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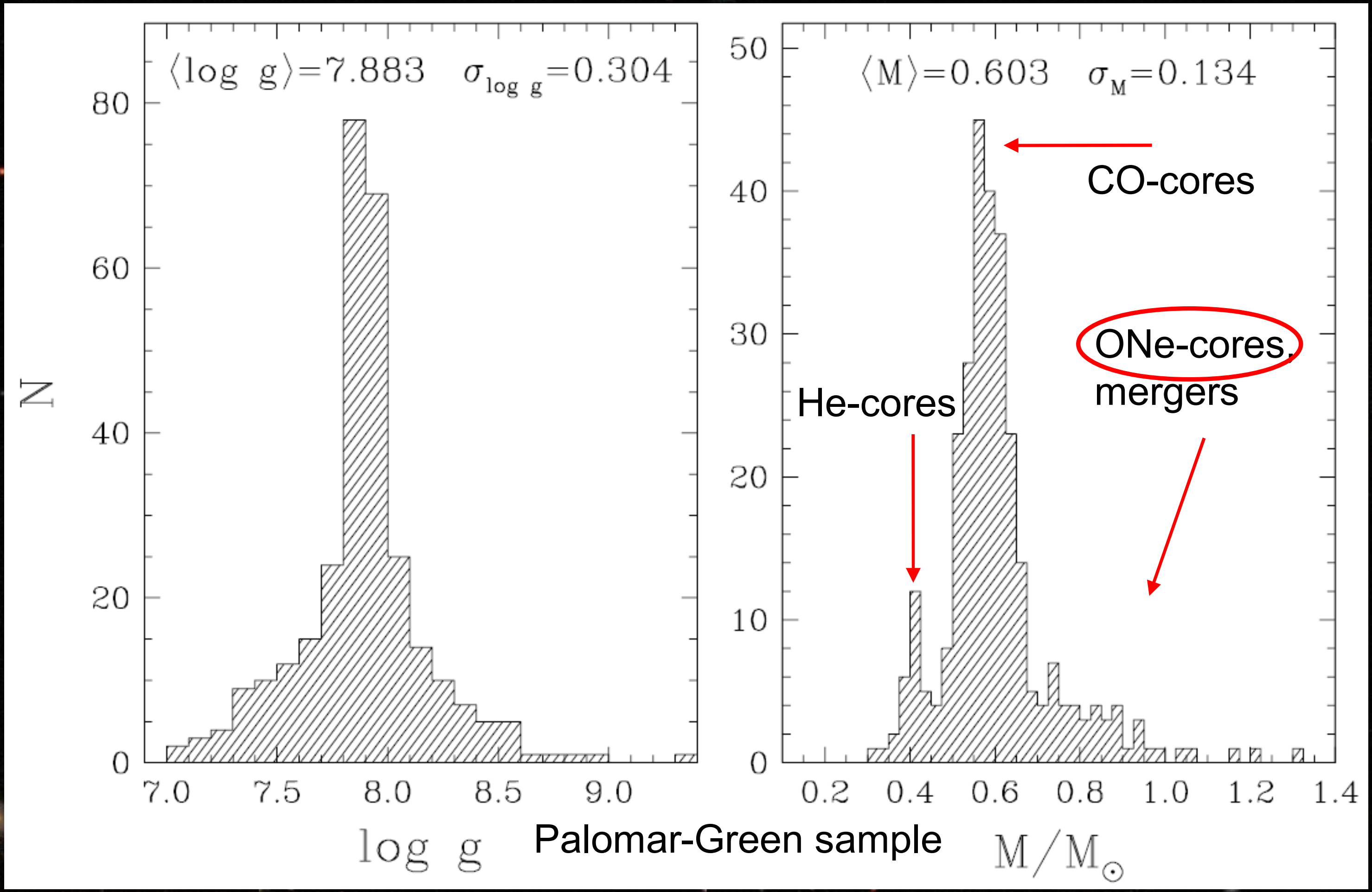
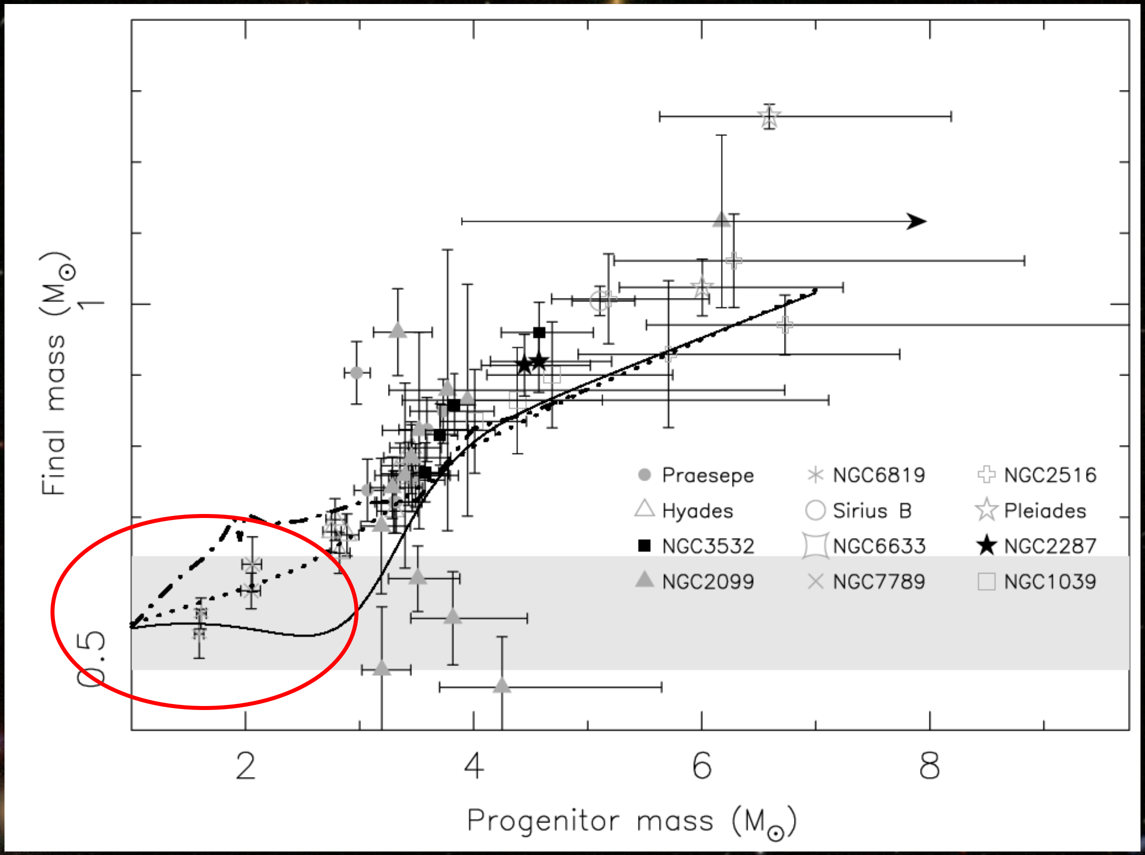
White dwarfs with oxygen-rich atmospheres

White dwarf mass distribution



Liebert et al. 2005, ApJS 156, 47

The initial-mass final-mass relation

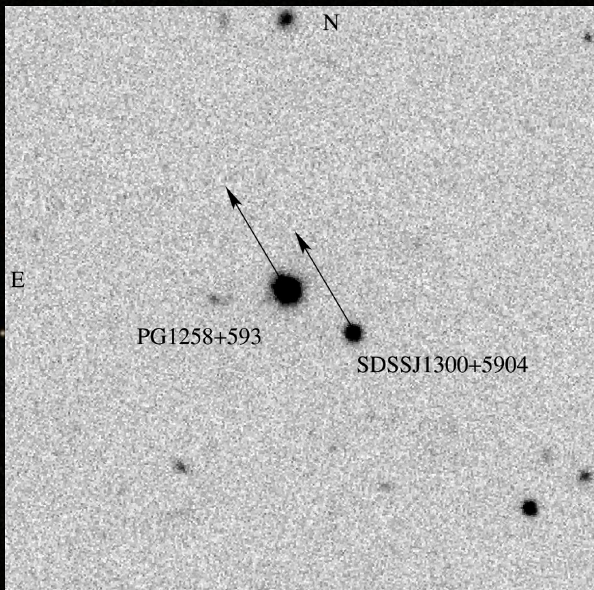


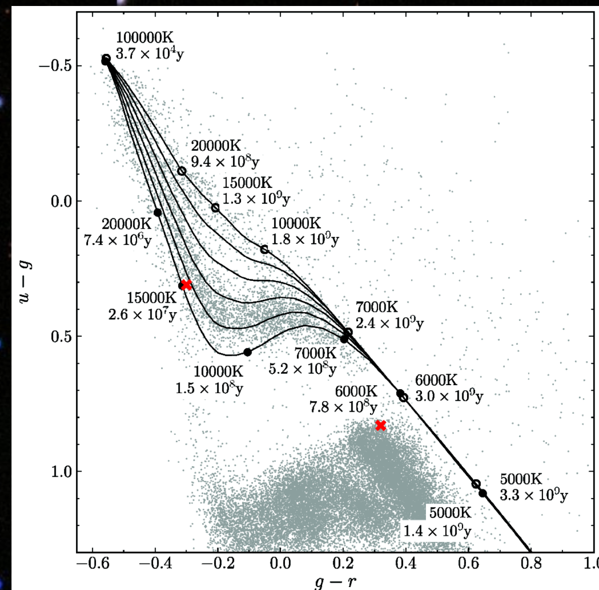
mostly based on WDs in open clusters & stellar models

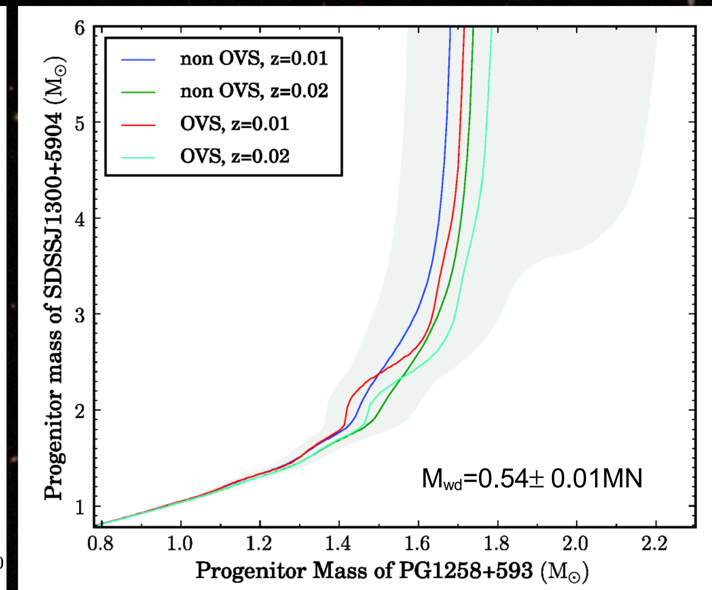
e.g. Dobbie et al. 2009, MNRAS 395, 2248

practically no constraints at M<2Msun

IMF constraints from common proper motion WD pairs [off topic]







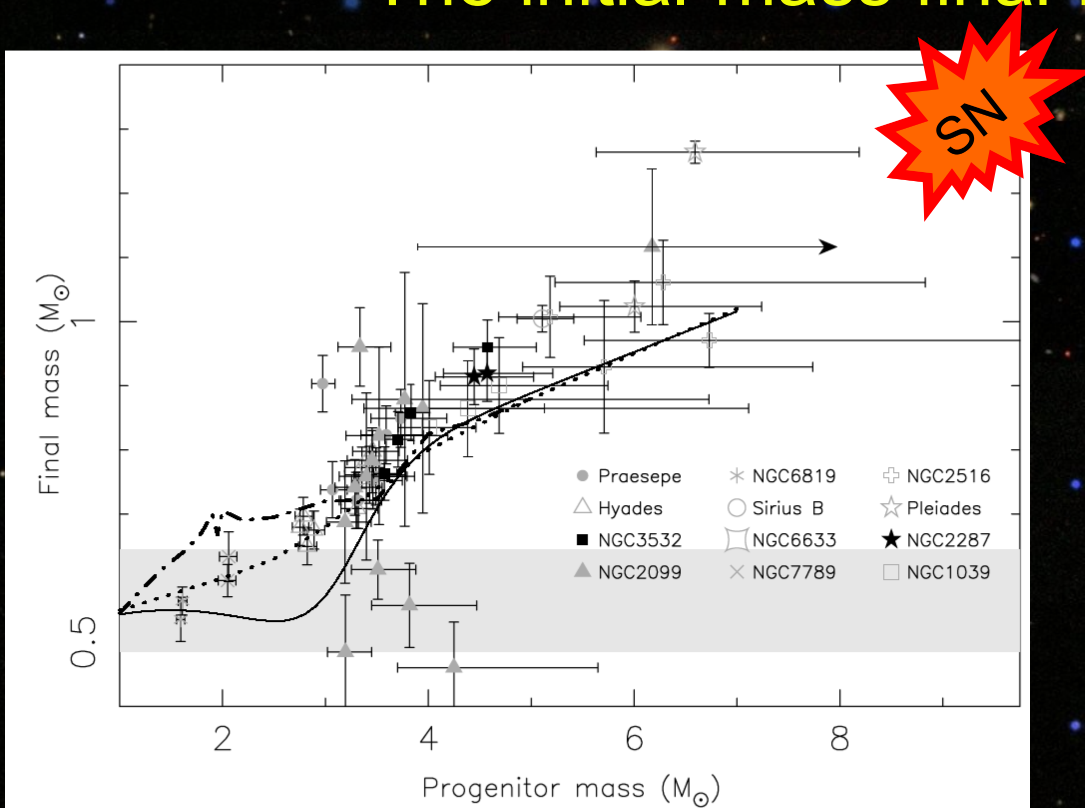
$\Delta\tau$=(1.67± 0.05)x109yr

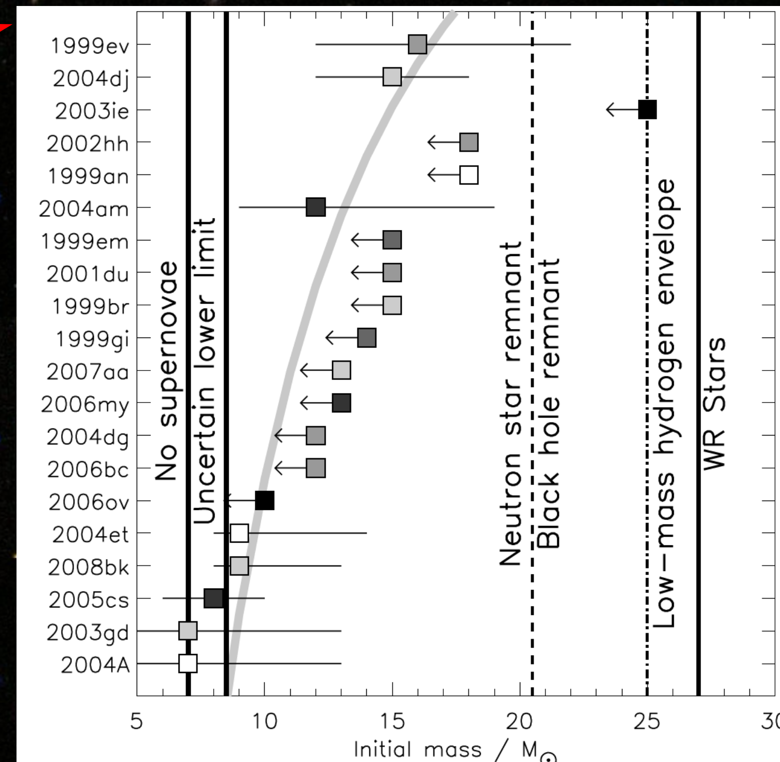
Girven et al. 2010, MNRAS 404, 159

WD pairs with unequal cooling ages strongly constraint their progenitor masses

see Finley & Koester 1997, ApJ 489L, 79

The initial-mass final-mass relation





SN for M>8.5$_{(+1-1.5)}$ Msun

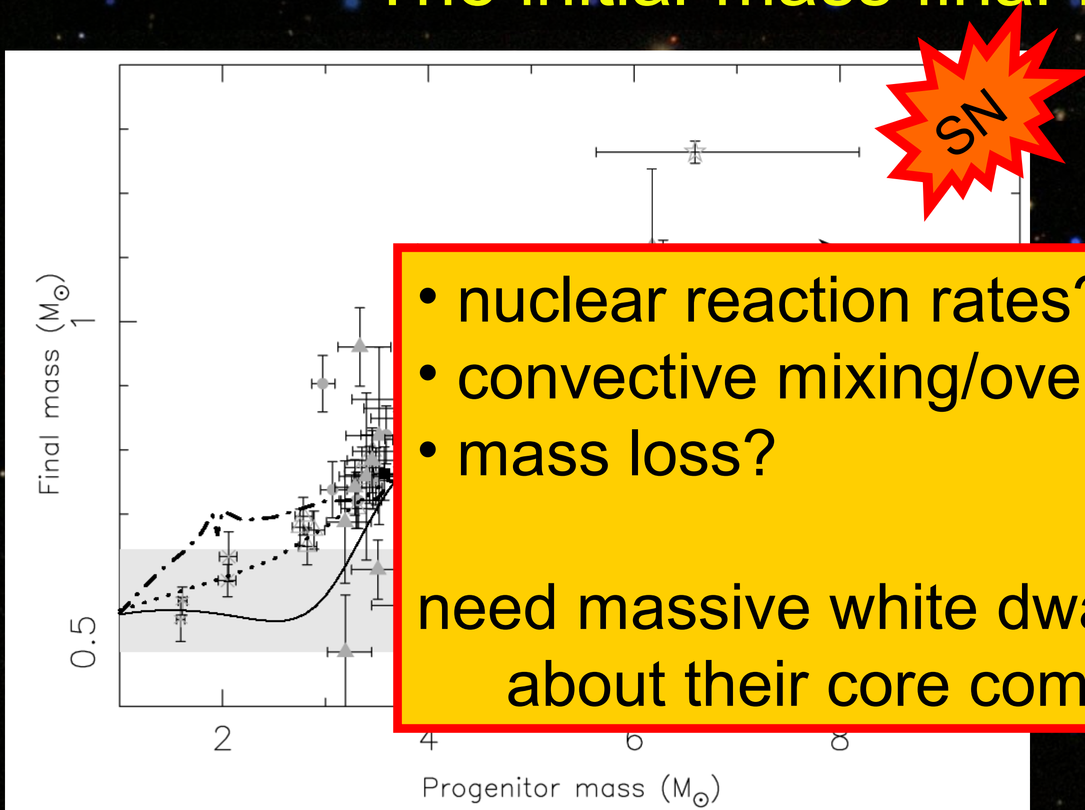
Smartt et al. 2009, MNRAS 395, 1409

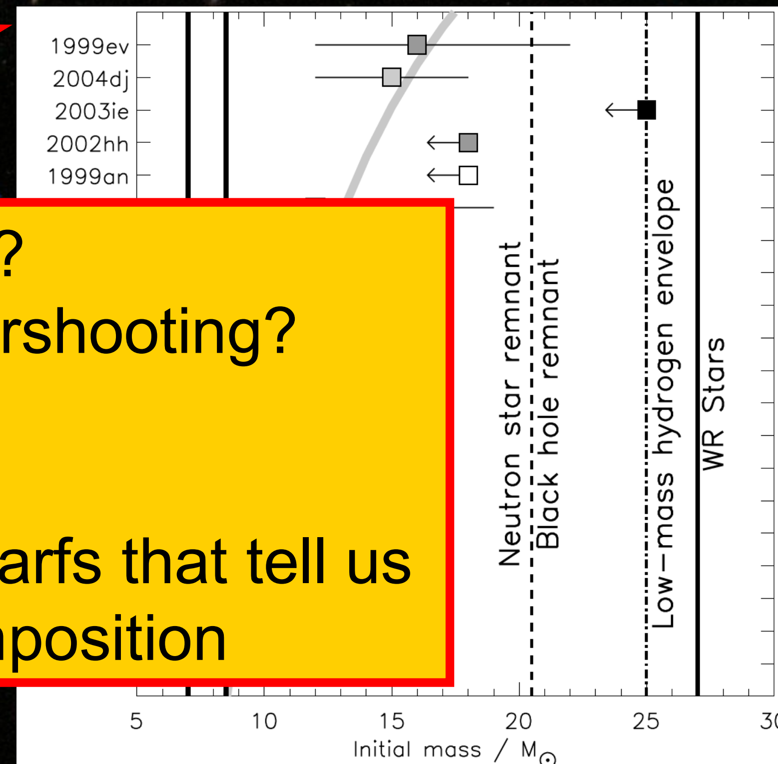
The above summary suggests that evolution of stars in the mass range of 8–10 $M_\odot$ as well as slightly above 10 $M_\odot$ will have a variety of interesting outcomes and thus deserves further study.

Nomoto 1984, ApJ 277, 791

- ONe core
- electron-capture SN
- core-collapse SN

The initial-mass final-mass relation





- nuclear reaction rates?
- convective mixing/overshooting?
- mass loss?

need massive white dwarfs that tell us about their core composition

SN for M>8.5$_{(+1-1.5)}$ Msun

Smartt et al. 2009, MNRAS 395, 1409

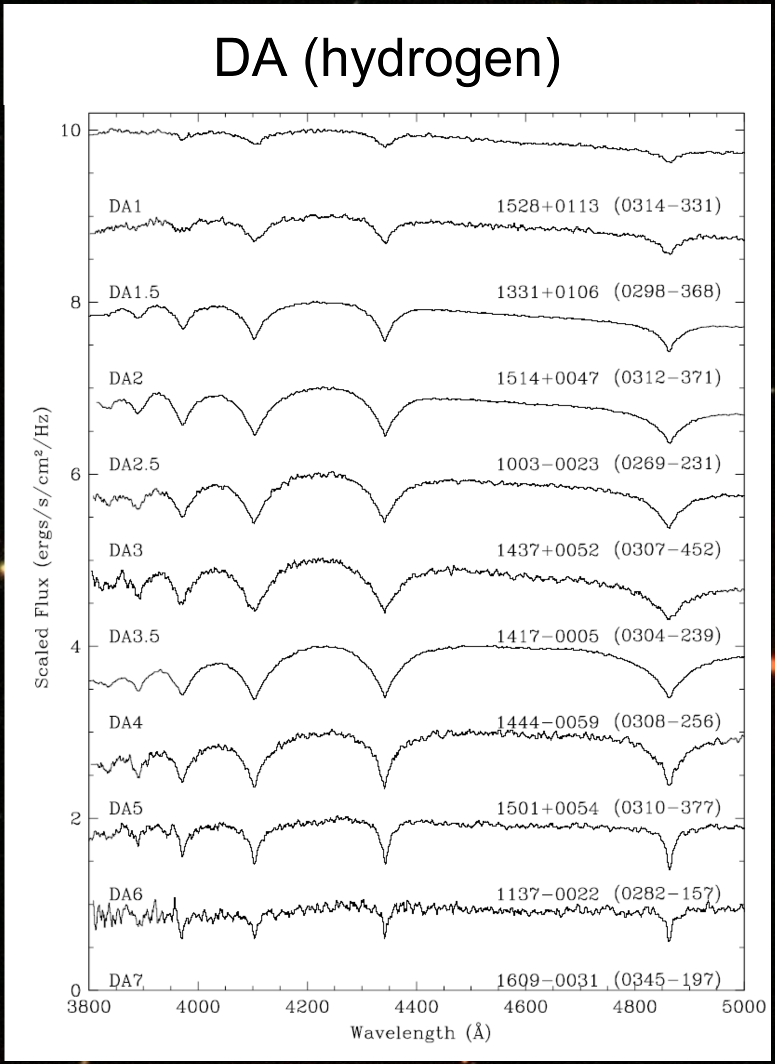
The above summary suggests that evolution of stars in the mass range of 8–10 $M_\odot$ as well as slightly above 10 $M_\odot$ will have a variety of interesting outcomes and thus deserves further study.

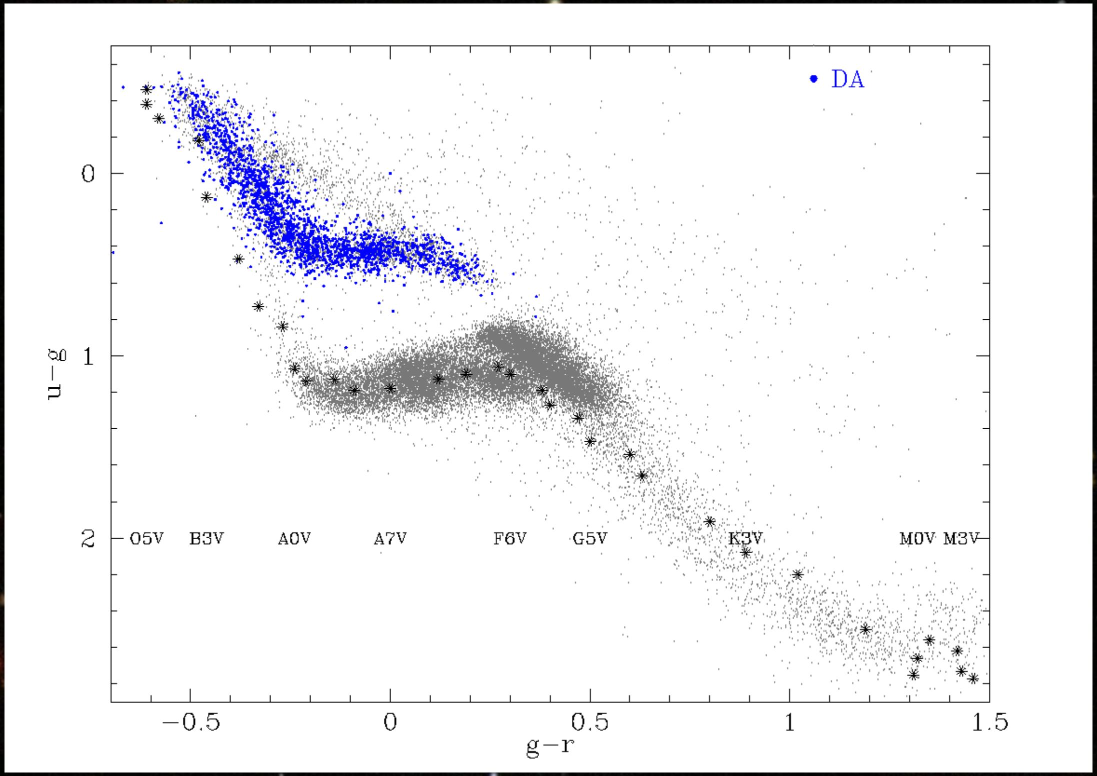
Nomoto 1984, ApJ 277, 791

- ONe core
- electron-capture SN
- core-collapse SN

SN2008ha, M85-OT, NGC300-OT

Hydrogen-rich (DA)

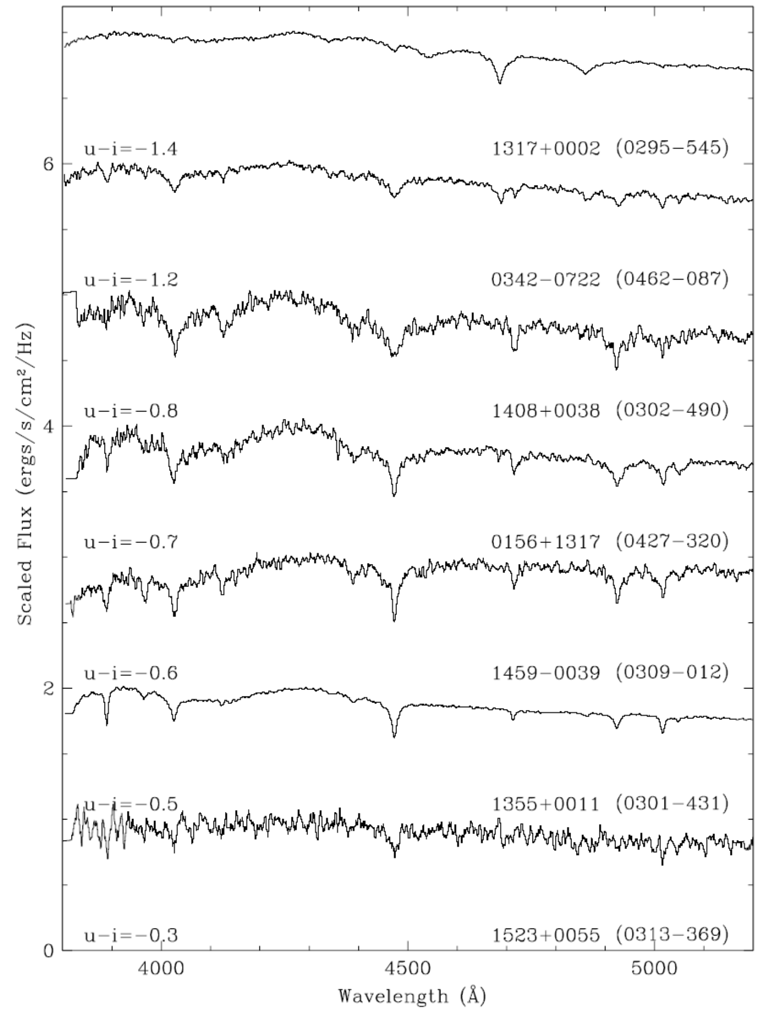


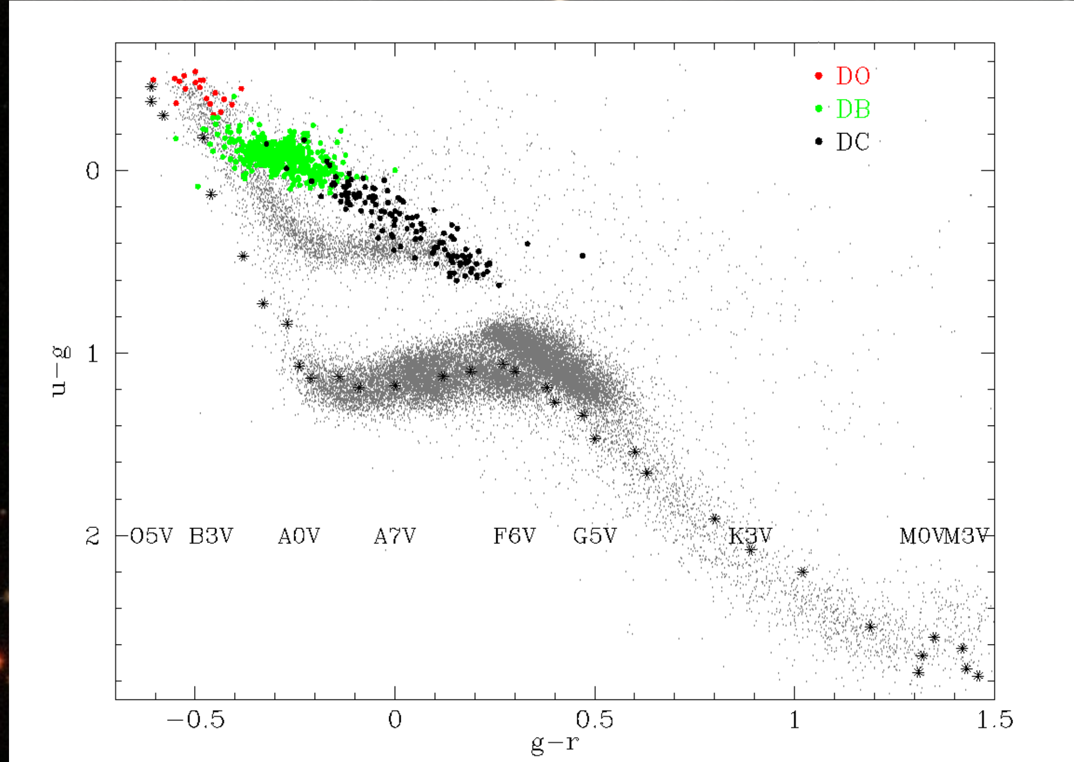


Teff = 6000 - 100000K

Helium-rich (DO/DB/DC)

DB (hydrogen)



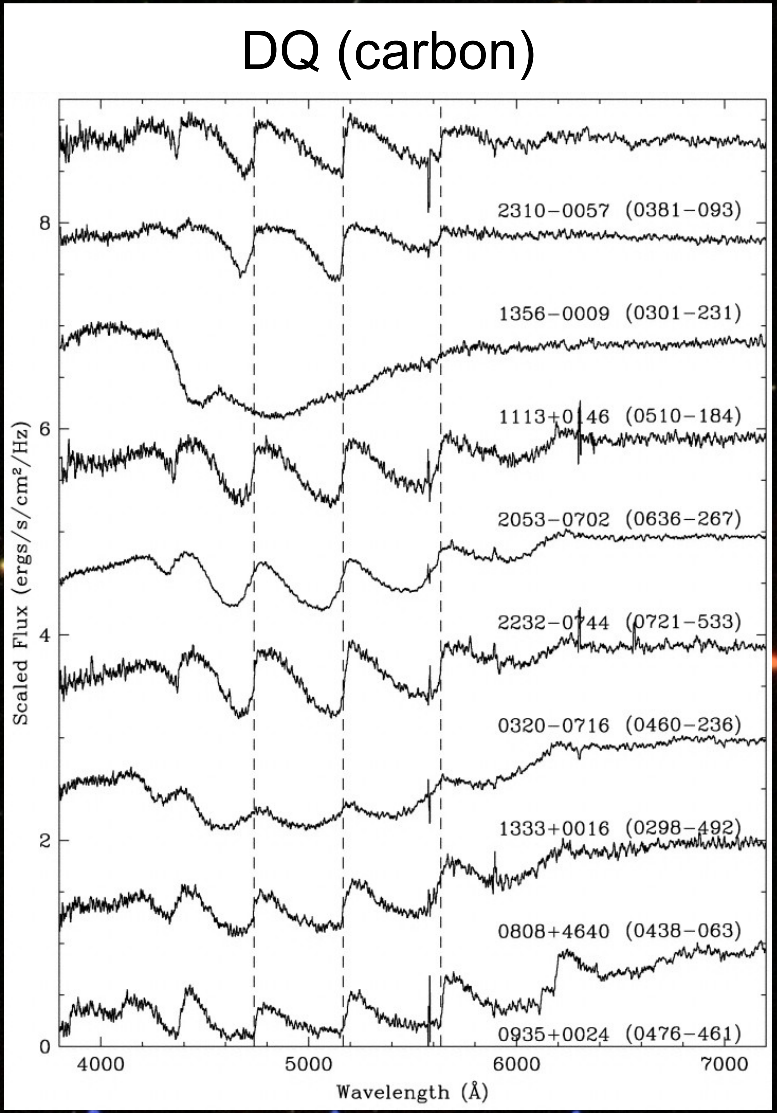


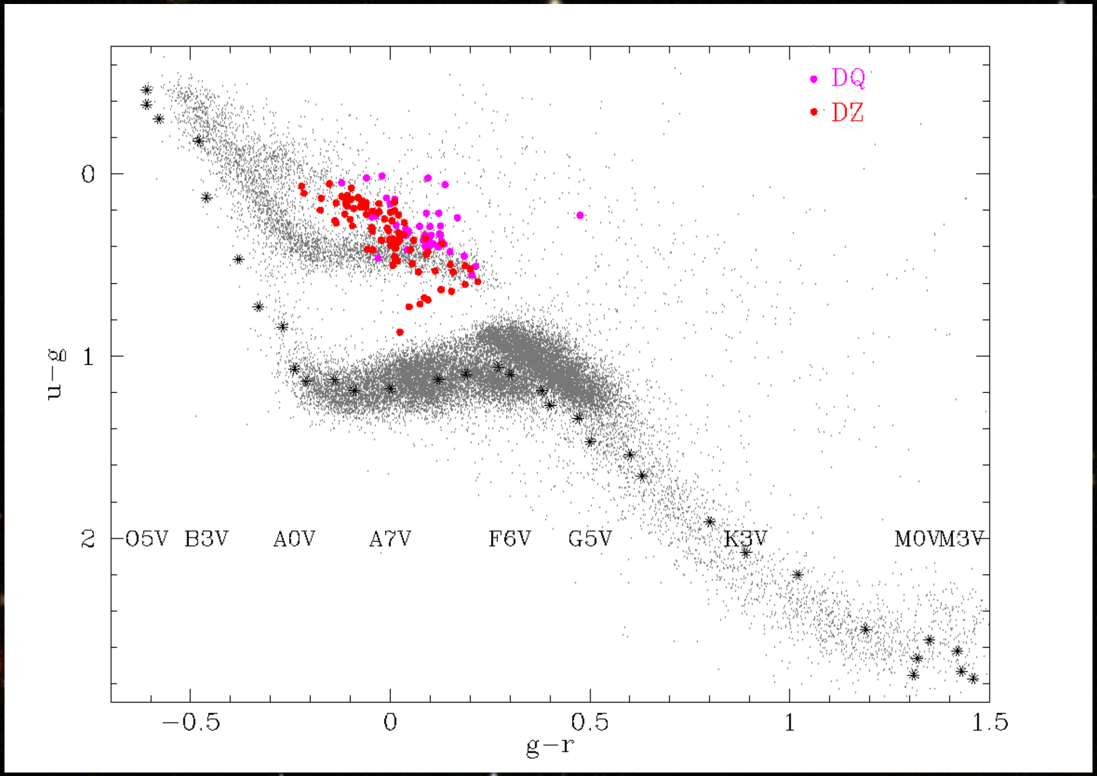
DO: Teff ≥ 40000K

DB: Teff = 10000 - 40000K

DC: Teff < 10000K

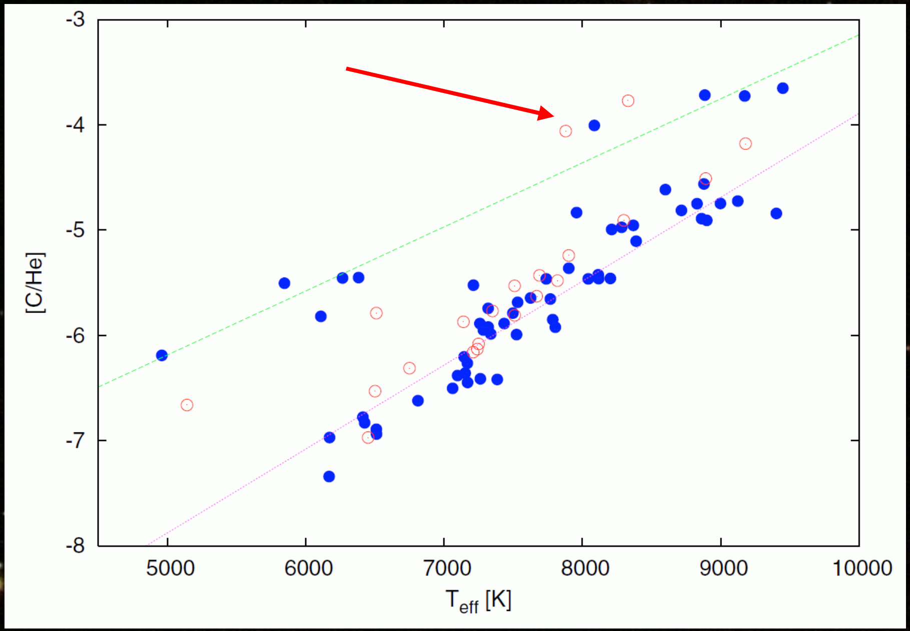
DQ = cool, carbon-rich



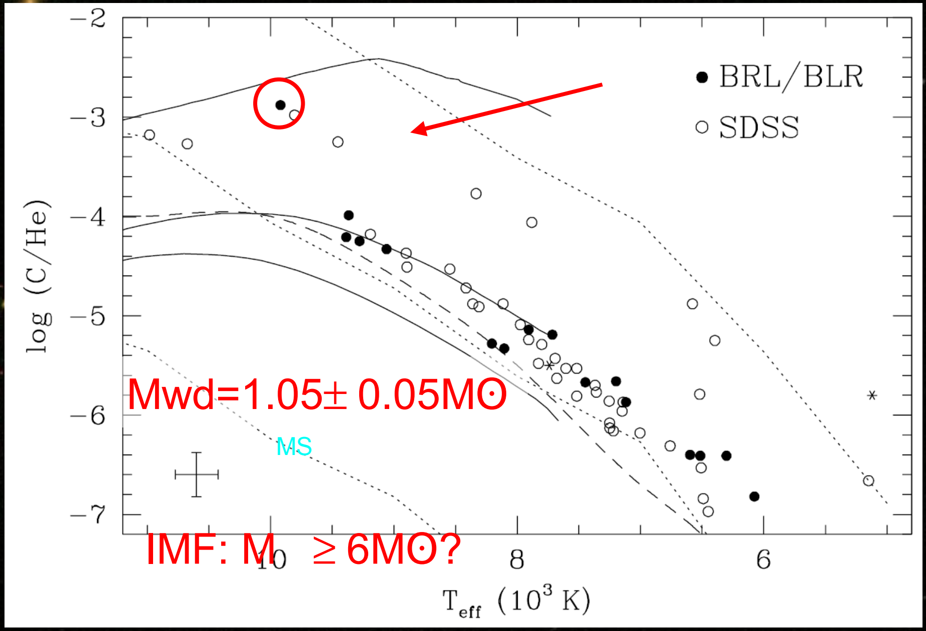


Teff < 12000K

Two DQ sequences



Koester & Knist 2006, A&A 454, 951

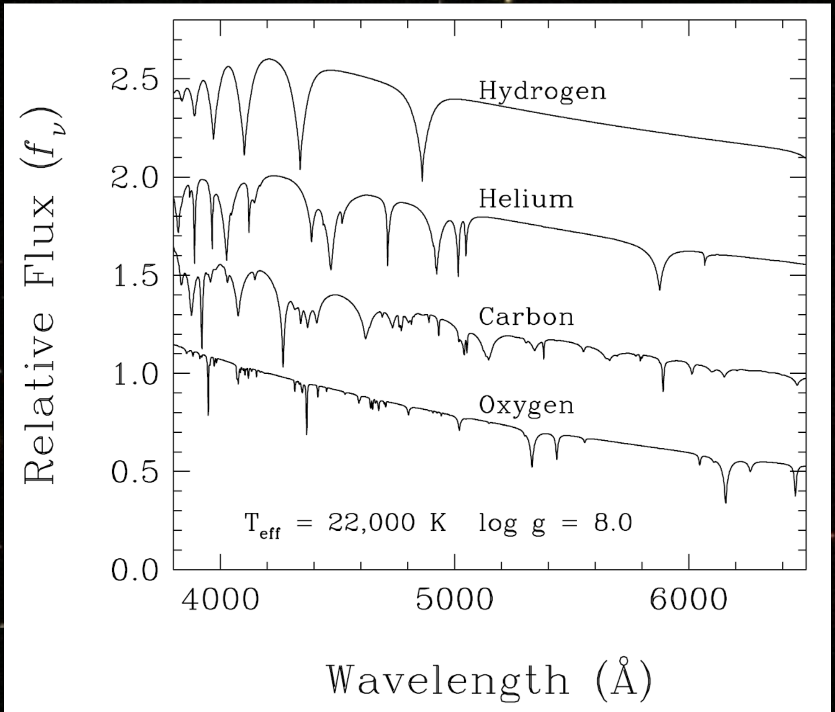


Dufour et al. 2005, ApJ 627, 404

Are very carbon rich DQs as the progeny of massive progenitors?

(see Klaus' talk on H1504+65 and Patrick's talk on hot DQs)

So far… O/C < 1

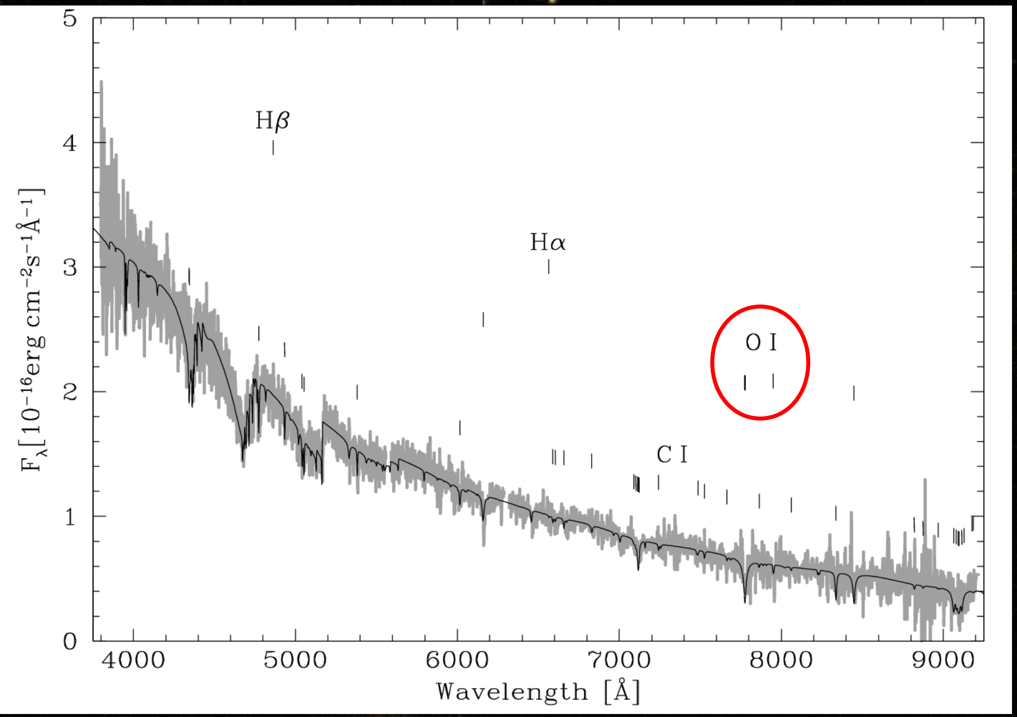


Model spectra
Dufour et al. 2008, ApJ 683, 978

⇒ simply search ~26000 SDSS spectra for oxygen absorption

…found them ☺

WDs with oxygen-rich atmospheres: SDSS0922+2928

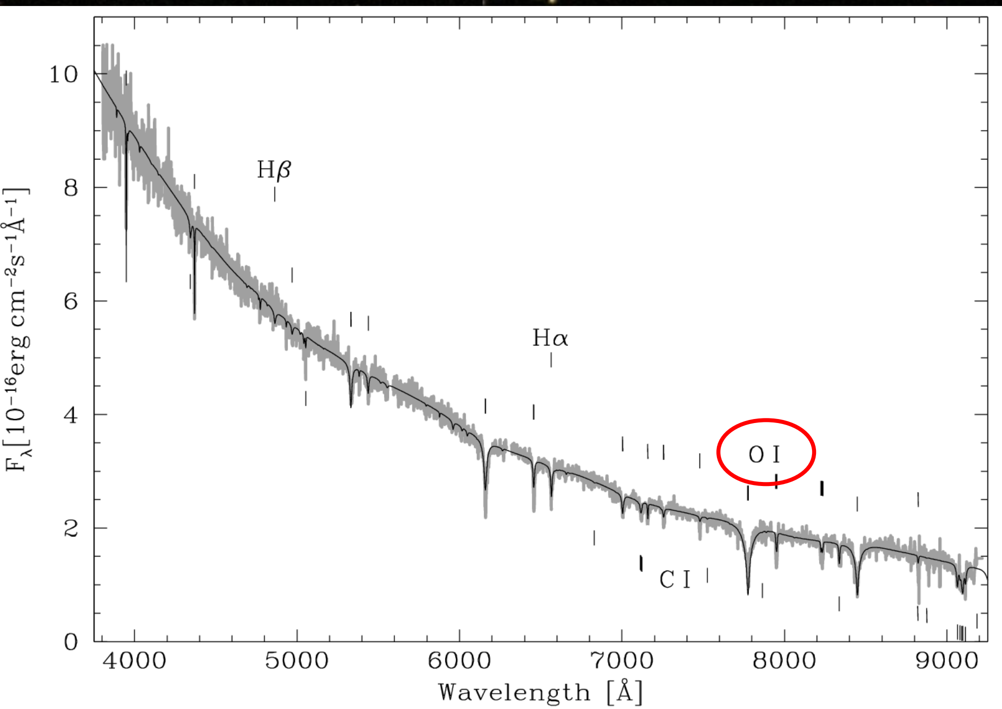


(phot) Teff=8270± 320K @ log g=8

log(H/He) = -5.0
log(C/He) = -2.6
log(O/He) = -2.0
O/C ≈ 4

Gänsicke et al. 2010, *Science* 327, 188

WDs with oxygen-rich atmospheres: SDSS1102+2054



(phot) Teff=8270± 320K @ log g=8

(spect) Teff≈ 10500K @ log g=8

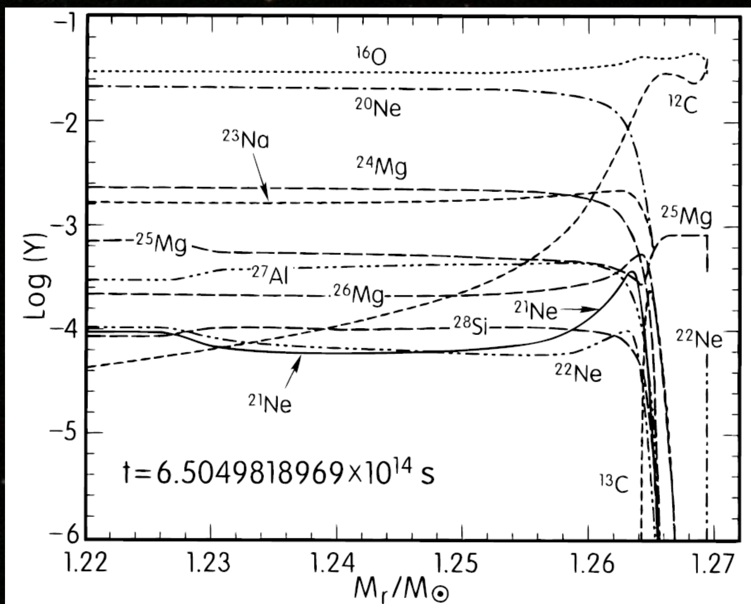
log(H/He) = -3.2 / -4.0
log(C/He) = -3.2 / -3.6
log(O/He) = -1.8 / -1.8
O/C ≈ 25 / 63

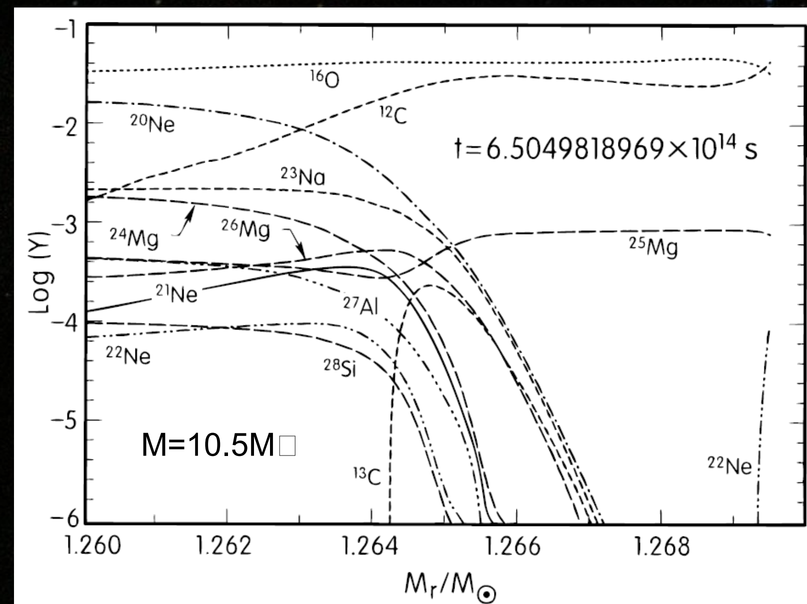
Gänsicke et al. 2010, *Science* 327, 188

What about the progenitor of such ONe core?

The problem: most ONe cores will have a CO layer that is sufficiently thick to hide the oxygen …

… unless descending from a star close to the core-collapse boundary?

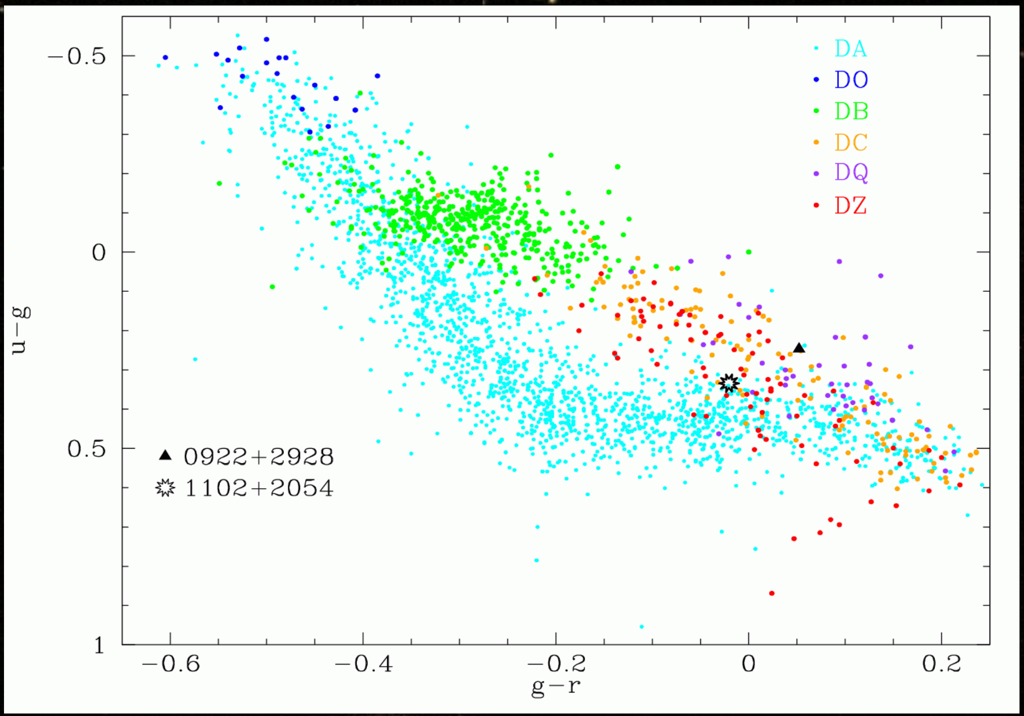




Garcia-Berro & Iben 1994, ApJ 434, 306
Ritossa et al. 1996, ApJ 460, 489
Iben et al. 1997, ApJ 489, 772
Garcia-Berro & Iben 1997, 485, 765

The mass ΔM_{CO} of the CO layer above the ONe core and the mass $\Delta M_{\text{neon free}}$ of the neon-free layer in the outer part of the CO layer are decreasing functions of model mass. In the 9, 10, and 10.5 $M_\odot$ models, $\Delta M_{CO} = 0.05$, 0.015, and 0.0065 $M_\odot$, respectively, and $\Delta M_{\text{neon free}} \sim 0.014$, 0.009, and 0.0036 $M_\odot$, respectively.

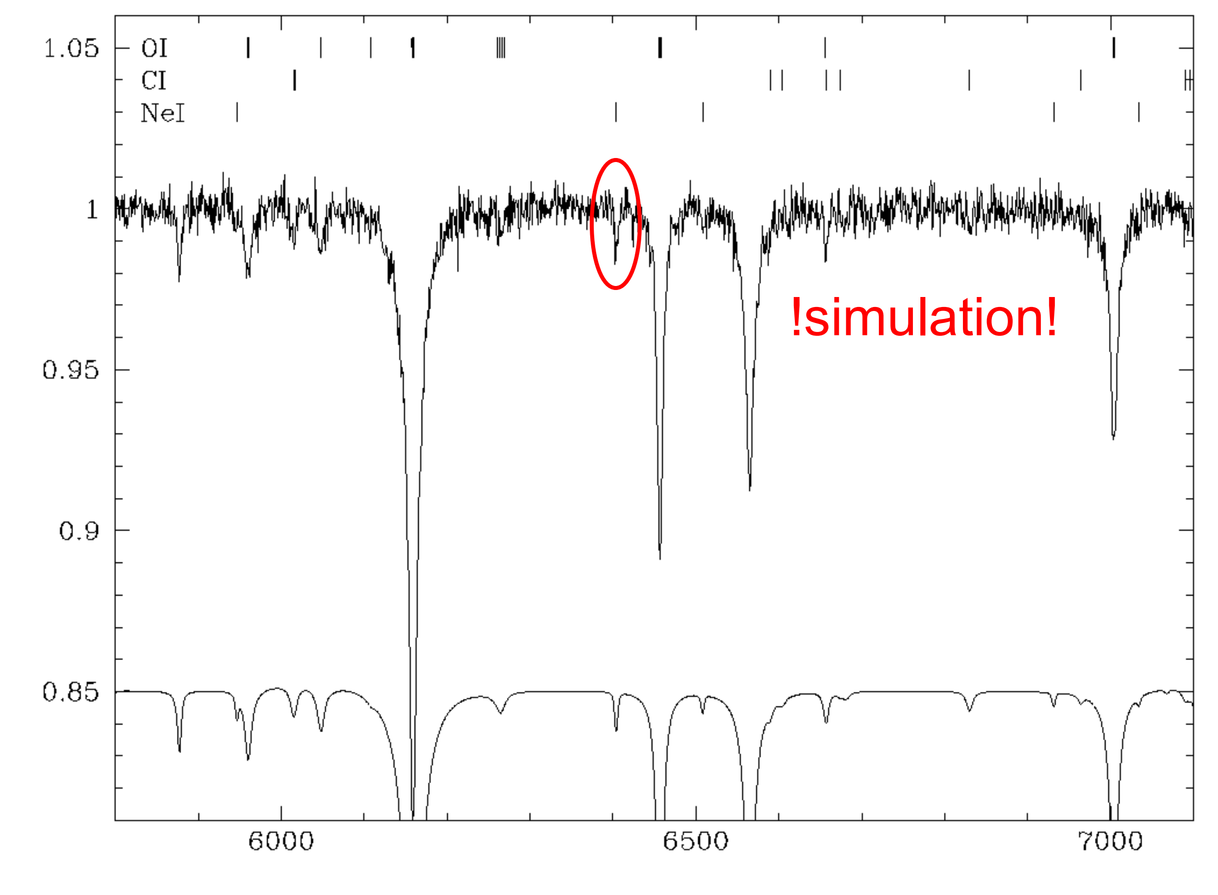
WDs with oxygen-rich atmospheres



- rare: 2 out of 1000s in SDSS
- O/C > 1 ⇒ definite ONe core (O heavier than C!)
- Must have descended from MS star near the core-collapse boundary ⇒ should be massive!

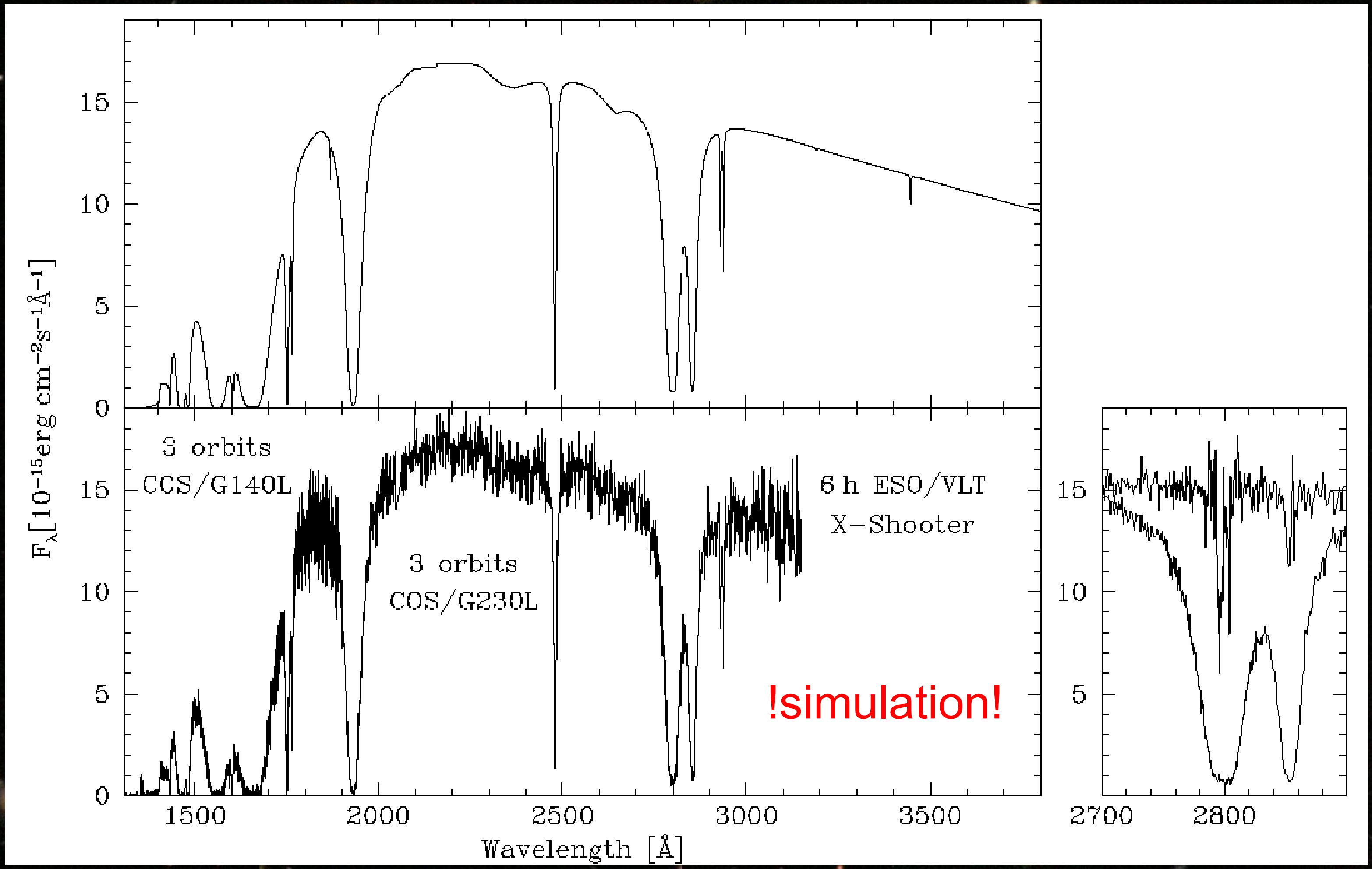
- preliminary (1-year) parallax: d=68$_{(+14-10)}$ pc ⇒ Mwd~1Msun @ Teff =10500K

Need: better spectra



Approved X-shooter observations sensitive to log[Ne/He]~-2
(we really could do with an ELT…)

Need: better spectra



HST/COS Cycle 18 program: Teff & sensitive to log[Mg/He]~-9

Conclusions

- we have identified two cool WDs with photospheric O/C>1
- must be ONe cores, and most likely descended from massive progenitors
- should be massive themselves…
- UV spectroscopy and better optical data will provide accurate Teff , Mwd as well as O, Ne, Mg abundances