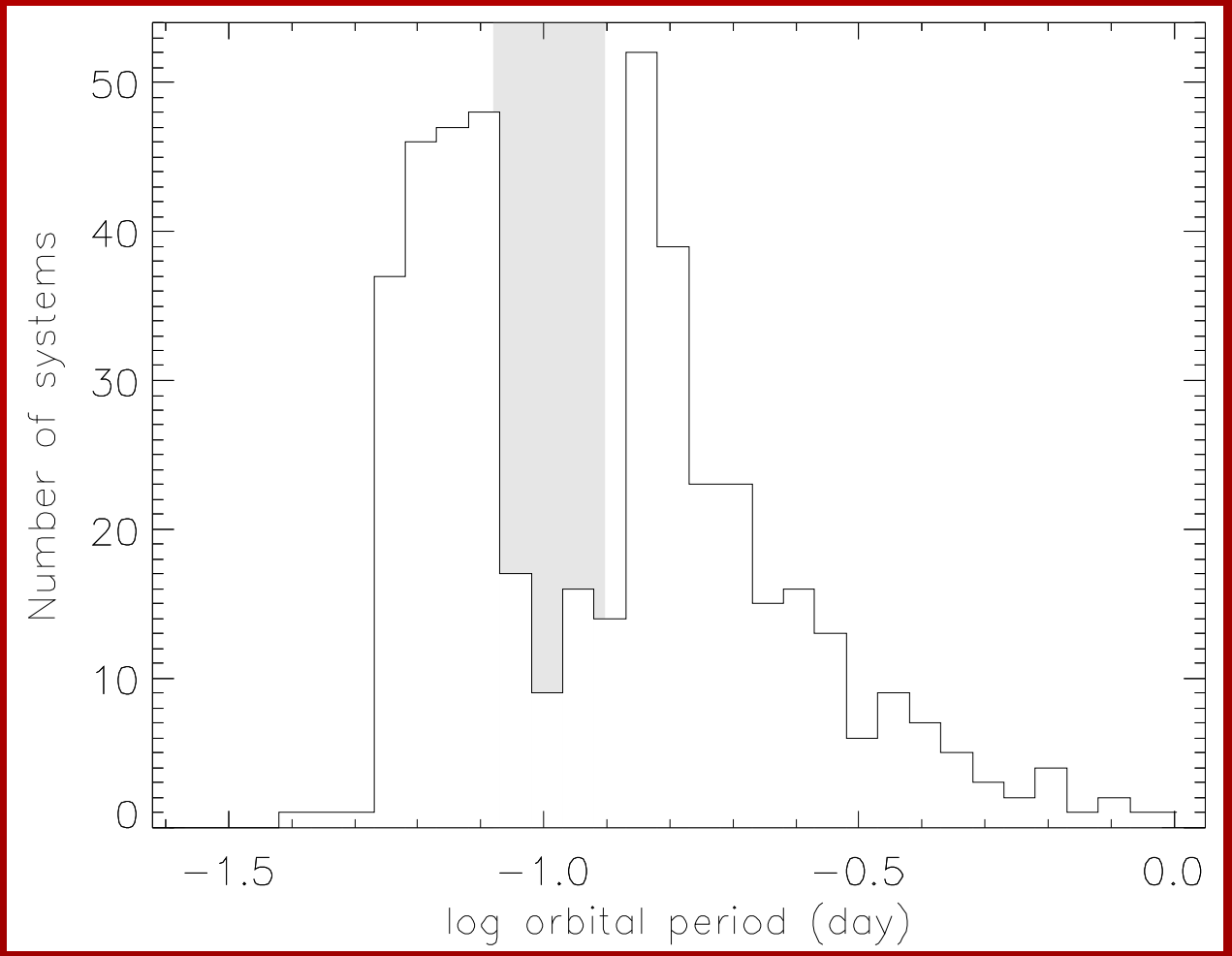
Small is Beautiful: Cataclysmic Variables from the SDSS

THE UNIVERSITY OF WARWICK

John Southworth
Tom Marsh
Boris Gänsicke
+ many others

Observed population of CVs

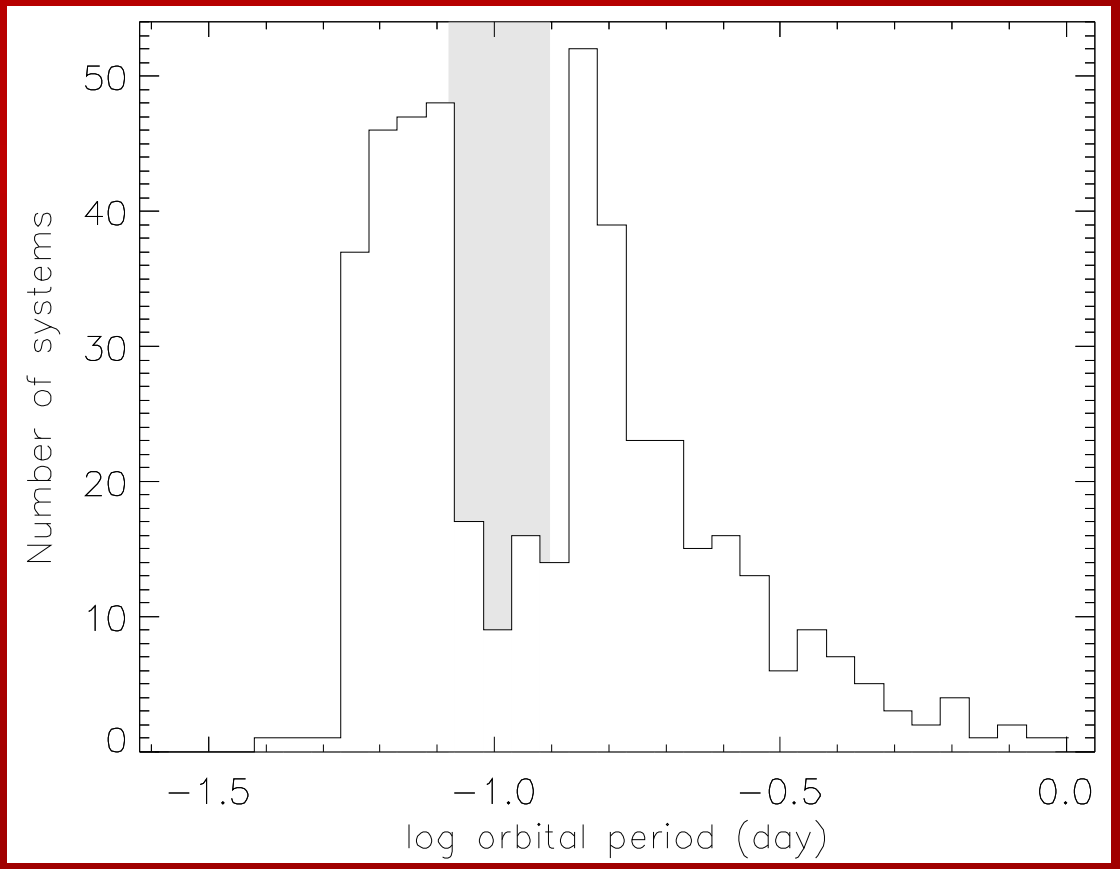
- Come from common envelope evolution
  - Close binary containing white dwarf and late-type dwarf



Ritter & Kolb, 2004, A&A, 404, 301

Observed population of CVs

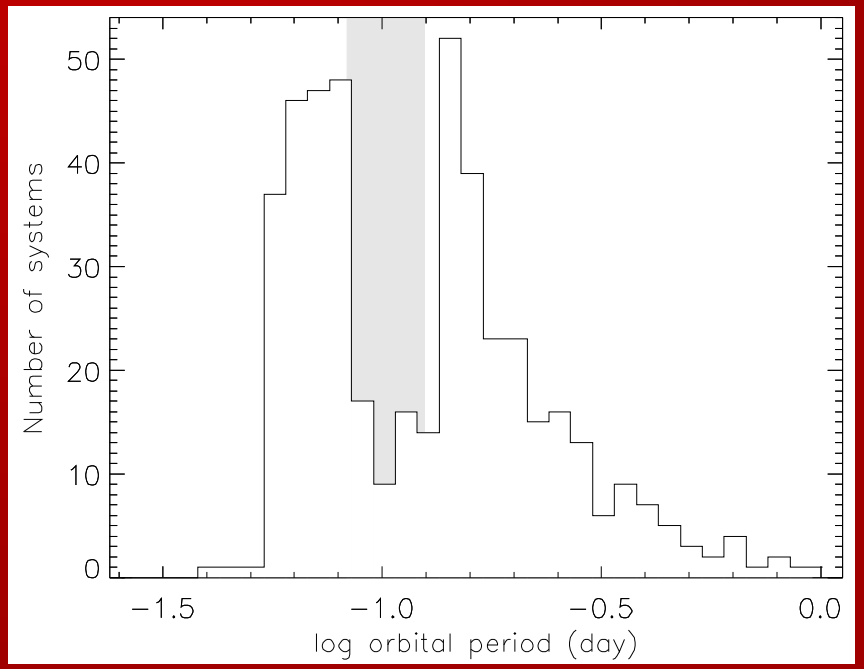
- Come from common envelope evolution
  - Close binary containing white dwarf and late-type dwarf
- Angular momentum loss by magnetic braking
  - P → 3 hours: donor shrinks and mass transfer ceases



Ritter & Kolb, 2004, A&A, 404, 301

Observed population of CVs

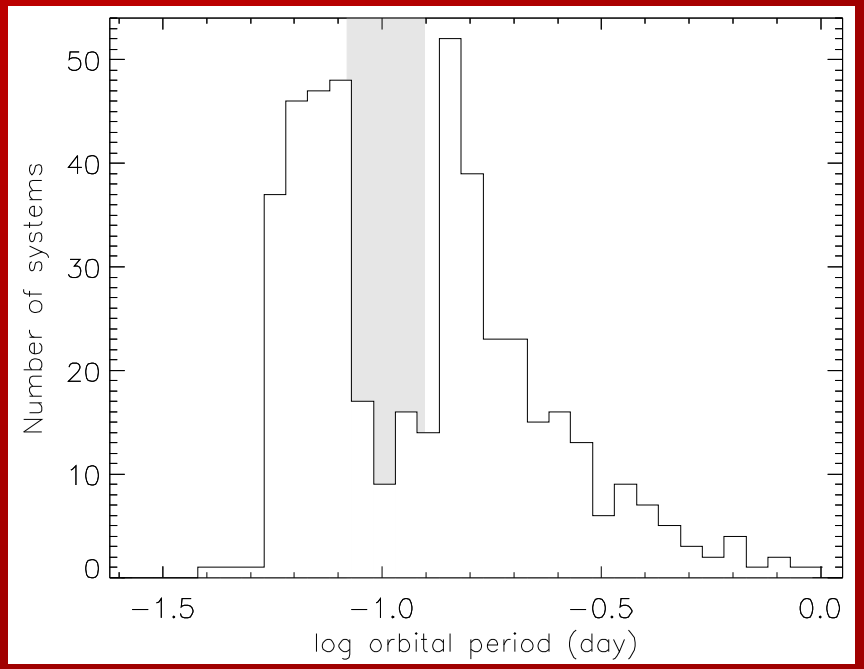
- Come from common envelope evolution
  - Close binary containing white dwarf and late-type dwarf
- Angular momentum loss by magnetic braking
  - P → 3 hours: donor shrinks and mass transfer ceases
- Angular momentum loss by gravitational radiation
  - P → 2 hours: secondary fills Roche Lobe again
  - Mass transfer restarts



Ritter & Kolb, 2004, A&A, 404, 301

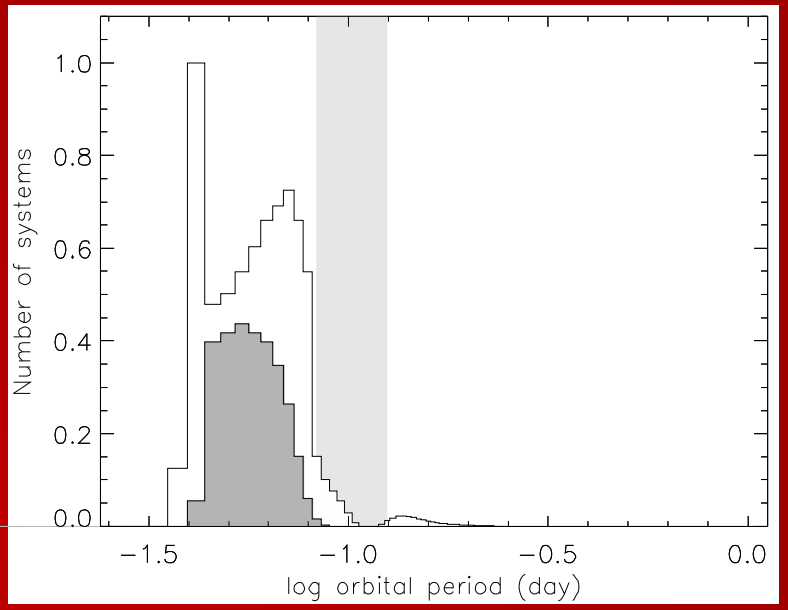
Observed population of CVs

- Come from common envelope evolution
  - Close binary containing white dwarf and late-type dwarf
- Angular momentum loss by magnetic braking
  - P → 3 hours: donor shrinks so mass transfer ceases
- Angular momentum loss by gravitational radiation
  - P → 2 hours: secondary fills Roche Lobe again
  - Mass transfer restarts
- 80 min minimum period
  - M dwarf is degenerate
  - Period starts to increase
- Old CVs: very faint



Theory vs. observations

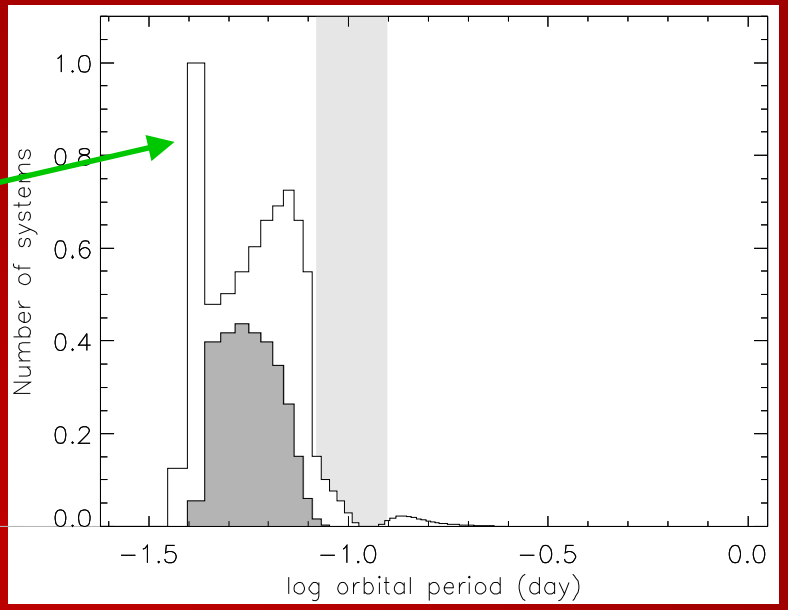
- Population synthesis models



Howell et al., 2001, ApJ, 550, 879

Theory vs. observations

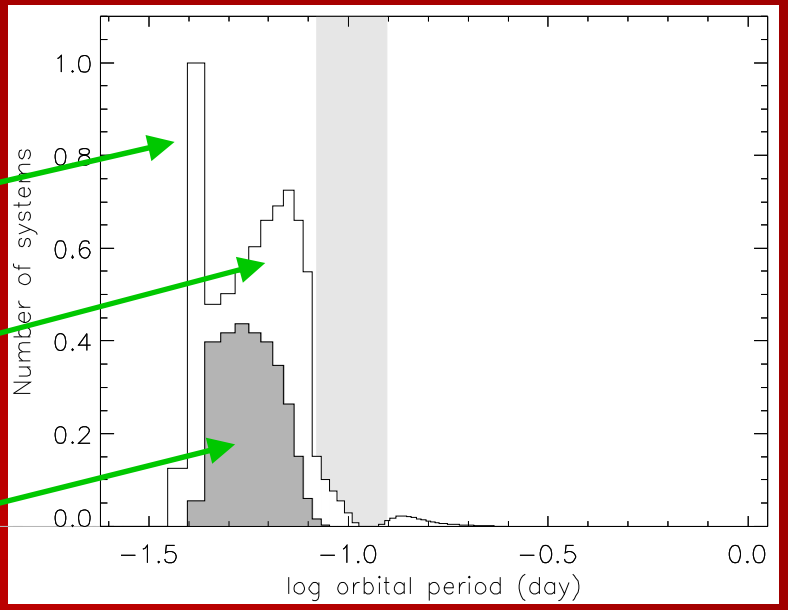
- Population synthesis models:
  - Minimum period reached is spike at ≈ 65 minutes



Howell et al., 2001, ApJ, 550, 879

Theory vs. observations

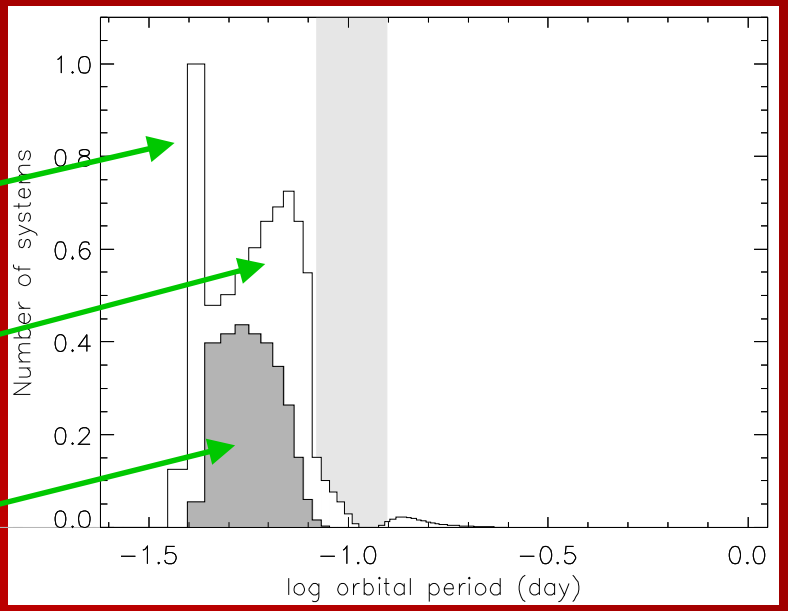
- Population synthesis models:
  - Minimum period reached is spike at ≈ 65 minutes
  - 99% of CVs should have periods below 2 hours
  - 70% of CVs should have brown dwarf donors

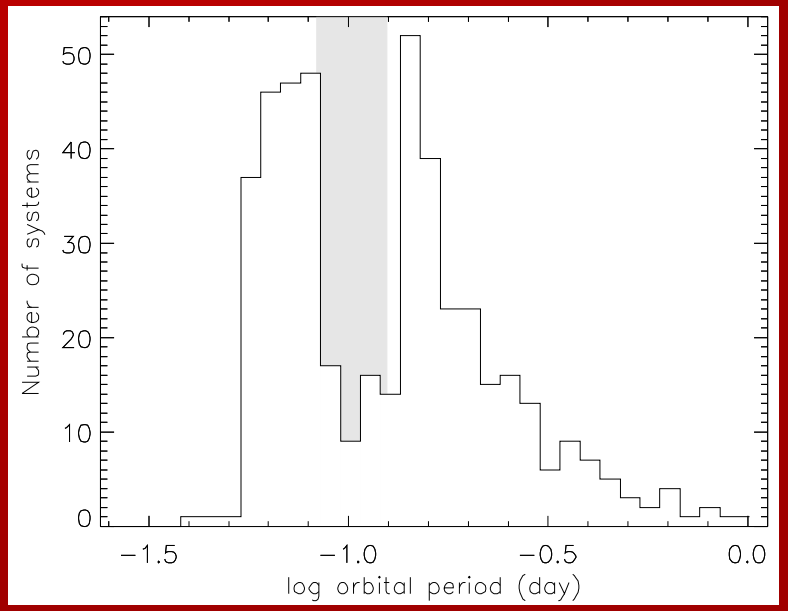


Howell et al., 2001, ApJ, 550, 879

Theory vs. observations

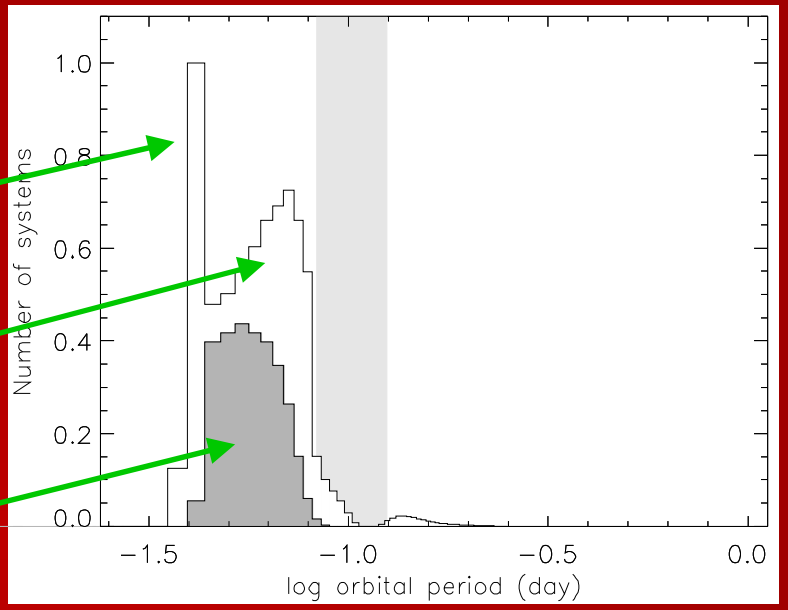
- Population synthesis models:
  - Minimum period reached is spike at ≈ 65 minutes
  - 99% of CVs should have periods below 2 hours
  - 70% of CVs should have brown dwarf donors
- Observations:

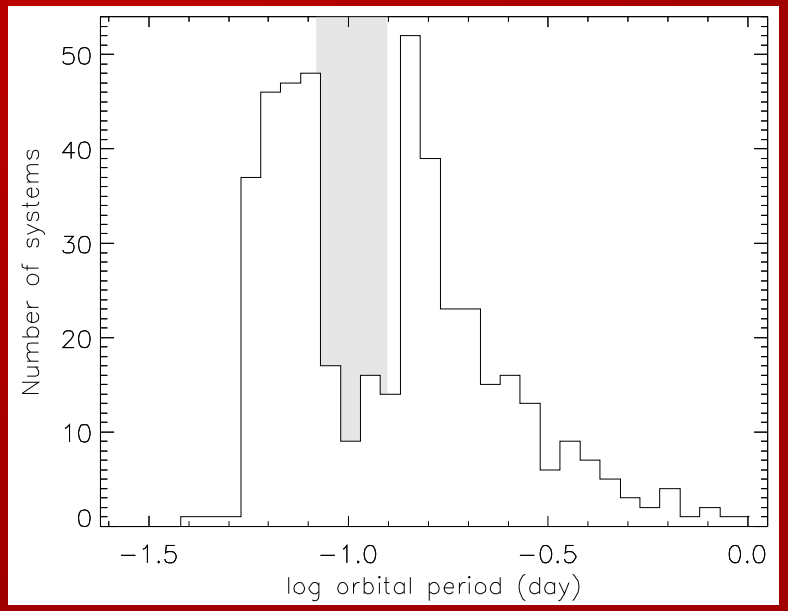




Theory vs. observations

- Population synthesis models:
  - Minimum period reached is spike at ≈ 65 minutes
  - 99% of CVs should have periods below 2 hours
  - 70% of CVs should have brown dwarf donors
- Observations:
  - Min period = 77 min, no spike
  - About 50% of CVs have periods below 2 hours
  - No definite brown dwarf donor





SDSS CVs: a very different sample

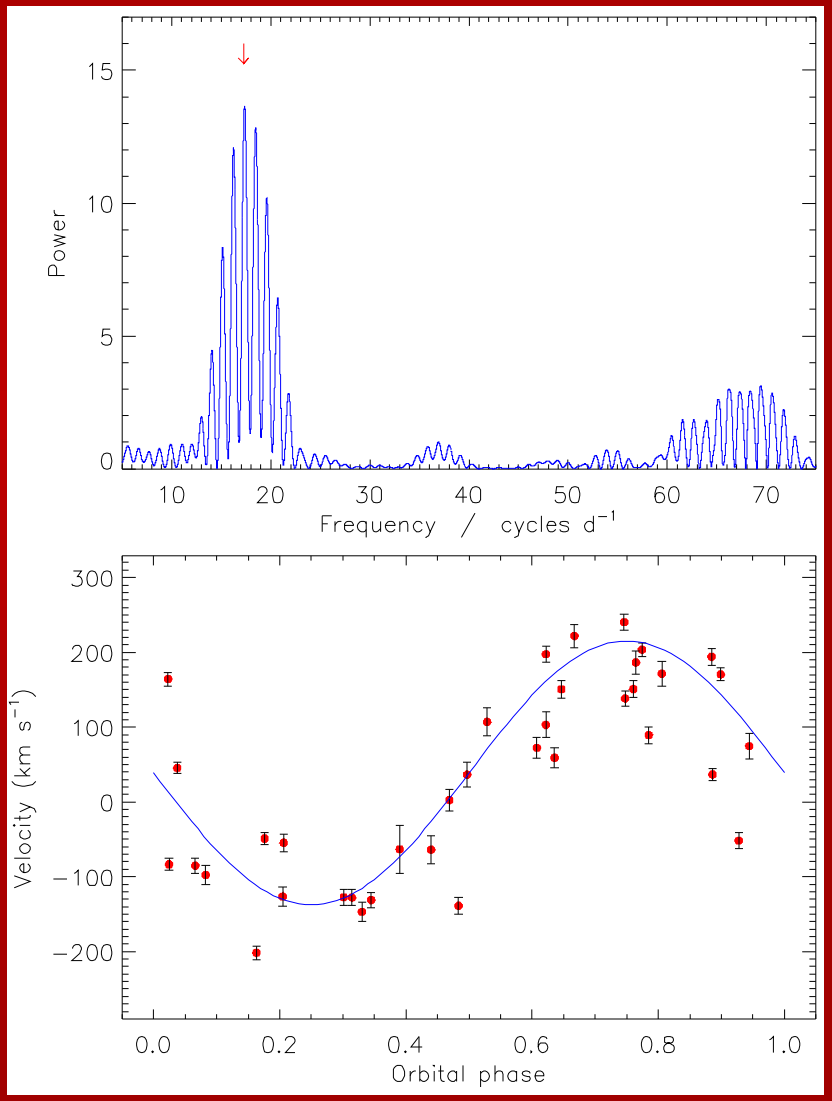
- CVs traditionally discovered by:
  - Outbursts
  - X-ray emission
  - Photometric surveys for blue objects

SDSS CVs: a very different sample

- CVs traditionally discovered by:
  - Outbursts
  - X-ray emission
  - Photometric surveys for blue objects
- SDSS CVs discovered by:
  - *u'g'r'i'z'* colours different to normal MS stars
  - Balmer and helium spectral line emission
  - Faintest magnitude ~20: partially volume limited
- **SDSS may have** found **the faint short-period ones which should dominate the CV population**

SDSS J2333: a short-period intermediate polar

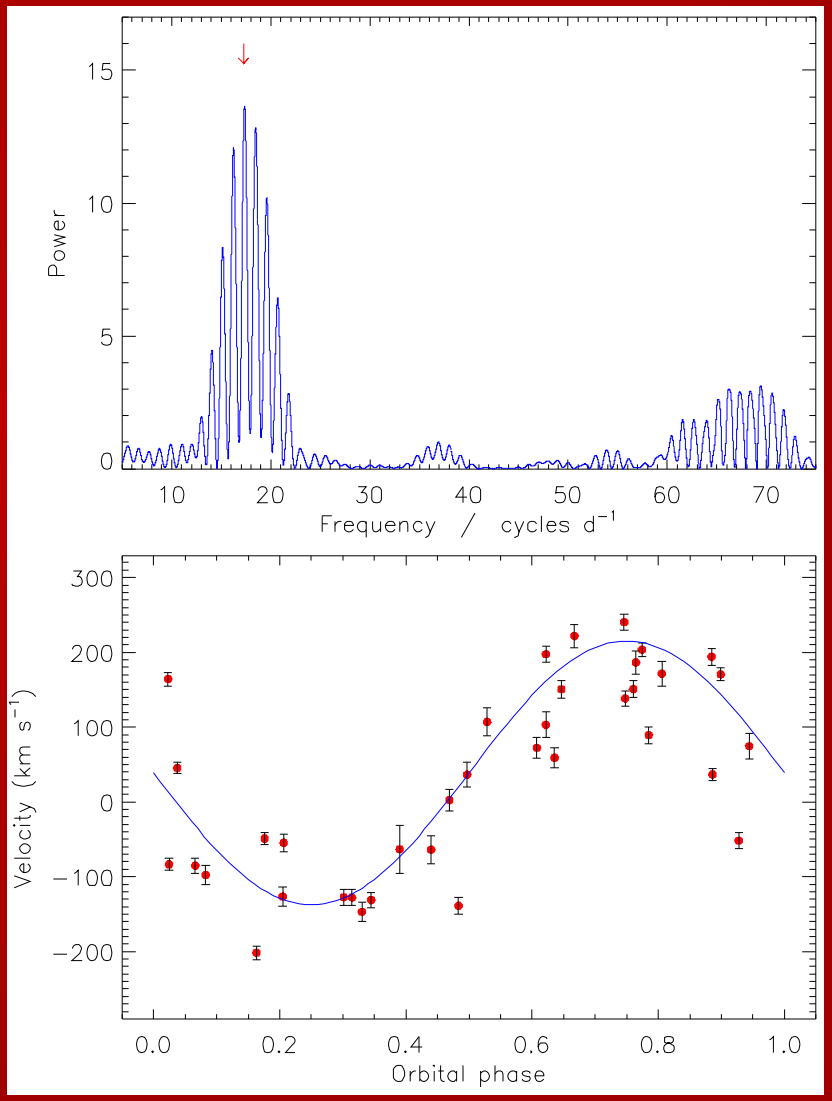
- Orbital period:
  - 83.12 ± 0.09 minutes
- Spin period:
  - 41.66 ± 0.13 minutes



Southworth et al., 2007, MNRAS, in press, arXiv:0704.0513

SDSS J2333: a short-period intermediate polar

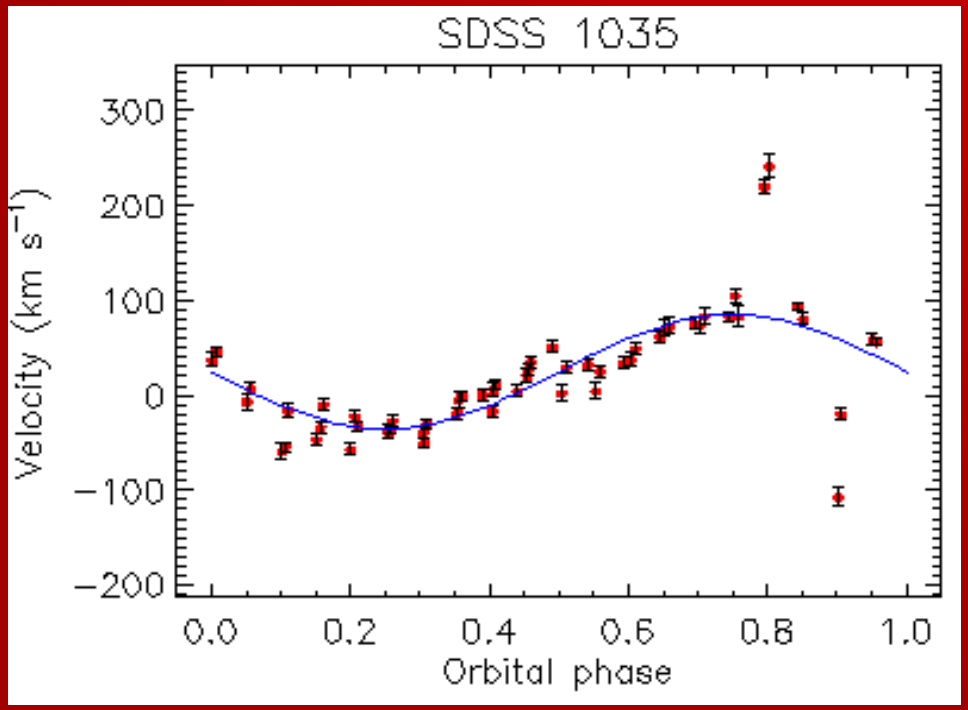
- Orbital period:
  - 83.12 ± 0.09 minutes
- Spin period:
  - 41.66 ± 0.13 minutes
- Short-period IPs have long spin periods
  - come from the dominant population of long-period IPs with short spin periods



Southworth et al., 2007, MNRAS, in press, arXiv:0704.0513

SDSS J1035: an eclipsing CV with a brown dwarf donor

- VLT spectroscopy:
  - orbital period 82.1± 0.1 min

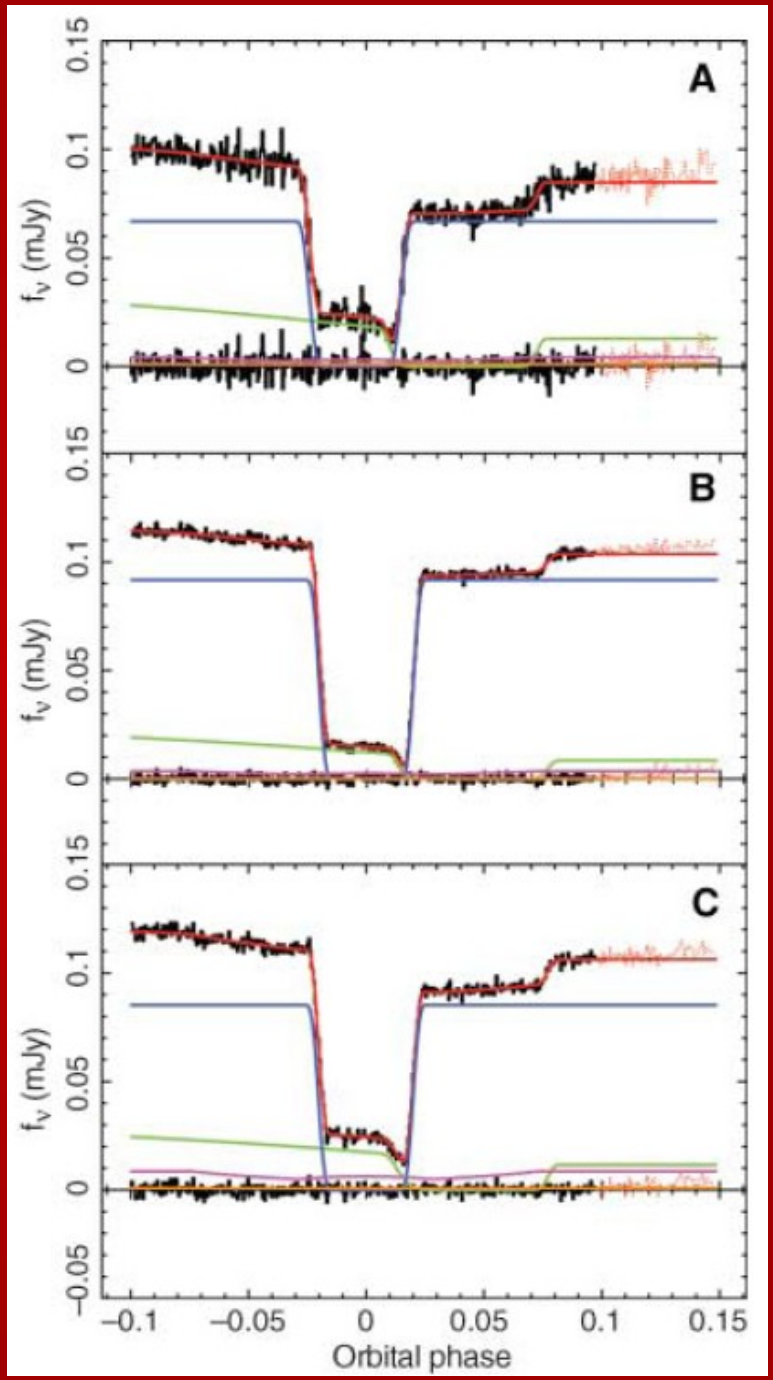


Southworth et al., 2006, MNRAS, 373, 687

SDSS J1035: an eclipsing CV with a brown dwarf donor

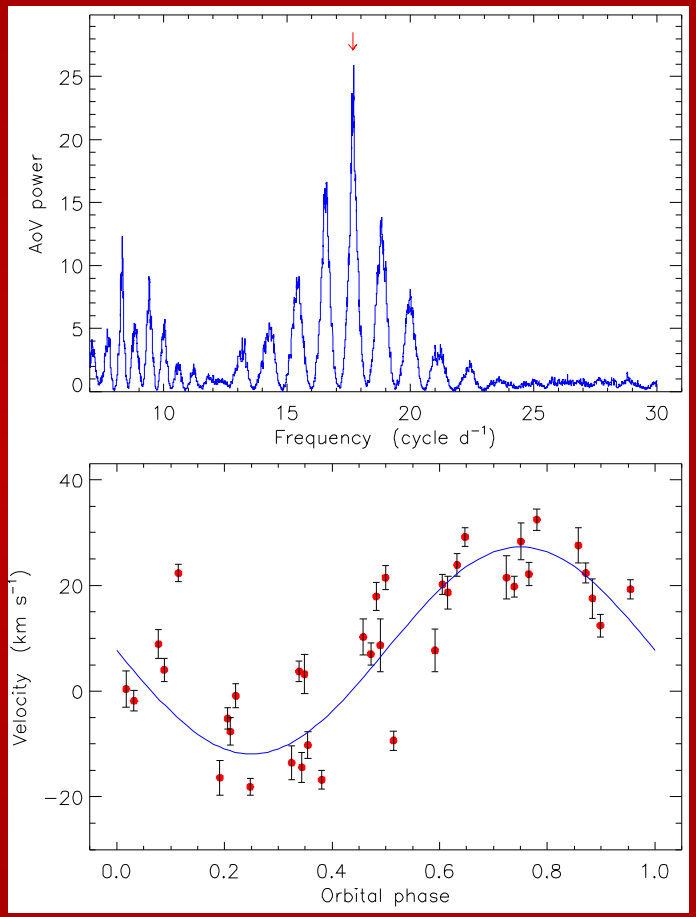
- VLT spectroscopy:
  - orbital period 82.1± 0.1 min
- ULTRACAM photometry:
  - geometrical model of eclipses
  - M_{WD} = 0.94 ± 0.01 M
  - M_2 = 0.052 ± 0.002 M
- Secondary star is a definite brown dwarf

Littlefair et al., 2006, *Science*, 314, 1578



More SDSS CVs

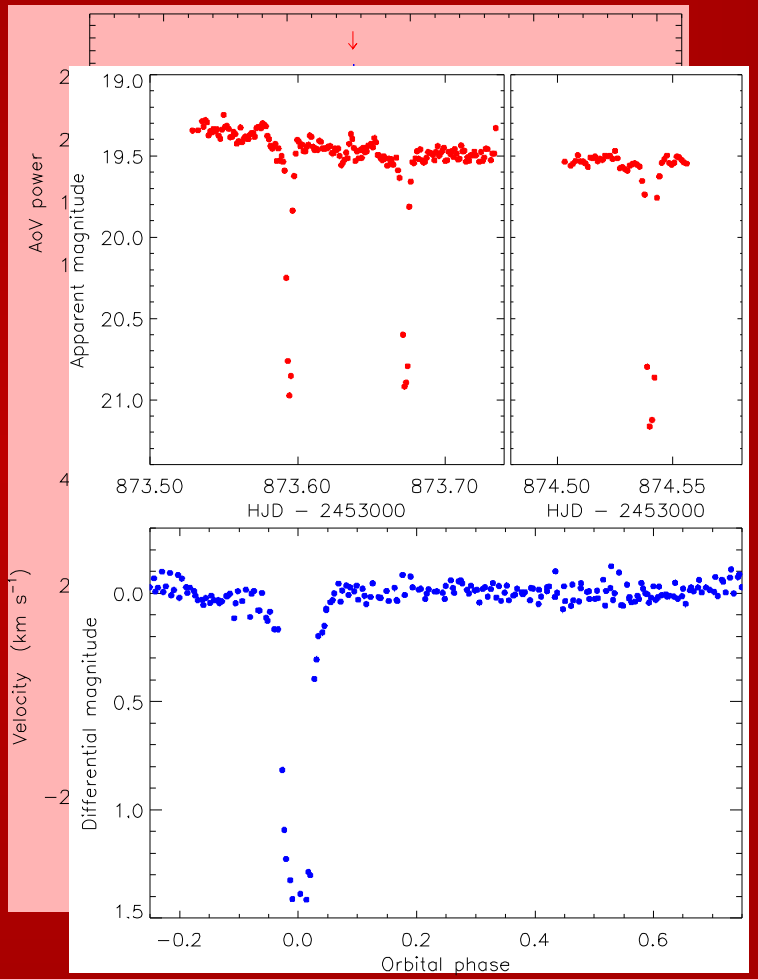
- SDSS J0131:
  - P = 81.5 ± 0.1 min



Southworth et al., 2007,
in preparation

More SDSS CVs

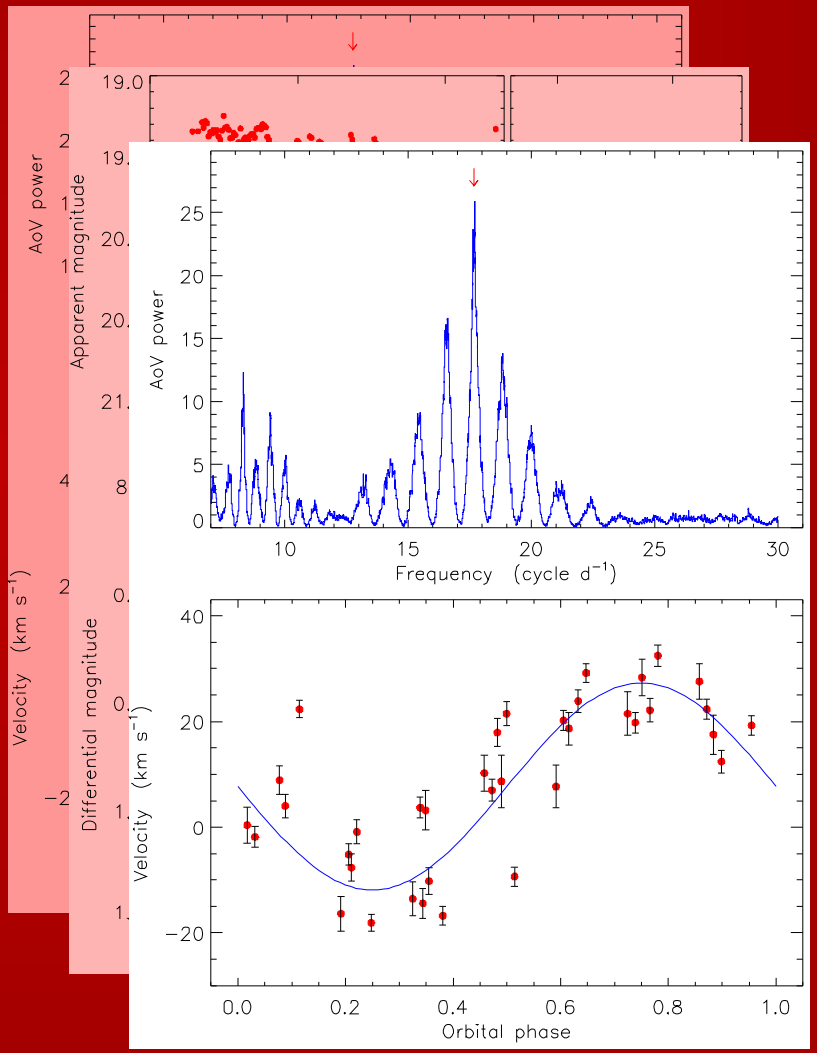
- SDSS J0131:
  - P = 81.5 ± 0.1 min
- SDSS J1555:
  - P = 113.54 ± 0.03 min
  - eclipsing system



Southworth et al., 2007,
in preparation

More SDSS CVs

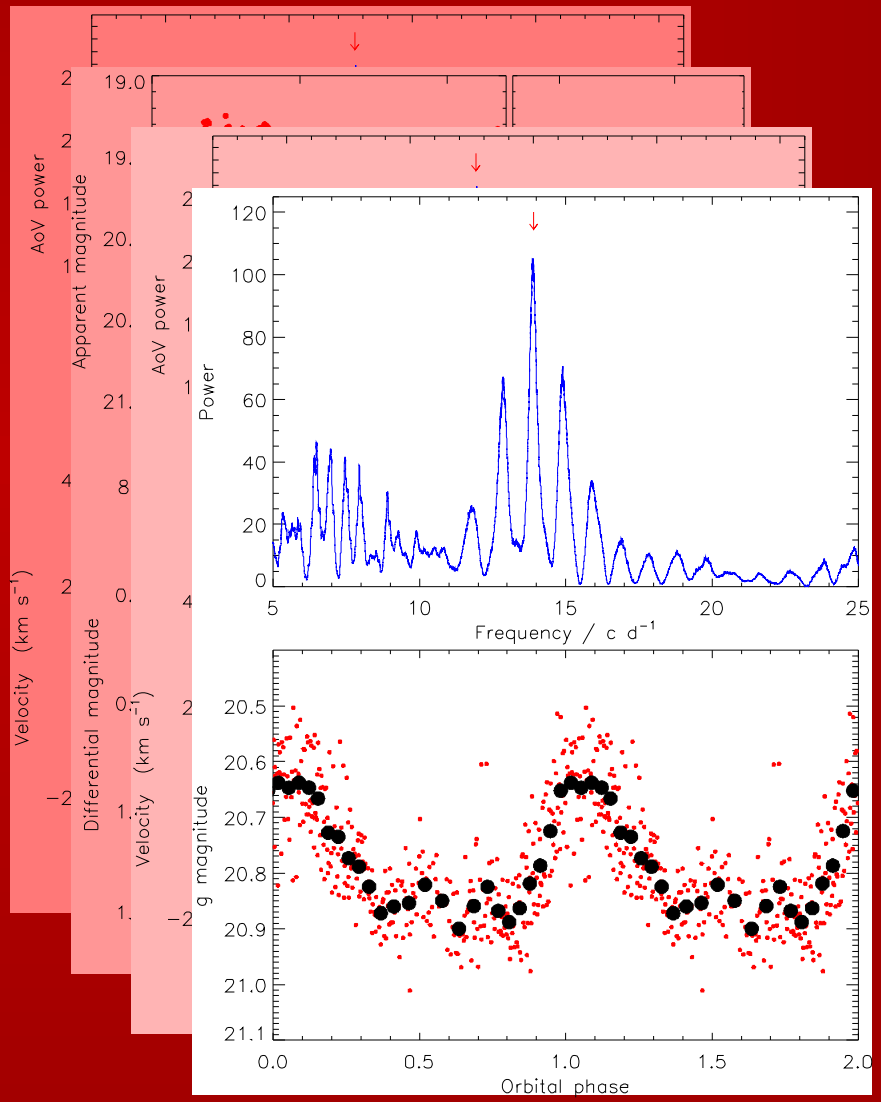
- SDSS J0131:
  - P = 81.5 ± 0.1 min
- SDSS J1555:
  - P = 113.54 ± 0.03 min
  - eclipsing system
- SDSS J2059:
  - caught in outburst
  - P = 107.5 ± 0.1 min



Southworth et al., 2007,
in preparation

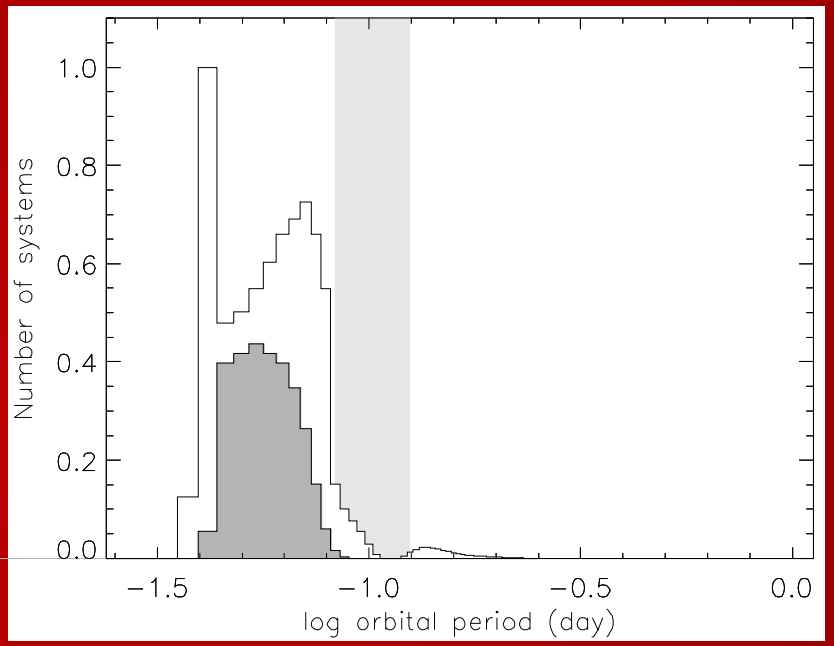
More SDSS CVs

- SDSS J0131:
  - P = 81.5 ± 0.1 min
- SDSS J1555:
  - P = 113.54 ± 0.03 min
  - eclipsing system
- SDSS J2059:
  - caught in outburst
  - P = 107.5 ± 0.1 min
- SDSS J2104:
  - P = 103.6 ± 0.1 min



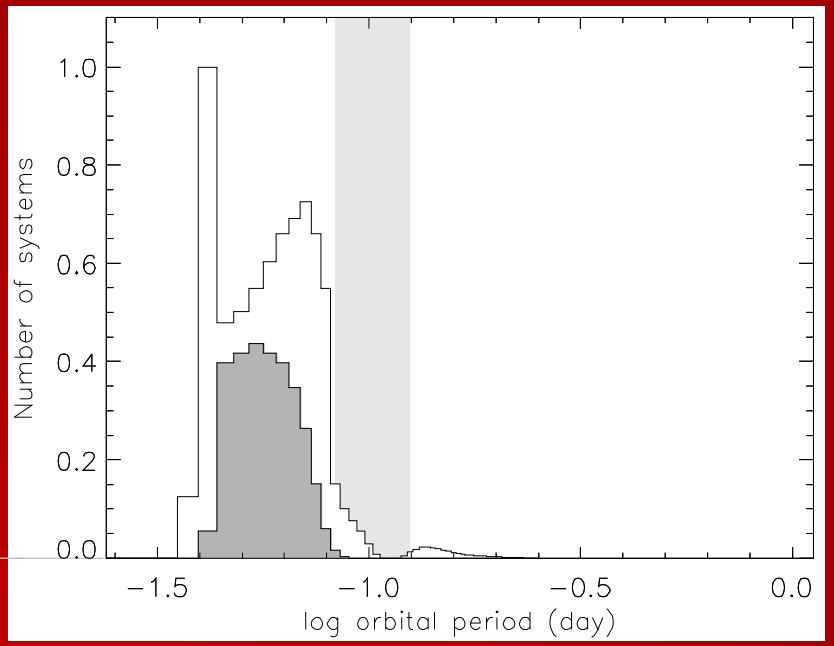
SDSS CV sample

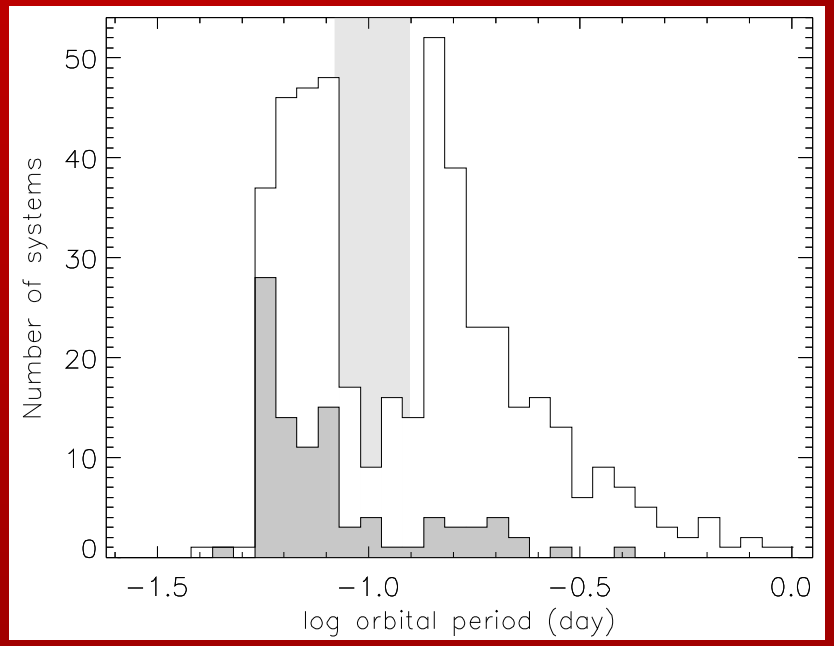
- Period distribution of known CVs doesn't match theoretical predictions
  - too few short-period ones
  - no definite brown dwarf secondary stars



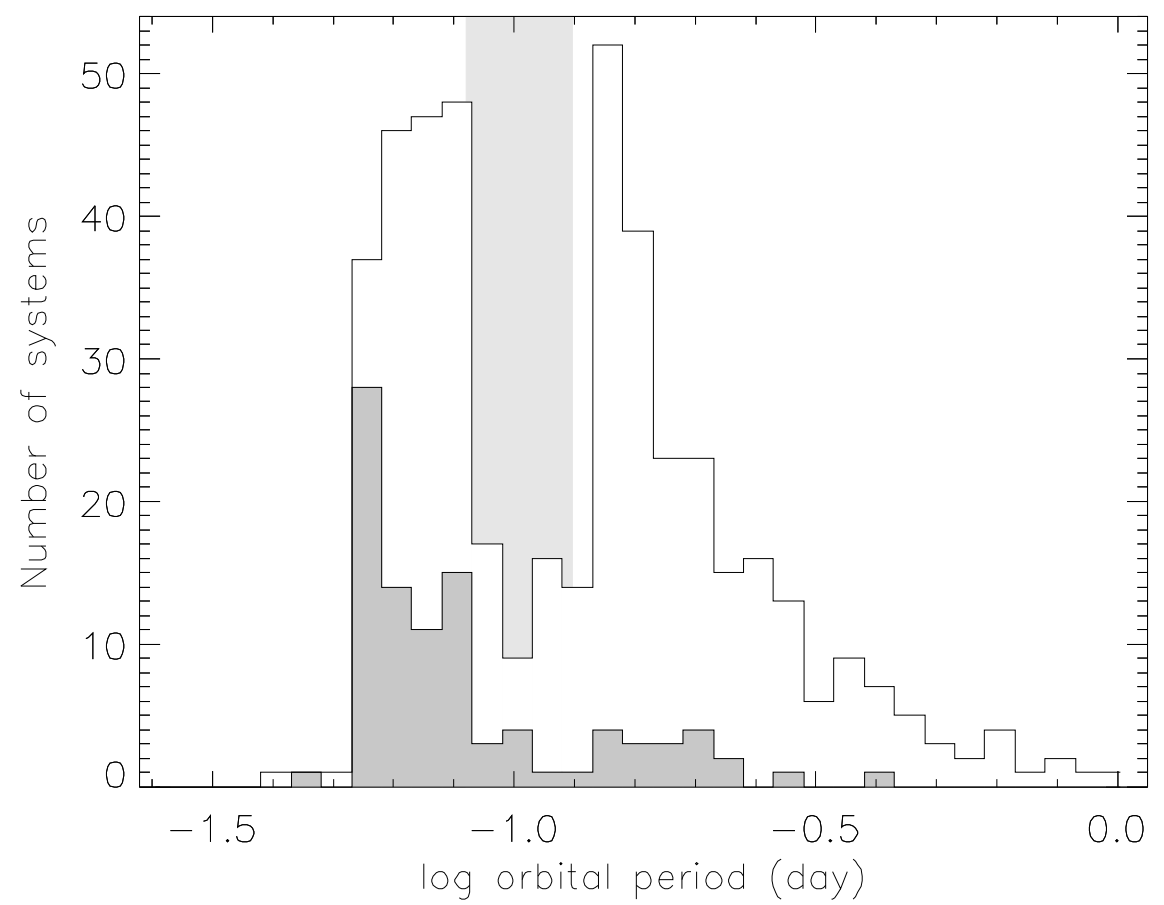
SDSS CV sample

- Period distribution of known CVs doesn't match theoretical predictions
  - too few short-period ones
  - no definite brown dwarf secondary stars
- SDSS CV sample: spectroscopically selected
  - far higher proportion of short-period systems
  - first confirmed brown dwarf secondary star





The SDSS CV sample



The SDSS may finally have found the long-predicted dominant population of CVs

- John Southworth
- University of Warwick
- j.k.taylor@warwick.ac.uk
- http://www.astro.keele.ac.uk/~jkt