Ashes to Ashes

White Dwarfs from Double White Dwarf Mergers

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White Dwarfs from Physics to Astrophysics
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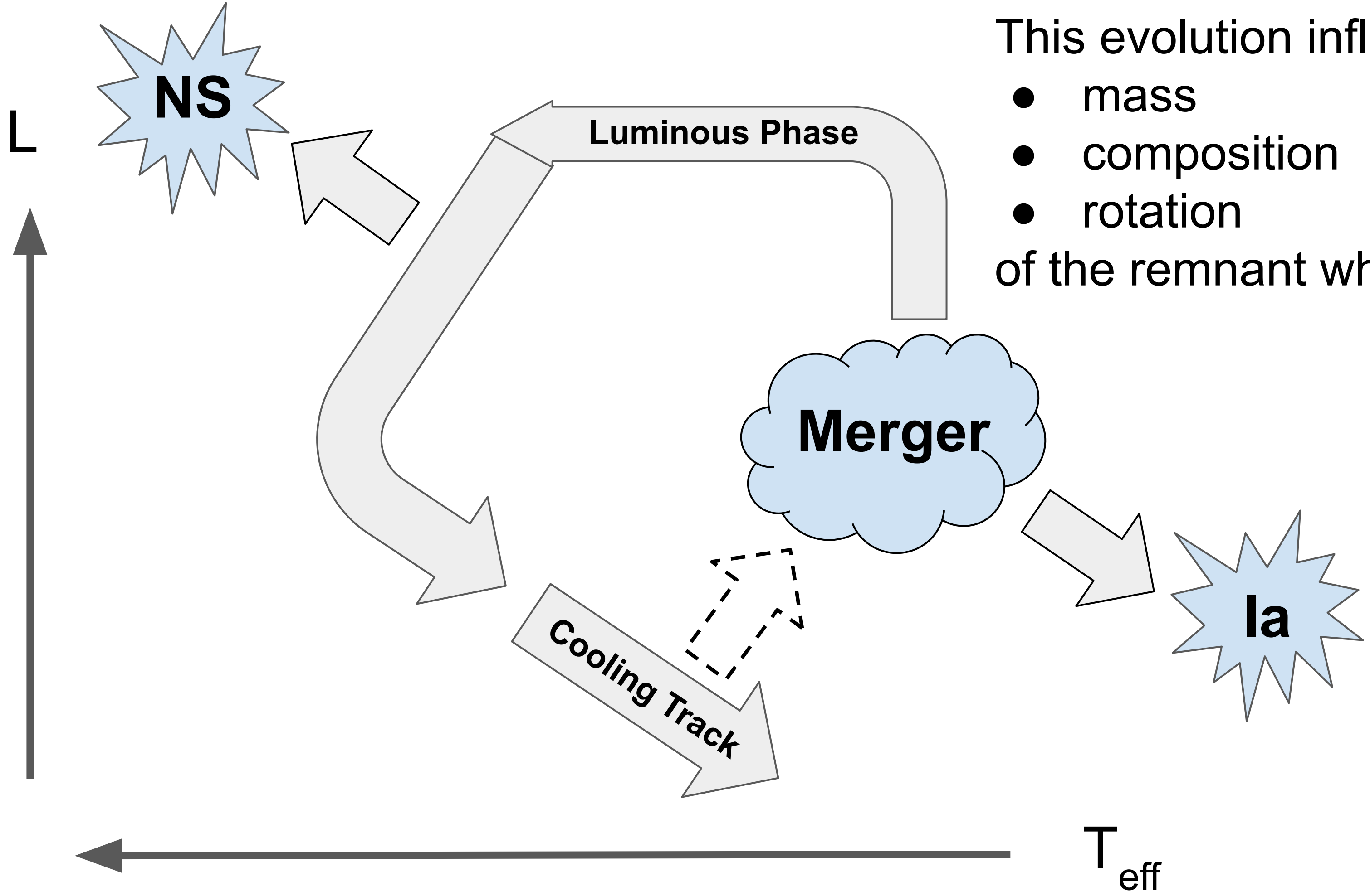
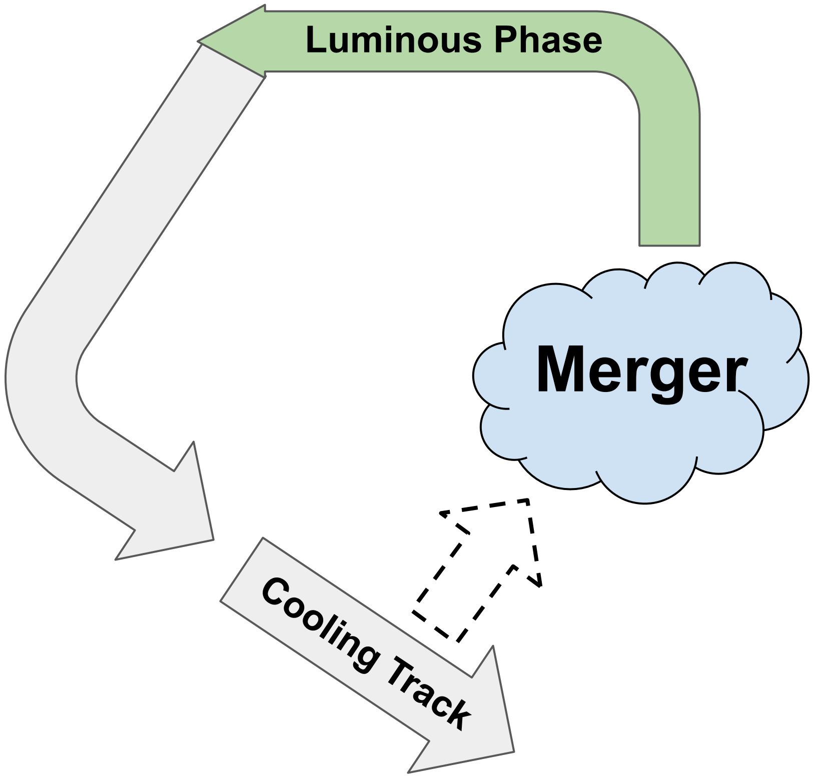
This evolution influences the

- mass
- composition
- rotation

of the remnant white dwarf.





Helium-rich merger remnants remain luminous for their nuclear timescales.

- Single hot subdwarfs (~100 Myr)
- R Coronae Borealis stars (~100 kyr)

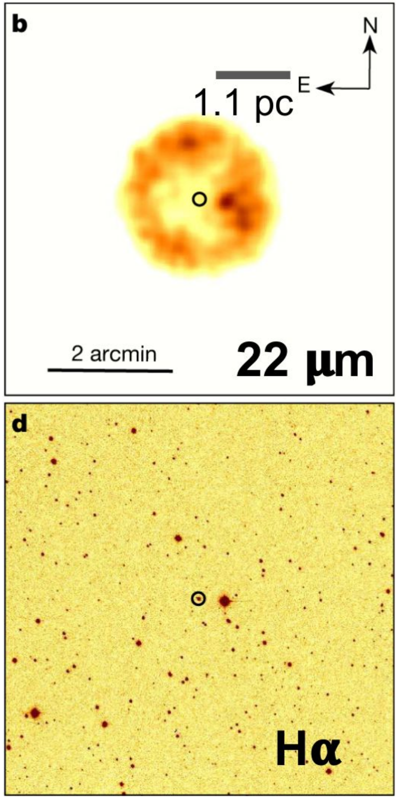
Other merger remnants remain luminous for their ~10 kyr thermal timescales.

WS35 / J00531 / IRAS 00500+6713

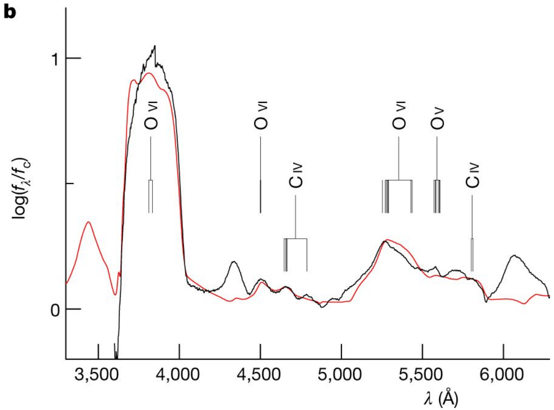
"A massive white dwarf merger product before final collapse"

Gvaramadze et al. *Nature*, 569, 684 (2019)

Infrared nebula with absent Hα.

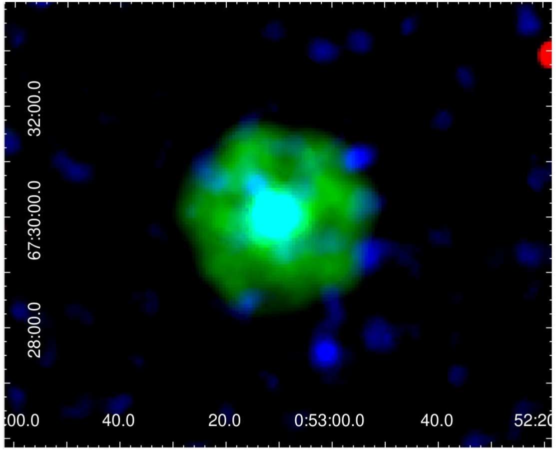


Wolf-Rayet type central object with absent HeII.



Gvaramadze et al. (2019)

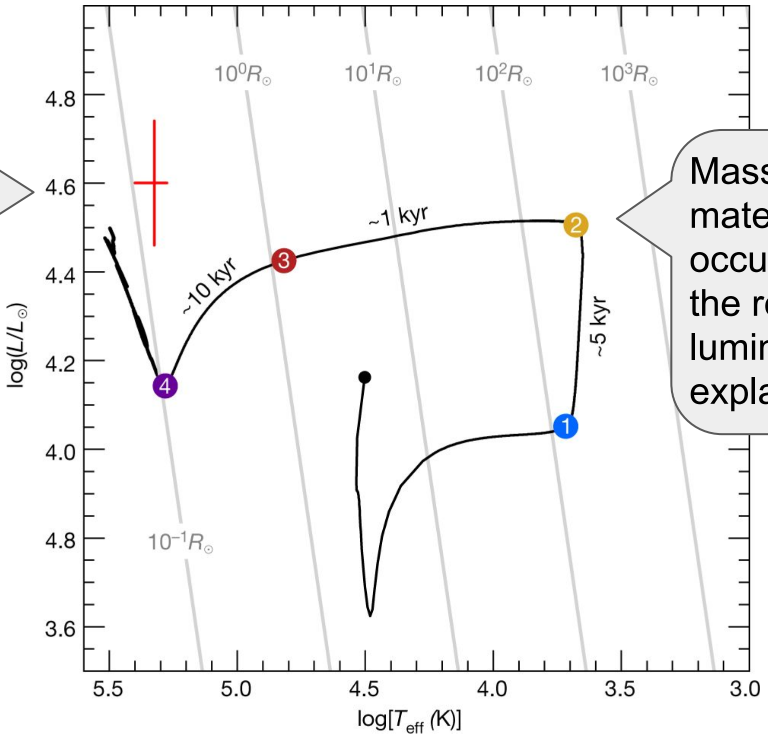
X-ray emission showing lines of C/O-burning products.



Oskinova et al. (2020)

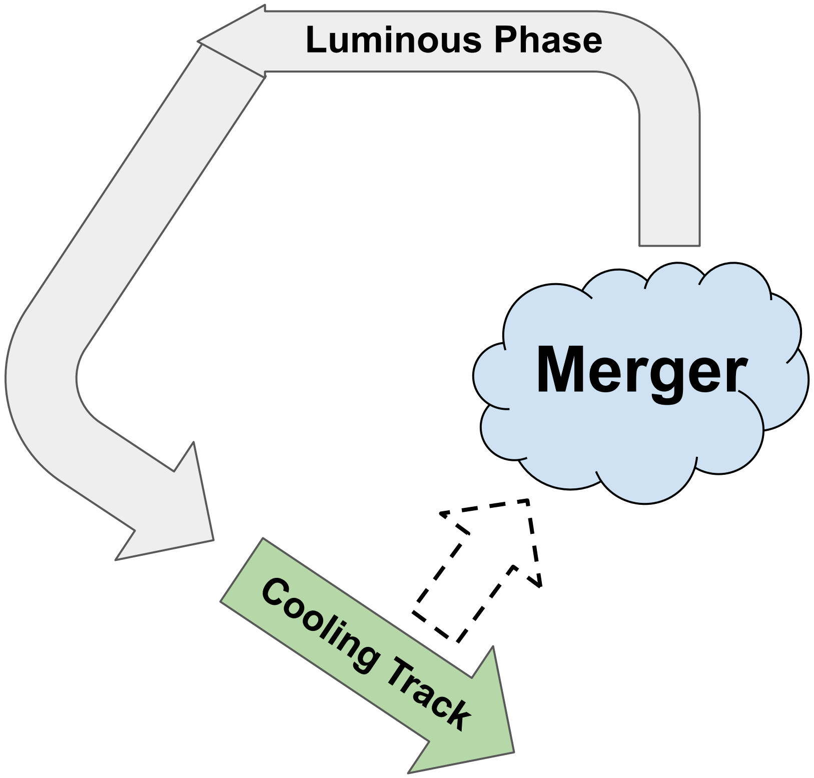
A WD-WD merger is a natural explanation for this object.

Hot, C/O-dominated object with luminosity intermediate between CSPNe ($\log L/L_{\odot} < 4$) WR stars ($\log L/L_{\odot} > 5.2$).



Mass loss of H/He-free material at ~100 km/s occuring ~10 kyr before the remnant reaches a luminous, blue phase explains a ~1 pc nebula.

Gvaramadze et al. (2019); Model from JS et al. (2016)



White dwarfs descended from WD-WD mergers may stand out in their:

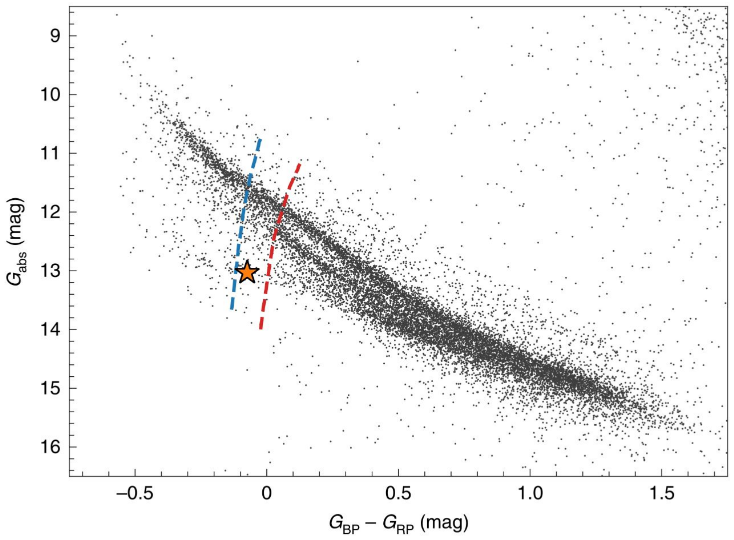
- compositions (less H/He, more C)
- rotation rates (rapid, P~10 min)
- magnetic fields (strong, B~100 MG)
- kinematics (fast, older ages)

The population of WDs $\gtrsim 1\ M_\odot$ is an excellent place to look for WDs from mergers because they may represent $\gtrsim$20% of objects at these masses.

(e.g., Temmink et al. 2020)

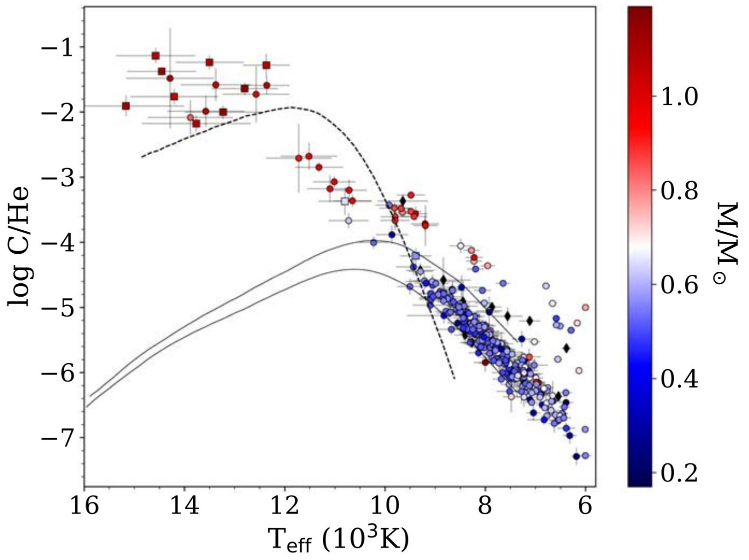
WDs from mergers may stand out in their compositions.

A 1.14 $M_\odot$ white dwarf with a mixed hydrogen-carbon atmosphere.



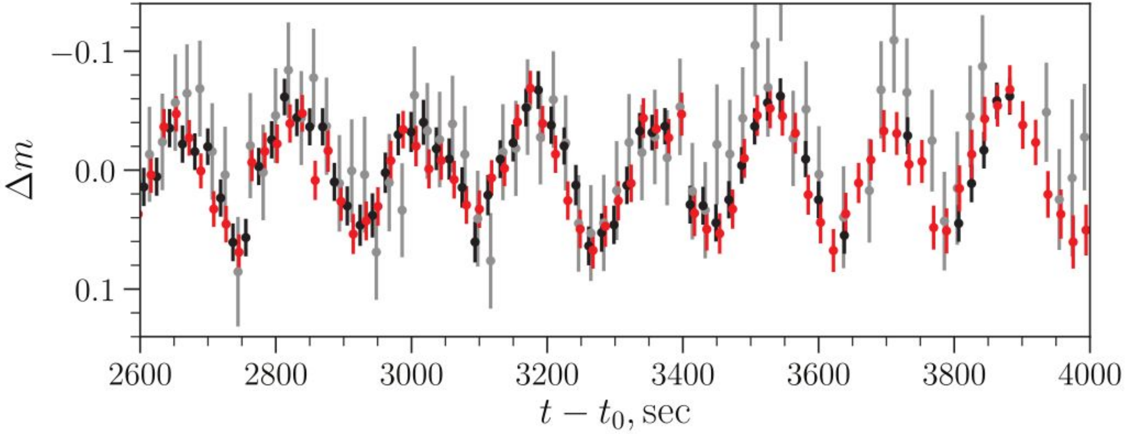
Hollands et al. (2020)

Massive DQ WDs show a distinct carbon abundance pattern.



Coutu et al. (2019); see also Koester & Kepler (2019)

WDs from mergers may stand out in their rotation rates.



WDJ183202.83+085636.24
M = 1.33 $M_\odot$
P_{rot} = 353 s
Pshirkov et al. (2020)

RE J0317-853
M = 1.3 $M_\odot$
P_{rot} = 725 s
Barstow et al. (1995);
Ferrario et al. (1997)

SDSSJ125230.93−023417.7
M = 0.65 $M_\odot$
P_{rot} = 317 s
Reding et al. (2020)

ZTF J190132.9+145808.7
M = 1.35 $M_\odot$
P_{rot} = 416 s
Caiazzo et al. (submitted)

WDs from mergers may stand out in their magnetic fields.

RE J0317-853 has a ~300 MG field.

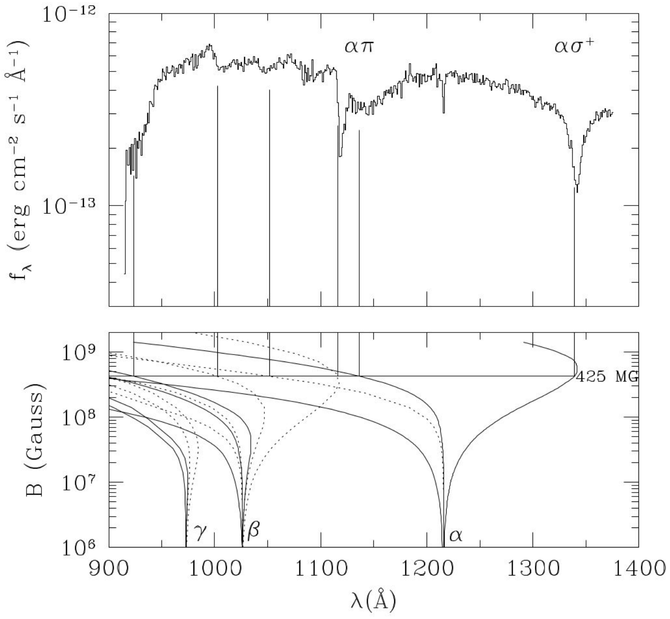


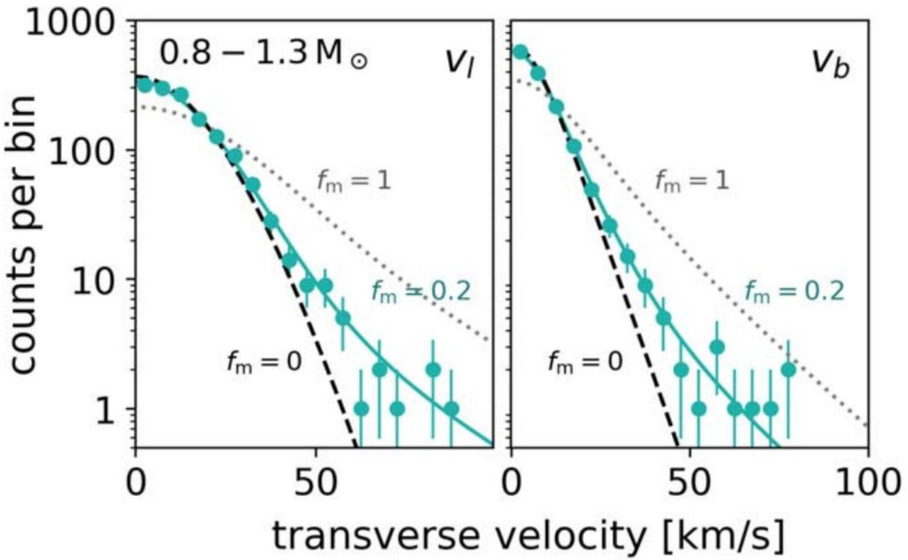
Figure from Vennes et al. (2003)

J190132.74+145807.18 is strongly magnetic (Caiazzo et al.).

In the 100 pc WD sample in the SDSS footprint (Kilic et al. 2020) there are some DC WDs with $T_{eff} \approx$ 40kK and M ≈ 1.3 $M_\odot$:

- WDJ011810.31-015612.23
- WDJ071816.42+373139.24

WDs from mergers may stand out in their kinematics.



Cheng et al. (2020)

At a given mass, merger WD systems are older than single star WD systems because of the:

- longer time to form the WDs
- delay time of the merger

Older populations experience more “heating” in the galactic disc so and show higher velocity dispersions.

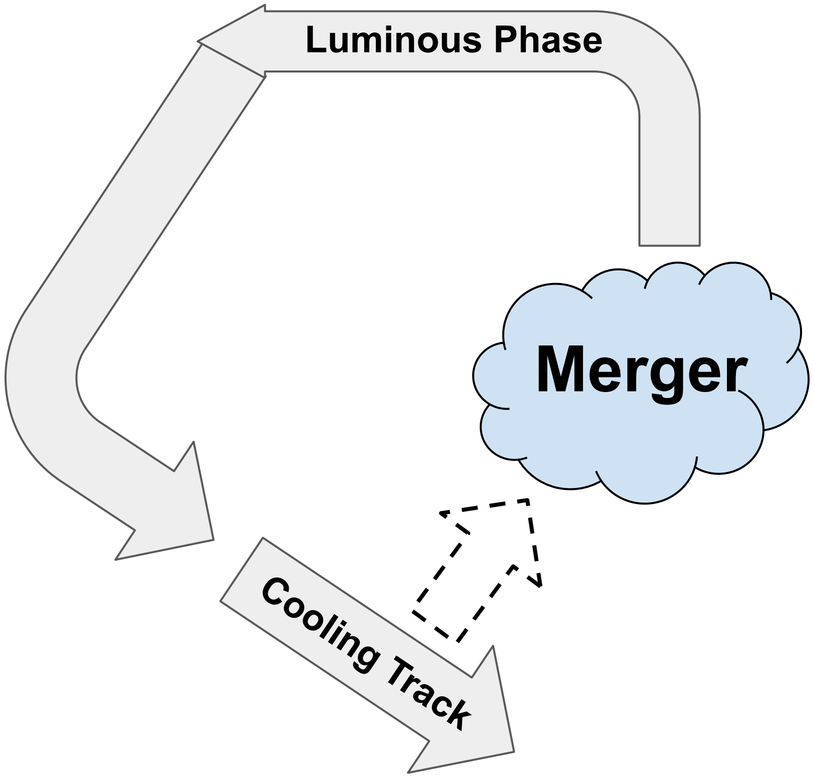
WDs from mergers may stand out in multiple ways.

1	Name	Gaia DR2 ID	Spectral Type	Magnetic	Rotation	Kinematics
2	SDSS J114012.81+232204.7	3980865789203927680	DA			
3	SDSS J132926.04+254936.4	1448232907440917760	DA			
4	SDSS J172736.28+383116.9	1343557102670161664	DA			
5	SDSS J180001.21+451724.7	2115952197141317888				
6	SDSS J221141.80+113604.5	2727596187657230592	DAH	Magnetic		> 50 km/s
7	SDSS J225513.48+071000.9	2712093451662656256	DC-like	Magnetic		
8	SDSS J235232.30−025309.2	2448933731627261824	DA			> 50 km/s
9	WD J004917.14−252556.81	2345323551189913600				
10	WD J010338.56−052251.96	2524879812959998592	DAH	Magnetic		
11	WD J025431.45+301935.38	129352114170007680	DC			
12	WD J032900.79−212309.24	5099116118775025408				
13	WD J042642.02−502555.21	4781653099991148928				
14	WD J043952.72+454302.81	253936196167057664				
15	WD J055631.17+130639.78	3343720447543820672				
16	WD J060853.60−451533.03	5567732956694899712				
17	WD J070753.00+561200.25	988421680189764224				
18	WD J080502.93−170216.57	5721057173131773184				> 50 km/s
19	WD J093430.71−762614.48	5203792030921237248				
20	WD J095933.33−182824.16	5671878015177884032				
21	WD J111646.44−160329.42	3559695493657381248				> 50 km/s
22	WD J125428.86−045227.48	3678497445865946624				
23	WD J174441.56−203549.05	4118923497232723072				
24	WD J181913.36−120856.44	4153618204302689920				
25	WD J183202.83+085636.24	4479342339285057408	DBA		353 s	
26	WD J190132.74+145807.18	4506869128279648512	DC (DAH)	Magnetic	416 s	

8 of the 25 objects in the Montreal WD database 100 pc sample with masses > 1.3 $M_\odot$ show at least one potential merger signature.

Kilic et al. (2021)

We want a uniformly characterized sample in order to be able to tell a unified story for the merger population in terms of its composition, rotation, magnetism, and kinematics.



We have increasingly complete and well characterized samples of the local white dwarf population.

Observations are clearly revealing the significant role that double white dwarf mergers play in the formation of single white dwarfs.

This growing number of likely merger products will let us tell a more complete story of the merger-formed WD population.