Searches for new AM CVn stars

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Hamburg-ESO Quasar Survey collaboration

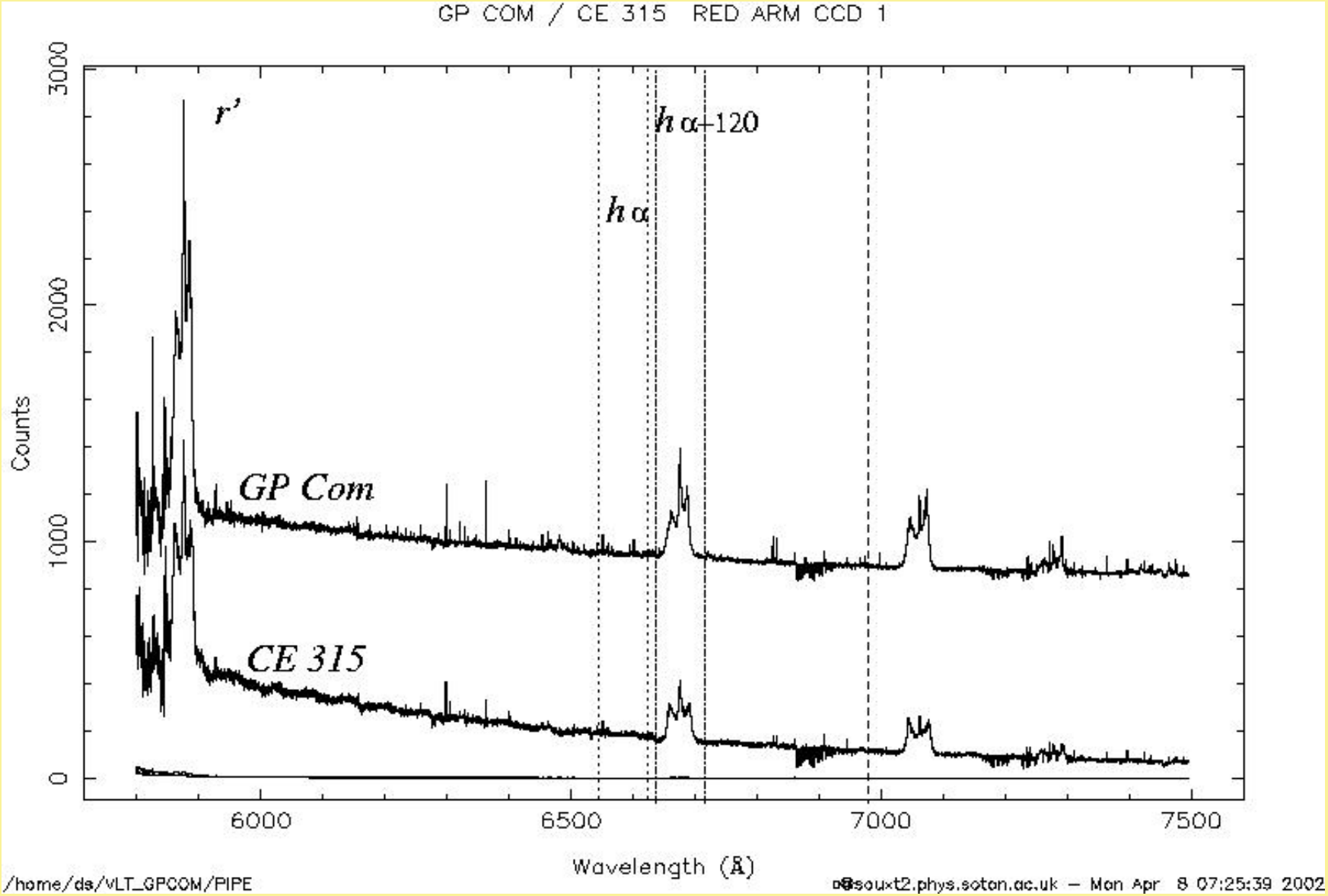
Increasing current sample

- Only 11 systems known
- From population synthesis: expect more than CVs
- $>$700 CVs known: where are the AM CVn stars

⋆Paramount to increase sample to test evolutionary theories

Where to look?

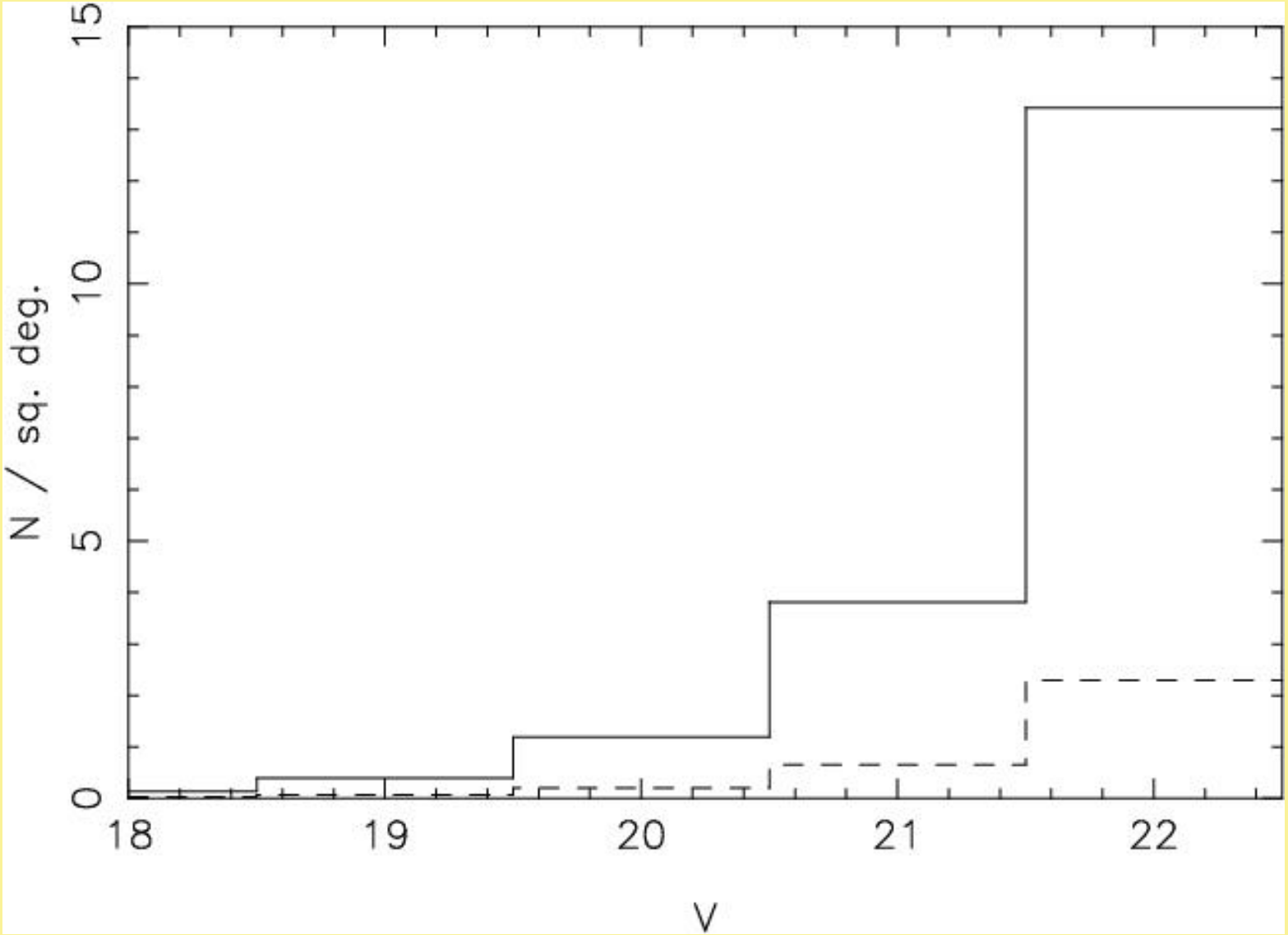
- Population synthesis expects most systems at long periods
  - $P_{\rm orb} > P_{\rm GPCom} = 46 min.$
- GP Com and CE 315 both blue : $B - V < 0$
  - Common trait in all AM CVn systems except V407 Vul
- Spectrum is dominated by strong He I emission lines
  - At least at $P_{\rm orb} >$ CP Eri (29min)
- HeI 6678Å falls in Hα+120
  - ! HeI 5015Å falls in OI 5008 Åfilter!


GP COM / CE 315 RED ARM CCD 1
r'
hα+120
hα
GP Com
CE 315
Counts
0
1000
2000
3000
6000
6500
7000
7500
Wavelength (Å)
/home/ds/VLT_GPCOM/PIPE
ds@souxt2.phys.soton.ac.uk – Mon Apr 8 07:25:39 2002

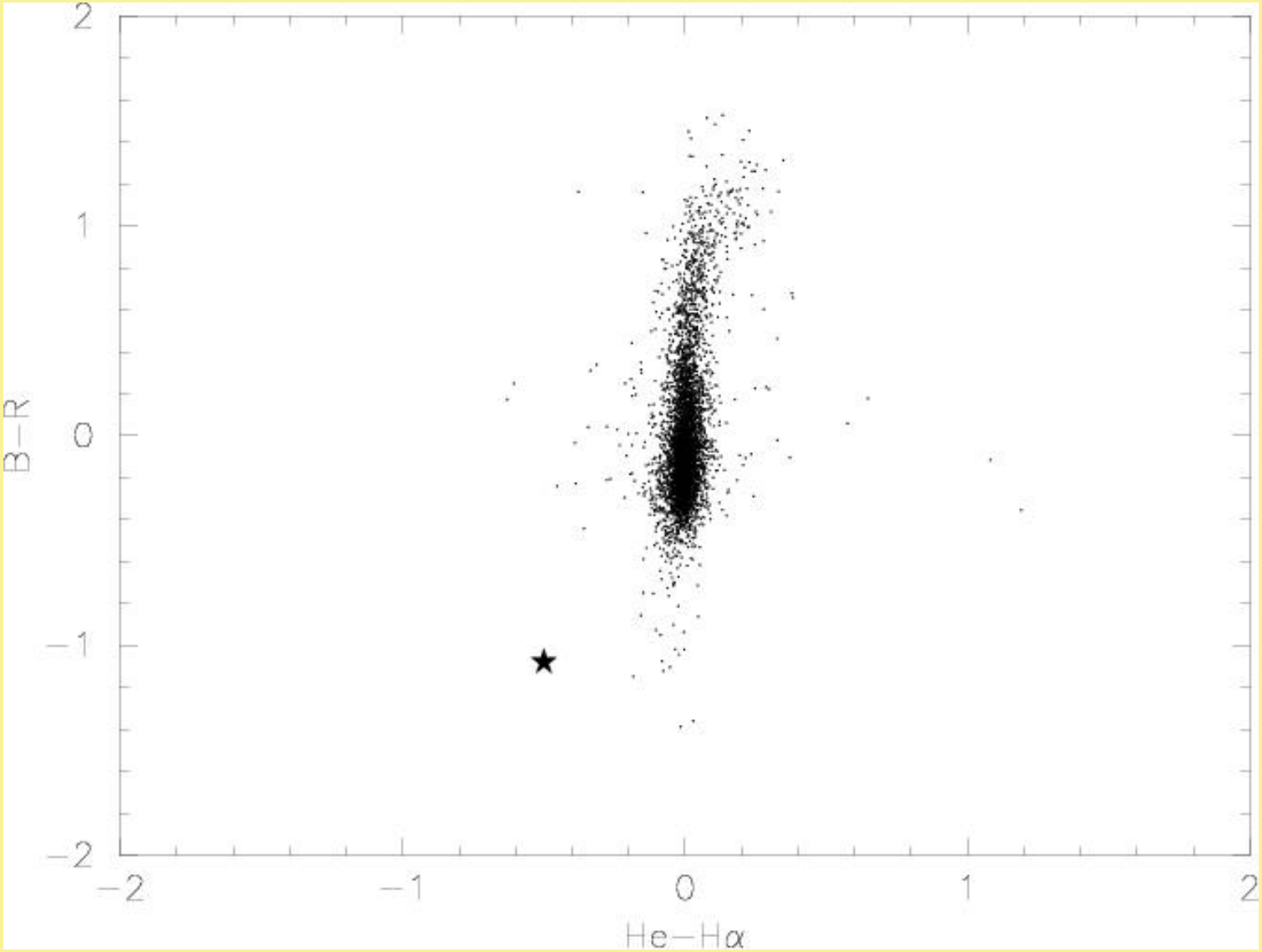
AM CVn mini-survey

- Used NOAO 4m + ESO 2.2m to survey 25 square degree
- Imaged in Hα, Hα+120, B (g') and R (R')
- Down to $R \sim B \sim$21

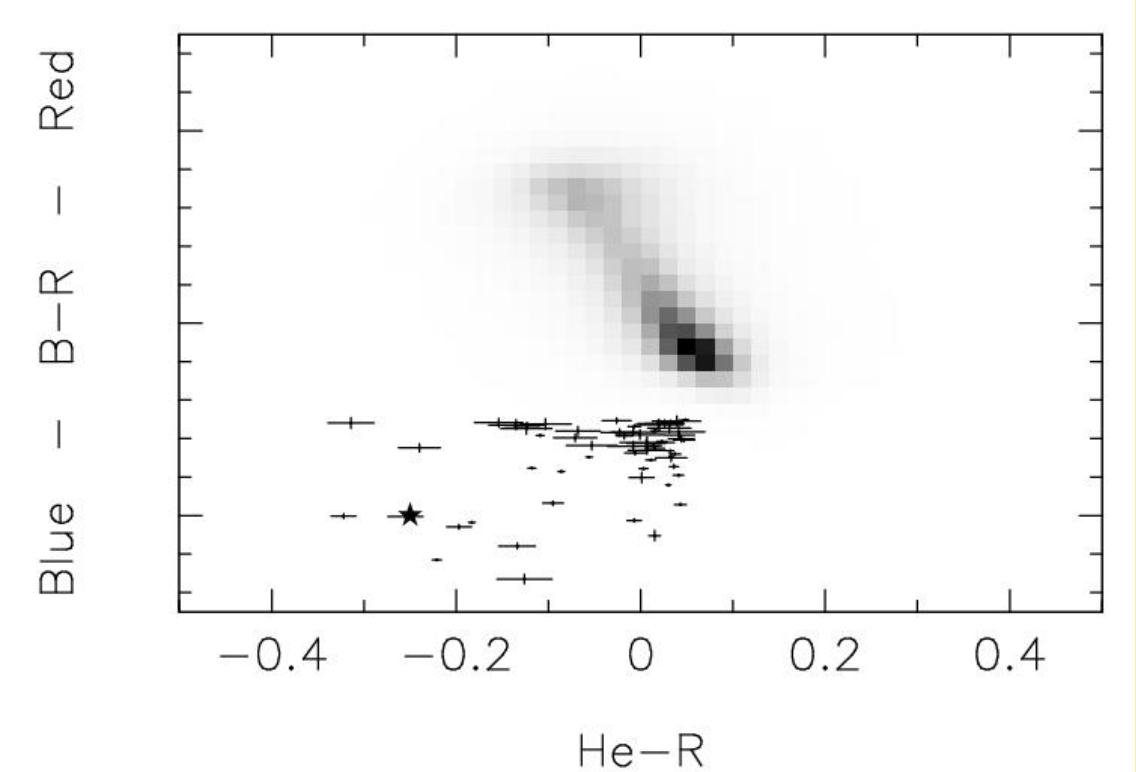
- ⋆Expect GP Com/CE 315 like systems to be blue in $B - R$
- ⋆and also blue in $He - H\alpha$


N / sq. deg.
0
5
10
15
18
19
20
21
22
V

Check on GP Com and CE 315



For all fields



8 candidates found out of $>$1.3 million objects

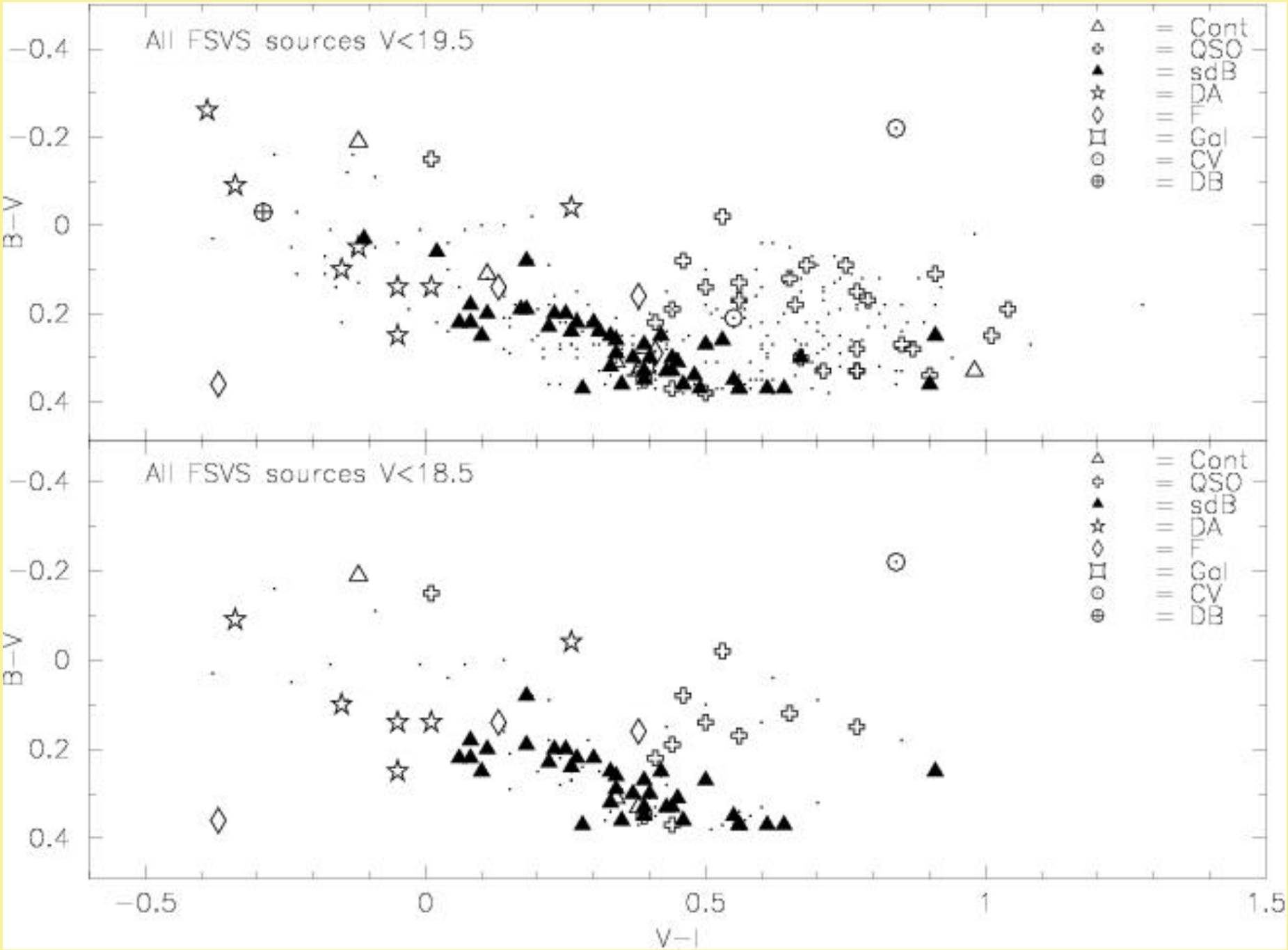
Spectroscopy is underway: no new systems found yet.

AM CVn stars in the Faint Sky Variability Survey

- FSVS is variability survey down to V=24 in 23 square degrees
- Blue ($B - V <$0.38) spectroscopy complete to V=18.5 in 17.7 sq. degr.

AM CVn stars in the Hamburg ESO Quasar Surveys (HES)

- Blue colour + emission lines: stand out in QSO surveys
- Explicitely checked for AM CVn stars in Hamburg - ESO Survey


All FSVS sources V<19.5
All FSVS sources V<18.5
B−V
V−I
−0.4
−0.2
0
0.2
0.4
−0.5
0
0.5
1
1.5
= Cont
= QSO
= sdB
= DA
= F
= Gal
= CV
= DB

Space density implications

- Implications for space density depends strongly on M_V
- ⋆Two assumptions: M_V(CE 315) = 14 and M_V(CE 315) = 12
- ⋆Implied distances: d_{14} (CE 315) = 50 pc and d_{12} (CE 315) = 125 pc

25 square degrees to V∼21 $\rho_{14} < 2.5 \times 10^{-5}$ pc^{-3}
$\rho_{12} < 1.6 \times 10^{-6}$ pc^{-3}.

In Nelemans et al. (2001) population synthesis:

25% systems have $P_{\rm orb} < P_{\rm CE315}$

$\Rightarrow$ $\rho_{14} < 1 \times 10^{-4}$ pc^{-3}
$\rho_{12} < 6.4 \times 10^{-6}$ pc^{-3}.

- ⋆Holds for emission line systems only

FSVS +HES AM CVn results

⋆No AM CVn stars found in FSVS Blue and HES

FSVS

$\Rightarrow \quad \rho_{14} < 1.1 \times 10^{-3}$ pc^{-3}

$\rho_{12} < 7.1 \times 10^{-5}$ pc^{-3}.

HES

⋆No AM CVn stars (all types) down to V=17.5 in 10 000 square degrees

$\Rightarrow \quad \rho_{14} < 7.9 \times 10^{-6}$ pc^{-3}

$\rho_{12} < 5 \times 10^{-7}$ pc^{-3}.

⋆Holds for all types

Limits on M_V of CE 315?

CE 315 has V=17.5 and μ=0.″35 yr^{-1} (same as GP Com!).

If M_V = 14 d = 50 pc $v_{\tan}$ = 83 km s^{-1}
If M_V = 12 d = 125 pc $v_{\tan}$ = 210 km s^{-1}
If M_V = 16 d = 31 pc $v_{\tan}$ = 52 km s^{-1}

⋆Distances to AM CVn stars are needed

⋆If GP Com = 70 pc, M_V (GP Com) = 11.7

GP Com, V803 Cen, AM CVn, HP Lib and CR Boo

currently measured with HST FGS (finished end 2003).

All limits grouped together:

M_V (CE 315) = 14	He-emission Survey	$\rho < 2.5 \times 10^{-5}$ pc^{-3}.
	FSVS	$\rho < 1.1 \times 10^{-3}$ pc^{-3}.
	HES	$\rho < 7.9 \times 10^{-6}$ pc^{-3}.
M_V (CE 315) = 12	He-emission Survey	$\rho < 1.6 \times 10^{-6}$ pc^{-3}.
	FSVS	$\rho < 7.1 \times 10^{-5}$ pc^{-3}.
	HES	$\rho < 5 \times 10^{-7}$ pc^{-3}.

Comparisons

□ Warner's (1995): $\rho = 3 \times 10^{-6}$ pc^{-3}

⋆But based on brighter systems and also assumed distances

□ Nelemans et al., 2001, total space densities

$\Rightarrow$ Effective spin-orbit coupling: $\rho = 1.7 \times 10^{-4}$ pc^{-3} with dominance of WD-WD family

$\Rightarrow$ Ineffective coupling: $\rho = 4.0 \times 10^{-5}$ pc^{-3} with dominance of He-WD family.

⋆Even optimistic HES limit factor 5 lower!

Ways out

- $M_V(CE315) > 14$: Improbable
- Old systems don't look like GP Com, CE 315 and CP Eri

- Most systems don't survive as AM CVn systems
  - ⋆Direct impact phase: Marsh, Nelemans, Steeghs (2003)
- AM CVns are a young population as IBWD
  - ⋆CE phase is efficient and systems emerge as wide WD+WD binaries

Future:

- Compare results of more large area surveys
  - EC survey, HE survey, SDSS, future Omegacam
- Extend new targeted surveys to deeper limits & larger area
- Extend spectroscopic follow-up FSVS down to V=20
- Identification of weak X-ray sources
  - ROSAT, CHaMP(Iain)
- More accurate modelling when distances are known
- Chemical abundances to identify parent populations of known systems