Helium white dwarfs in binaries

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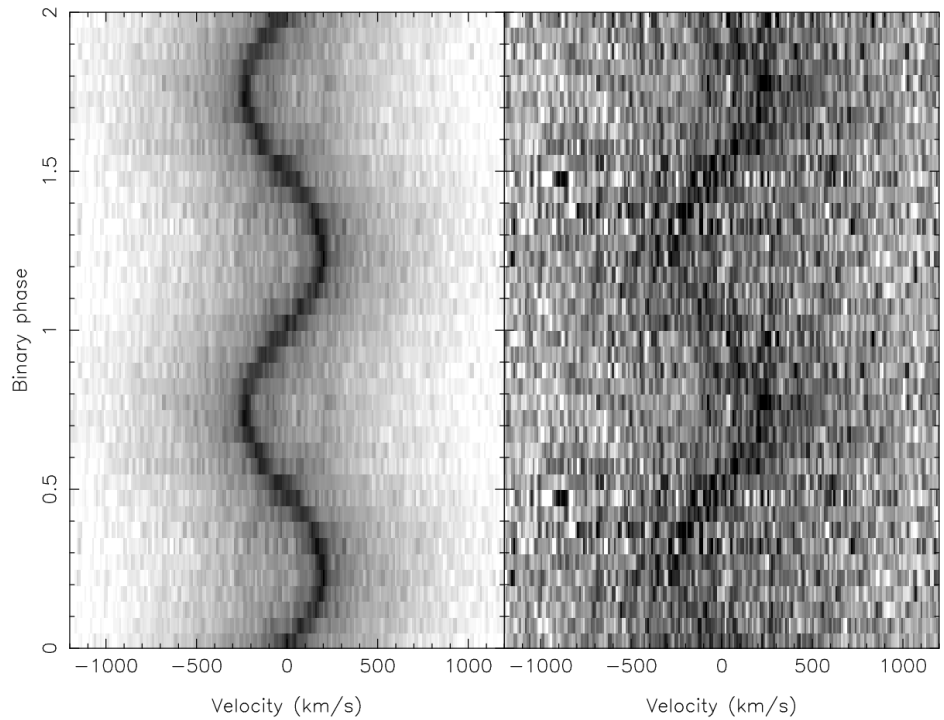


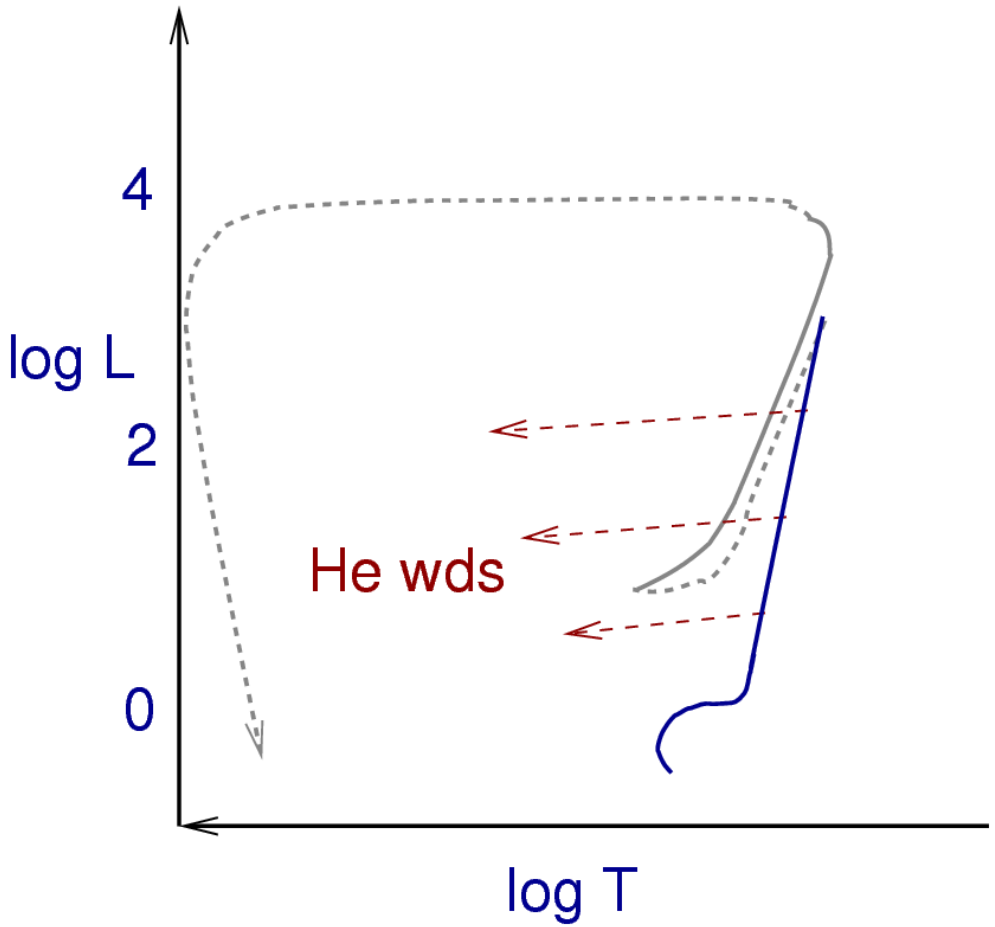
WD0957-666

Outline

1. What are helium white dwarfs and why are they interesting . . .
2. Finding helium white dwarfs
3. Double helium white dwarfs
4. Helium white dwarfs with main-sequence companions,

I will try to highlight what we don't know.

What are helium white dwarfs?



A helium white dwarf can be made if the hydrogen envelope is lost prior to helium ignition, by mass transfer in a binary.

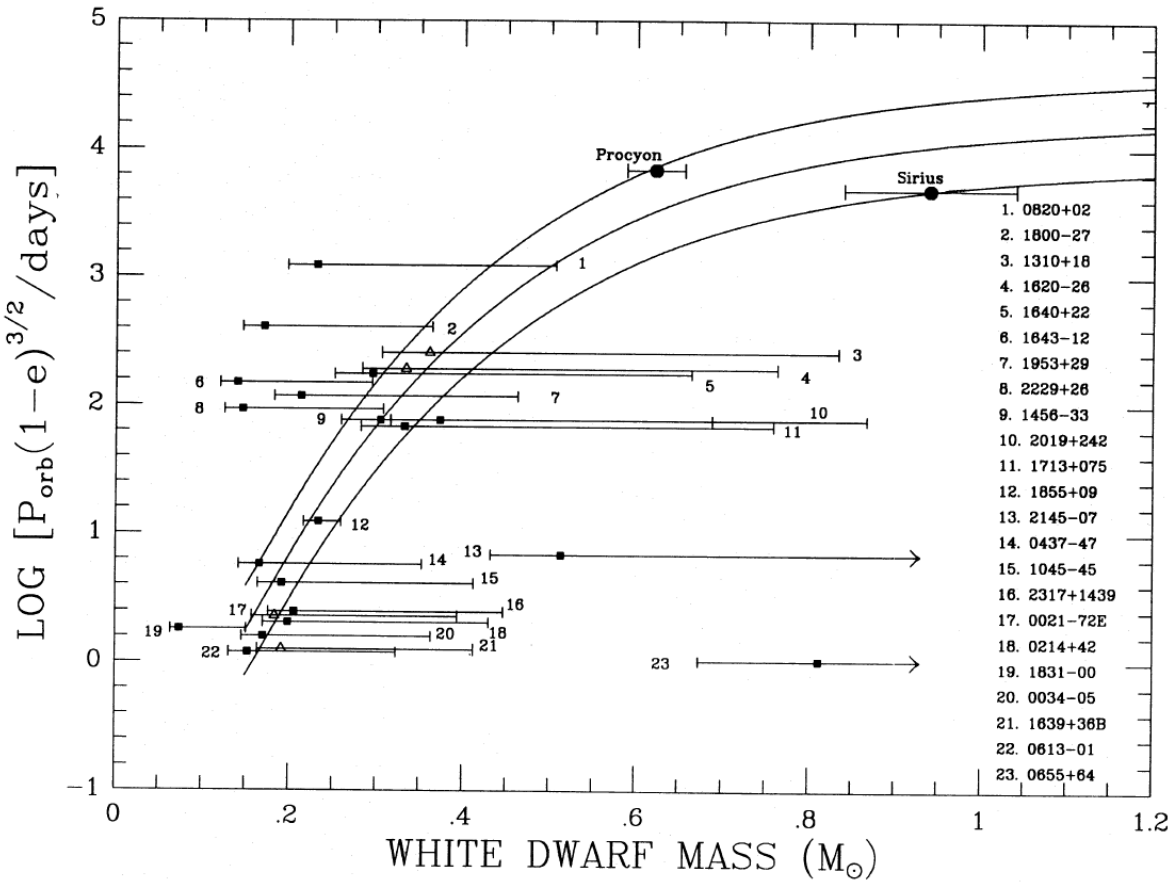
Why helium white dwarfs?

1. Helium white dwarfs are tracers of binary evolution.

2. They can cool very differently from CO white dwarfs and affect the use of white dwarfs for age measurements, e.g. white dwarf companions to millisecond pulsars and globular clusters (NGC 6397, Hansen et al 2003)

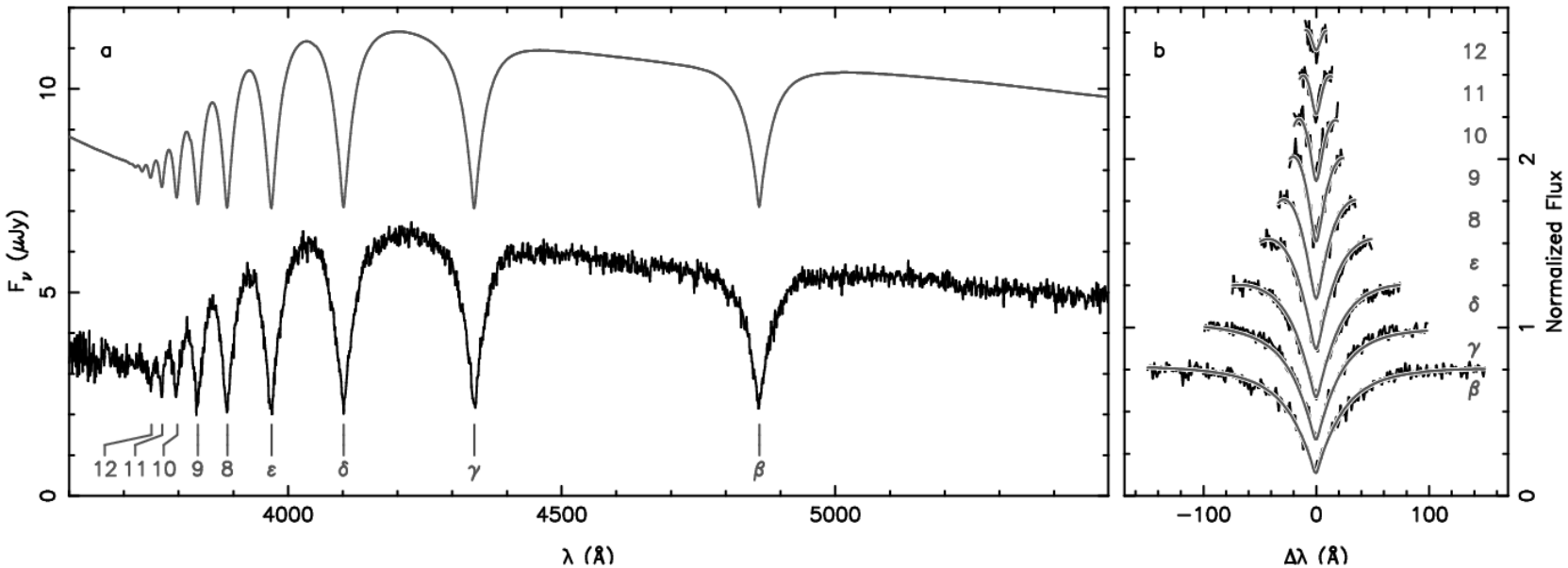
3. If helium white dwarfs can be made to explode, can expect significant differences from CO white dwarfs.

HeWD companions to millisecond pulsars



Red giant core mass/radius relation leads to relation between mass of white dwarf and orbital period after stable RLOF. (Joss et al 1987; Rappaport et al 1995). Many MSP companions are He WDs.

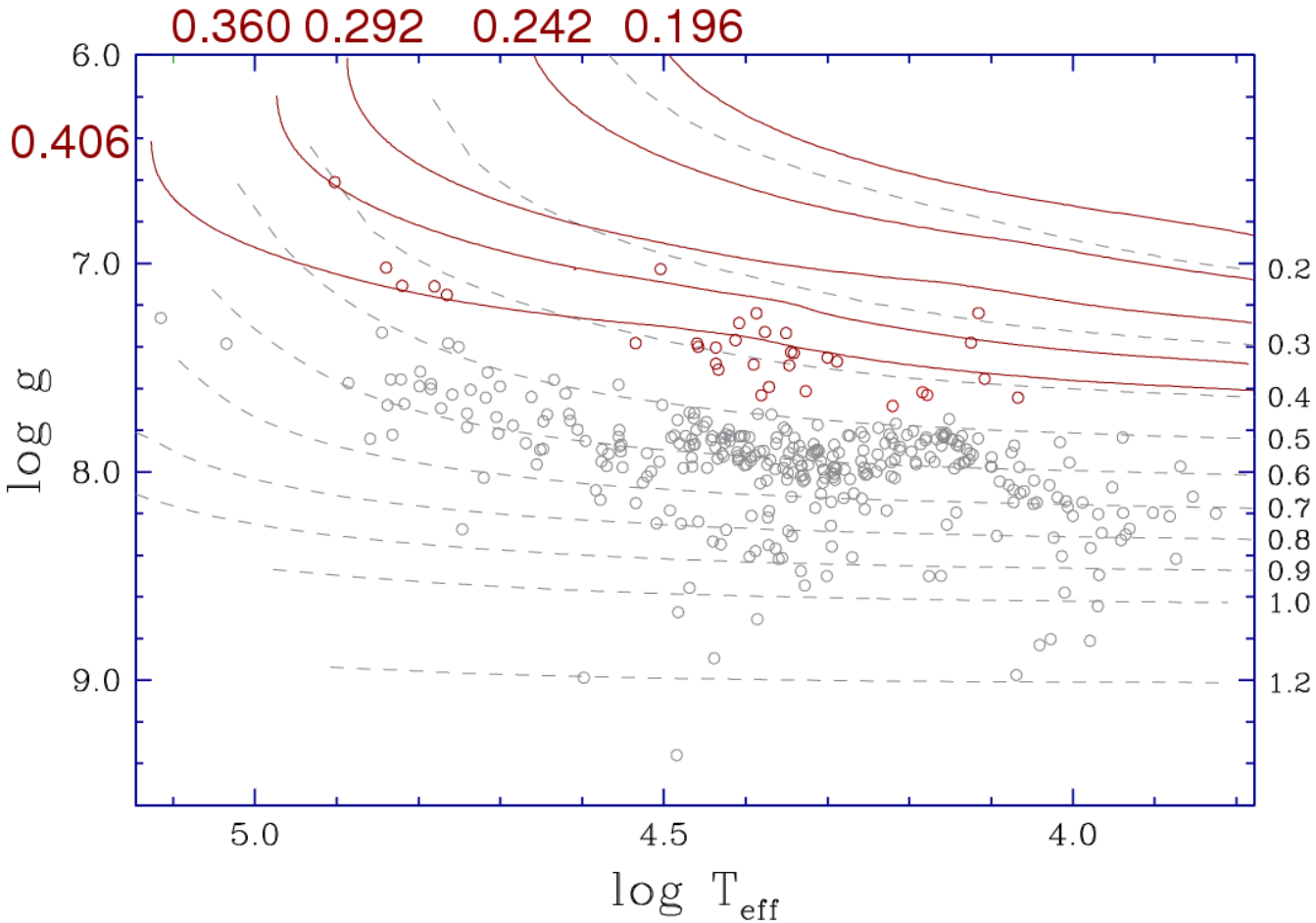
He WD companion to PSR J1911-5958A



Bassa et al (2006), $P = 20\,\mathrm{h}$, $M_{\mathrm{WD}} = 0.18\,\mathrm{M}_\odot$.

NB. Hydrogen flotsam: He and CO white dwarfs usually appear to be pure hydrogen. Only distinguishable by mass.

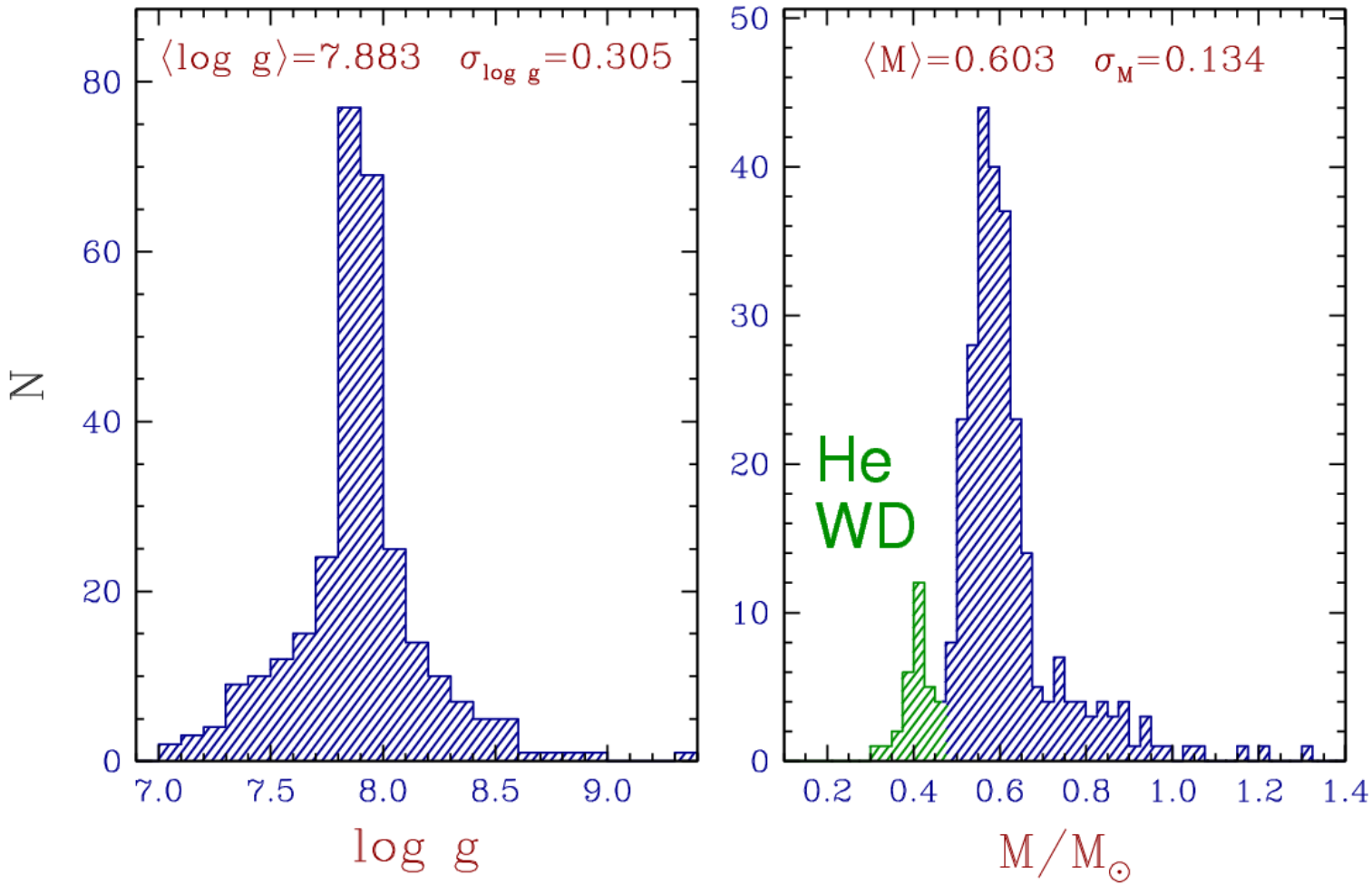
Helium white dwarfs in the PG survey



Data: Liebert, Bergeron & Holberg (2005).

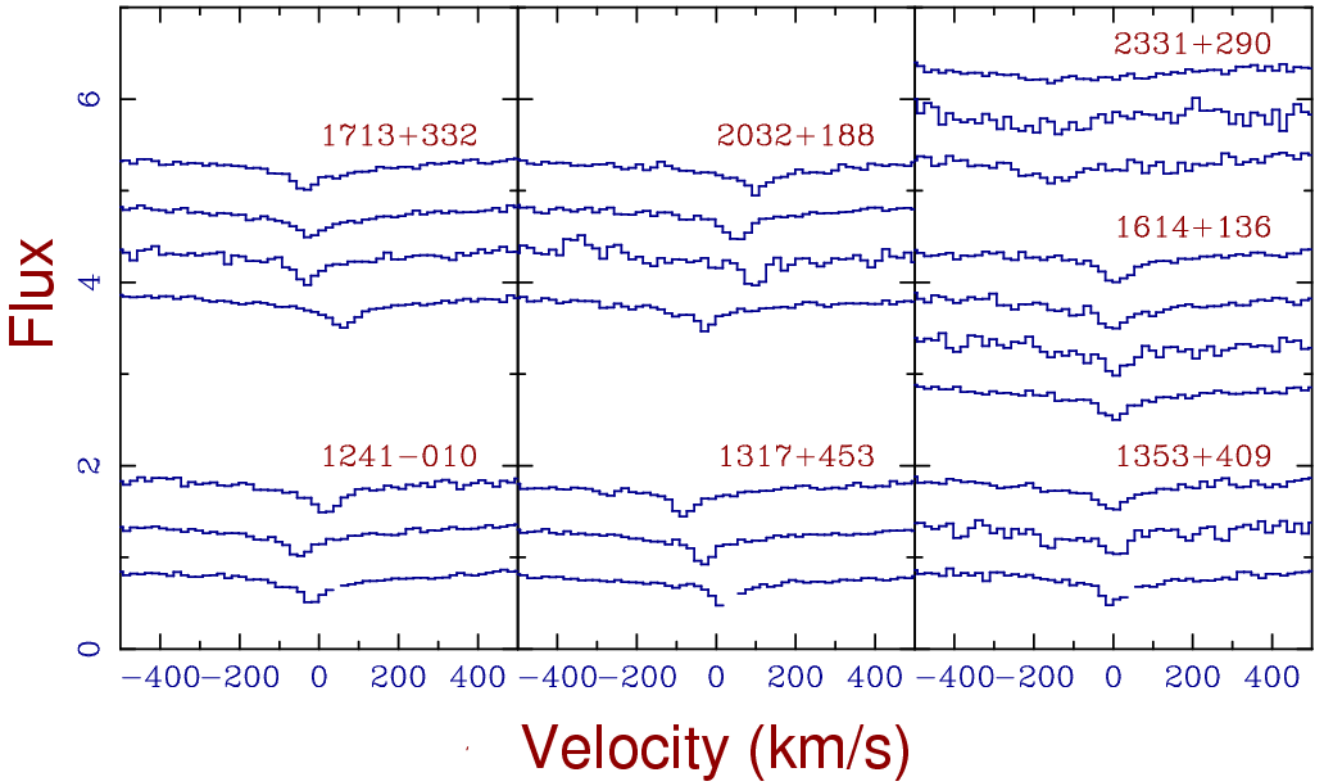
Models: Althaus et al (2001), Wood (1995).

Gravity and mass distributions



Liebert, Bergeron & Holberg (2005); see also Bergeron, Saffer & Liebert (1992)

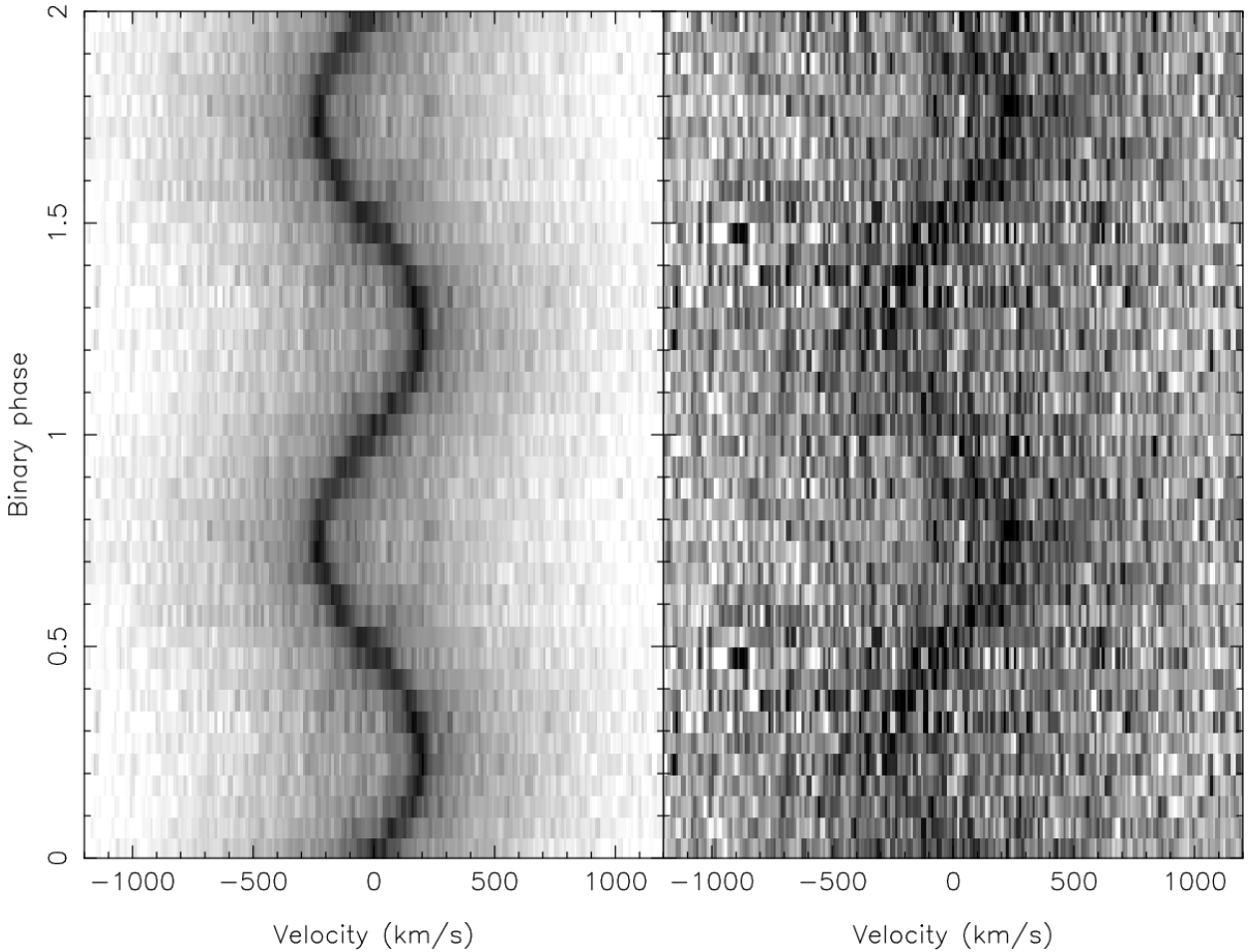
Hunting for double white dwarfs



Marsh, Dhillon & Duck (1995)

At a time when only 2 DWDs were known, focussing on the low mass systems from Bergeron, Saffer & Liebert (1995) lead to 5 new DWDs from 7 targets.

Double-lined systems



Moran, Marsh & Bragaglia (1997)

Maxted, Marsh & Moran (2002)

In some cases both white dwarfs can be seen allowing us to measure mass ratios. This is WD 0957-66, $P = 88$ min, $q = M_{\rm bright}/M_{\rm faint} = 1.15 \pm 0.10$.

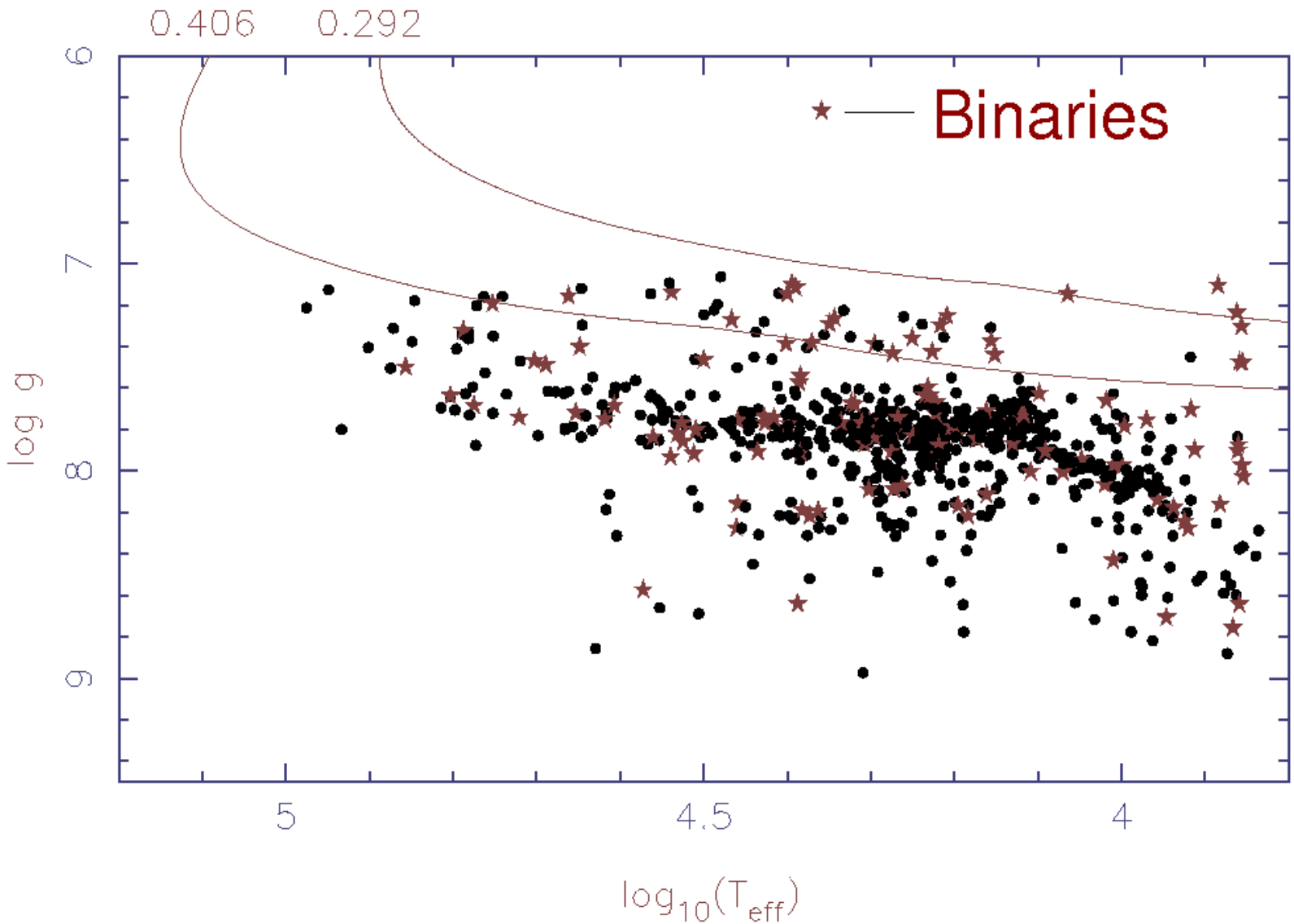
Problems

1. Mass ratios tend to be close to equality, whereas one might expect the second white dwarf to form to be least massive: CE physics wrong? $\longrightarrow$ Gijs Nelemans.

2. Why aren't all He white dwarfs in binaries?
   A: I don't know.

3. Why are there not more very low mass He white dwarfs $< 0.3\,\mathrm{M}_\odot$?

The SPY survey (Napiwotzki et al)

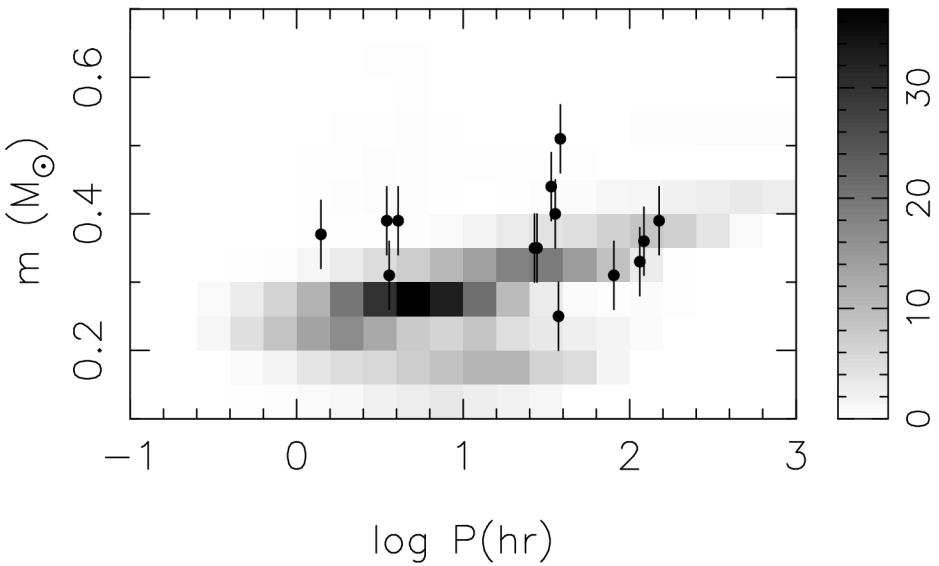


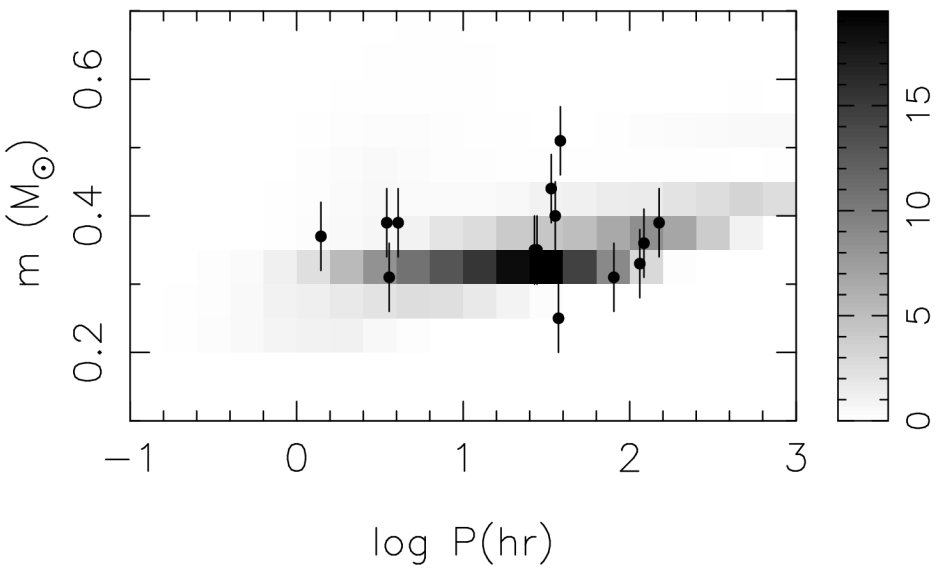
Where are the really low mass HeWDs?

Very few helium white dwarfs $< 0.3\,\mathrm{M}_\odot$ (honourable exceptions: Landsman et al 1997; Liebert et al 2006, millisecond pulsar companions).

+ Size should favour them in a nearby, magnitude limited samples, such as the PG survey (2x in favour of 0.2 vs $0.4\,\mathrm{M}_\odot$).
– Core mass–radius relation on the FGB goes against them: $R \propto M_c^4$, (e.g. Iben & Tutukov 1985), so $P(M_c) \propto M_c^3 P(R)$.
+ Thick H envelopes at very low white dwarf mass slow down cooling (Webbink 1975; Driebe et al 1998; Sarna et al 2000)

Where are the really low mass HeWDs?





Nelemans et al (2001)

Top: model with Driebe et al (1998) cooling

Bottom: thick H envelopes below 0.3 $\mathrm{M}_\odot$ assumed absent.

He WDs with cool companions

There are several examples of He WDs with MS or near MS companions amongst the ~ 40 detached WD/MS binaries with known period:

Name	$P_{\rm orb}$ h	$M_{\rm WD}$ $\mathrm{M}_\odot$	$M_{\rm MS}$ $\mathrm{M}_\odot$	Reference
LM Com	6.2	0.35(3)	0.17(2)	Shimansky et al (2003)
WD0137-349	1.9	0.39(4)	0.053(6)	Maxted et al (2006)
GD 448	2.5	0.41(1)	0.096(4)	Maxted et al (1998)
RR Cae	7.3	0.44(2)	0.18(1)	Maxted et al (2007)

Problem: there are NO clear-cut He WDs amongst ~ 600 cataclysmic variable stars.

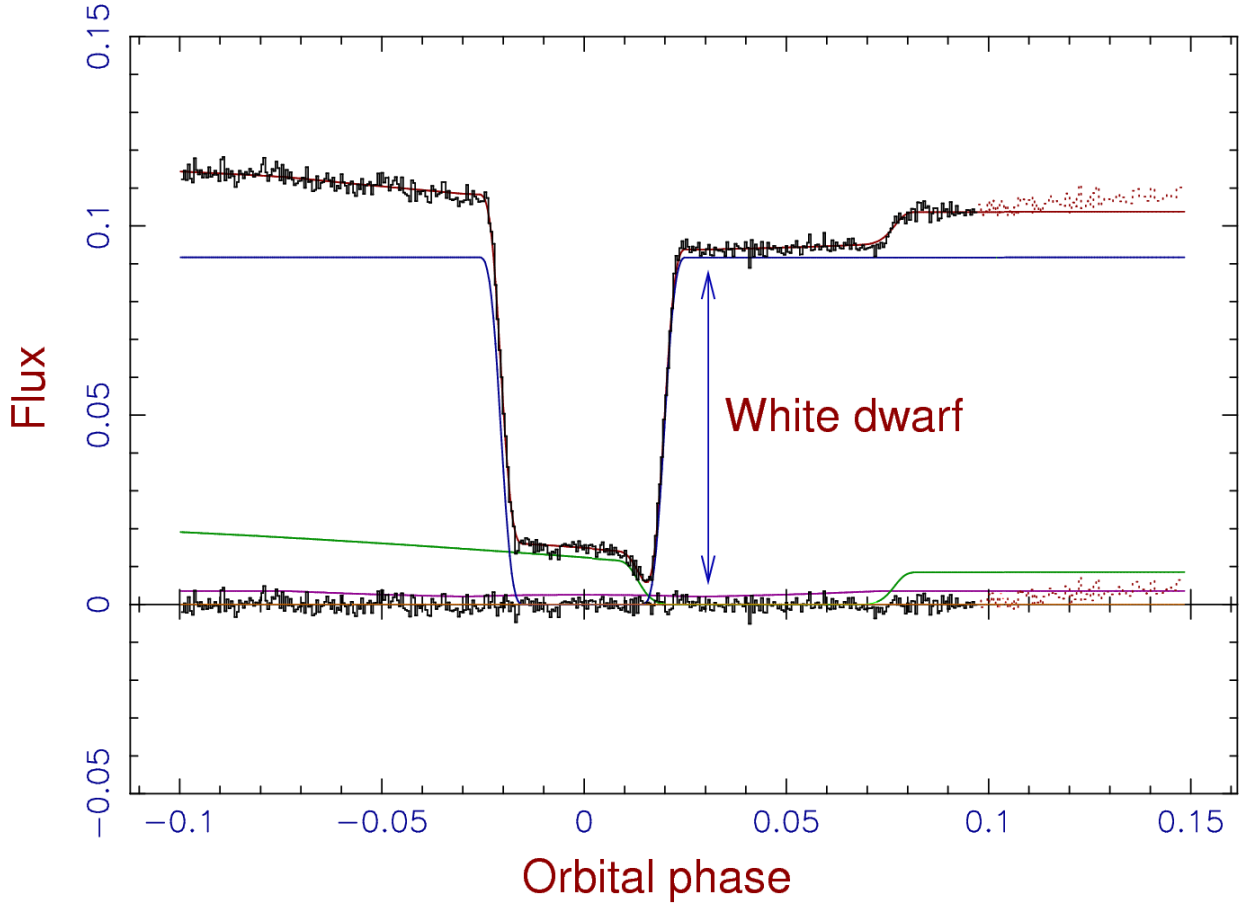
An old problem: white dwarf masses in CVs

Mean white dwarf mass in CVs is high ($\sim 1.0\,\mathrm{M}_\odot$, Ritter & Burkert 1986):

- Mass grows by accretion? . . . Nova ejecta suggest not.
- Masses high from the start? . . . He WDs in detached systems suggest not. Politano (1996) predicts $\sim 50\%$ of ZACVs have He white dwarfs.
- Selection effects? . . . High mass white dwarfs $\Rightarrow$ imply higher accretion luminosity $\Rightarrow$ bias towards high masses.

Selection was Ritter & Burkert's favoured model.

White-dwarf dominated CVs



SDSS1035+0551,
$P = 82$ min,
$g = 18.8$

Littlefair et al (2006)

$T_{\rm WD}$ depends only mildly upon $M_{\rm WD}$ (Townsley & Bildsten 2003), so when the white dwarf dominates the M-R relation should favour the detection of CVs with He white dwarfs.

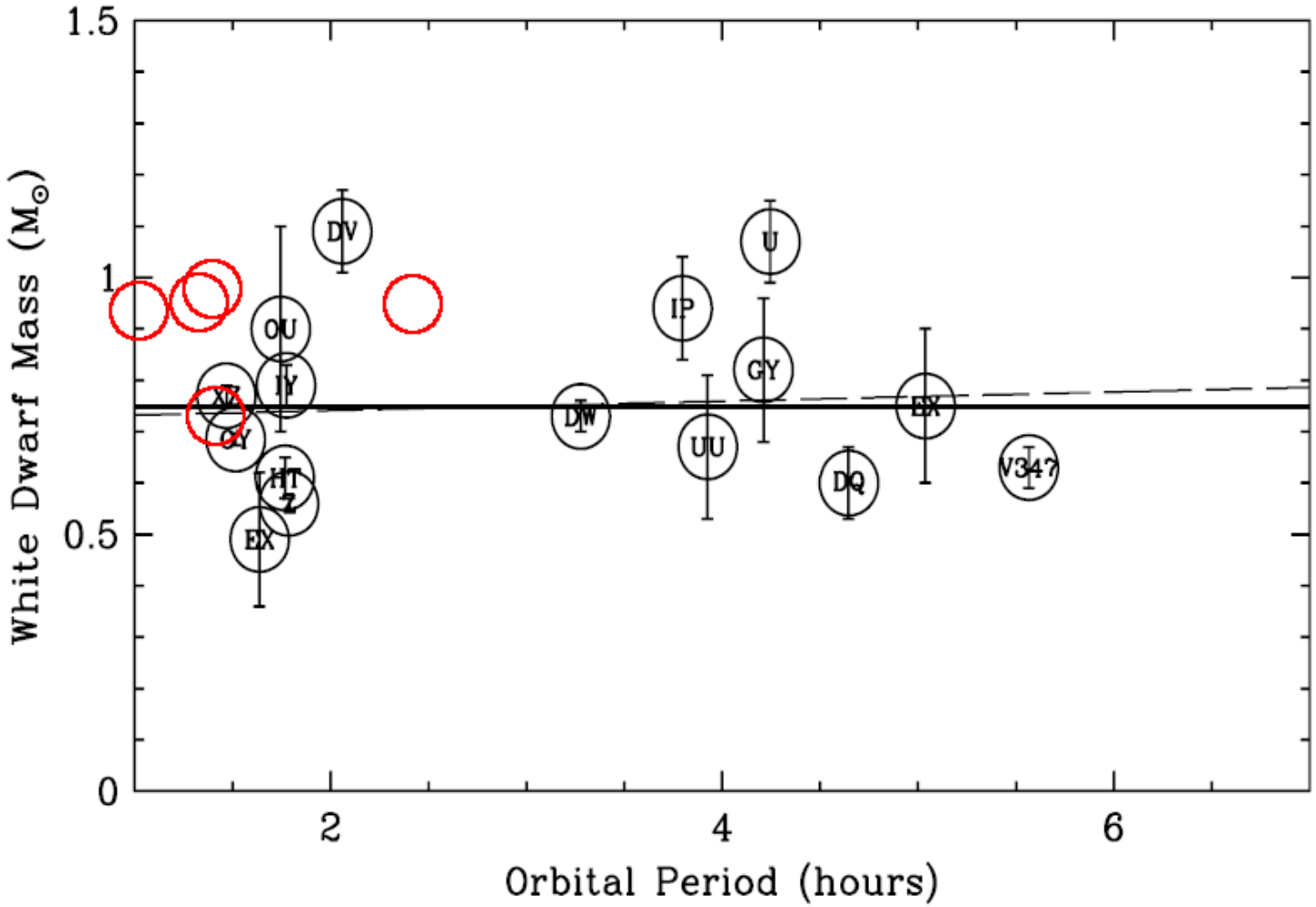
White-dwarf masses from the SDSS

$\Rightarrow$ measure $M_{\rm WD}$ in low L systems not found through outbursts. The SDSS survey (Szkody et al papers I, II etc) finds exactly these; Gänsicke et al have been following them up.

Use high-speed CCD camera ULTRACAM (Dhillon & Marsh 2001) to measure parameters:

Name	$M_{\rm WD}(\rm M_\odot)$	Reference
SDSS 1250+6655	0.70 ± 0.05	Littlefair et al, in prep
SDSS 1507+5230	0.92 ± 0.07	Littlefair et al, in prep
SDSS 1035+0551	0.94 ± 0.01	Littlefair et al (2006)
SDSS 1702+3229	0.94 ± 0.01	Littlefair et al (2006)
SDSS 0903+3300	0.96 ± 0.03	Littlefair et al, in prep

CV white dwarf masses



$\Rightarrow$ Still no clear sign of low mass white dwarfs

Conclusions

We now know of many helium white dwarfs, and, as expected, they are often associated with binarity and mass transfer.

Outstanding problems are:

- Where are the really low mass He WDs amongst field white dwarfs? Are they unrecognised so far?
- Why are so many He white dwarfs apparently single?
- Where are the $\sim 50\%$ of CVs with He white dwarfs?