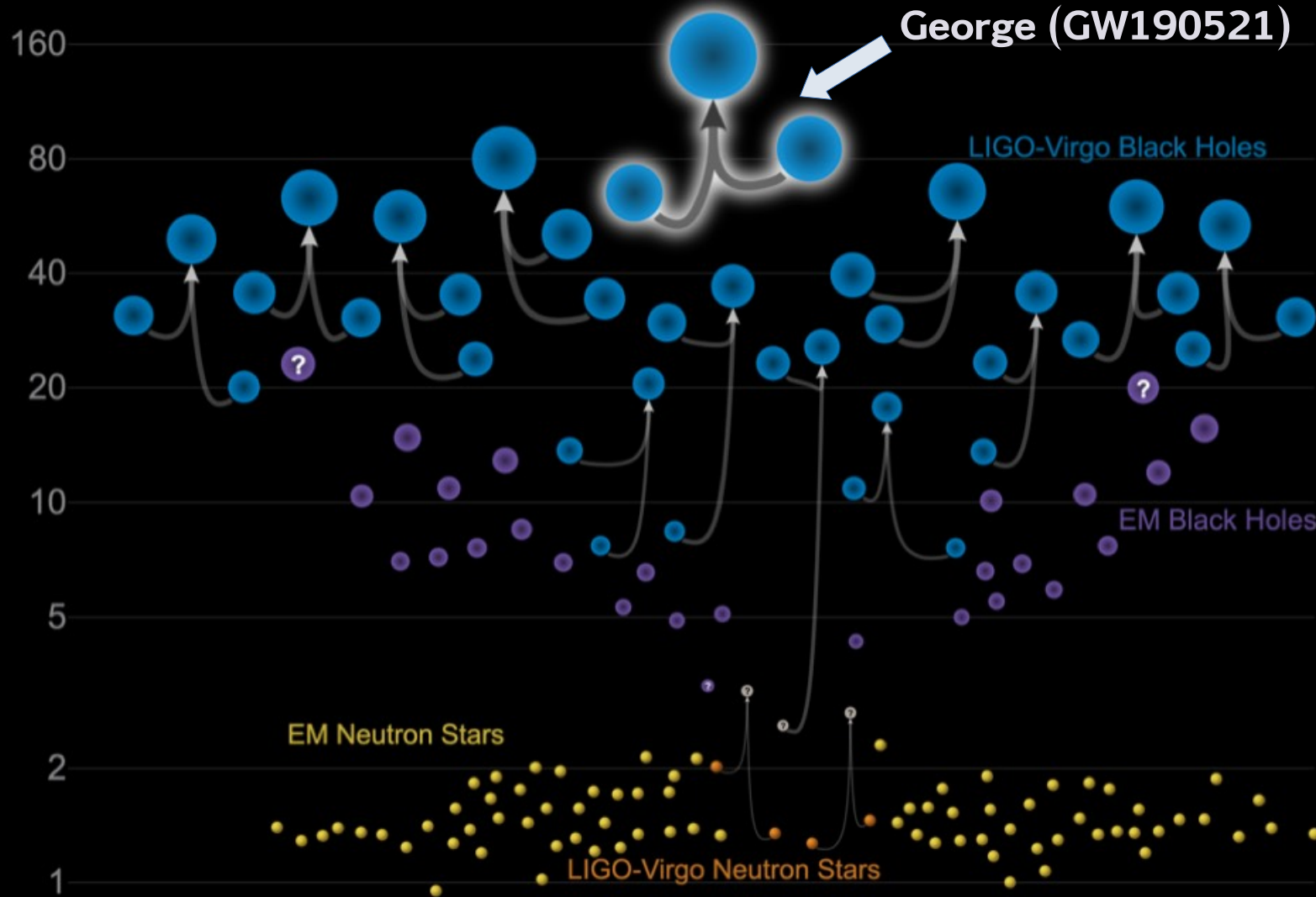
GW190521 (George)

$m_1 = 85 (+21/-14)$
 M_{sun}

$m_2 = 66 (+17/-18)$
 M_{sun}

Masses in the Stellar Graveyard

in Solar Masses



Updated 2020-09-02

Vink & al. (2020) [arXiv2010.11730]

(19th Oct. 2020)

Maximum Black Hole mass across Cosmic Time

- what we need:
 - a star that avoids the PI
 - while keeps enough mass to form a $>80 M_{\text{sun}}$ BH
- what they offer:
 - magic tricks with stellar codes (tweaked parameters)

Vink & al. (2020) [arXiv2010.11730]

(19th Oct. 2020)

Maximum Black Hole mass across Cosmic Time

- LIST OF MAGIC TRICKS

- extending “line driven wind” type mass loss from 10kK down to 8kK (?)
- lowering overshooting efficiency (??)
- making the wind strength scale with host metallicity (???)

