The SWARMS Survey: A Search for Type Ia Supernova Progenitors with SDSS

LMC image
from MCELS
(C. Smith et al.)

Carles Badenes

Princeton University
Weizmann Institute of Science
Tel-Aviv University

Stellar Death and Supernovae
KITP, Santa Barbara
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Collaborators:
F. Mullally, R. Lupton (Princeton), S. Thompson (UD), S. Ransom (NRAO)

The SWARMS Survey

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KITP 08/17/09

SWARMS
Sloan **W**hite dw**A**rf **R**adial velocity data **M**ining **S**urvey

- **Strategy:** Use the multiple exposures (≥3, ~15 min each) taken for all the spectra in the Sloan Digital Sky Survey (SDSS) to look for radial velocity (RV) shifts among the ~10,000 White Dwarfs (WDs) in the SDSS DR4 catalog [Eisenstein et al. 06, ApJS 167, 40; E06].

- **Goal:** Find the double degenerate WD (DDWD) progenitors of Type Ia SNe [Webbink 84, ApJ 277, 355; Iben & Tutukov 84, ApJS 54, 335]: WD binaries with $M_A+M_B \geq M_{Ch}$ and $t_{Merge} < t_{Hubble}$ [Nelemans, Clayton, Tohline].

- **First results:** Badenes et al. 09, ApJ submitted; Mullally et al. 09, in prep.

First Binary Found: SDSS 1257+5428

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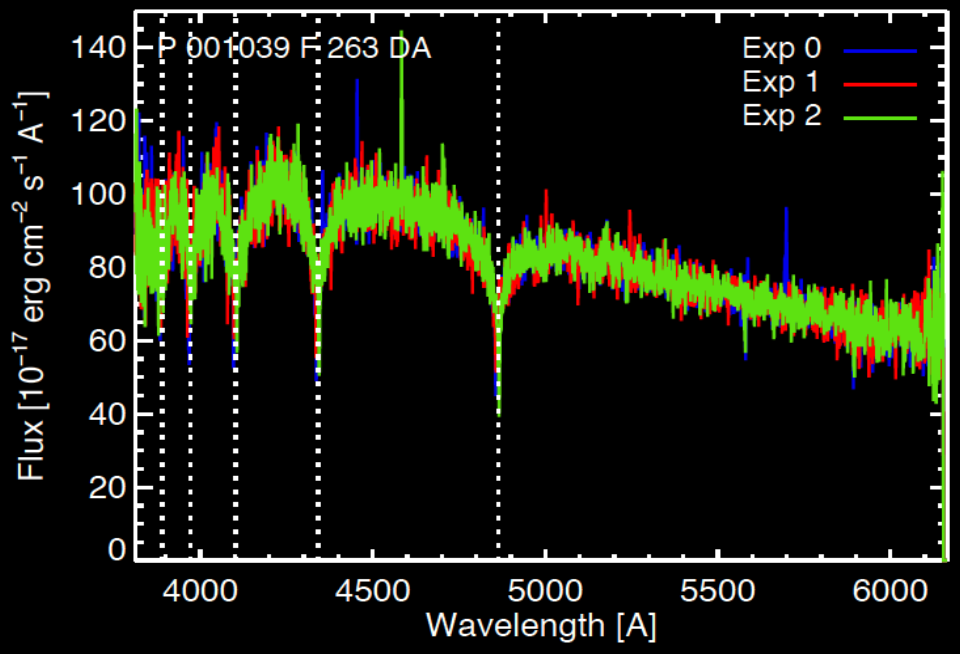

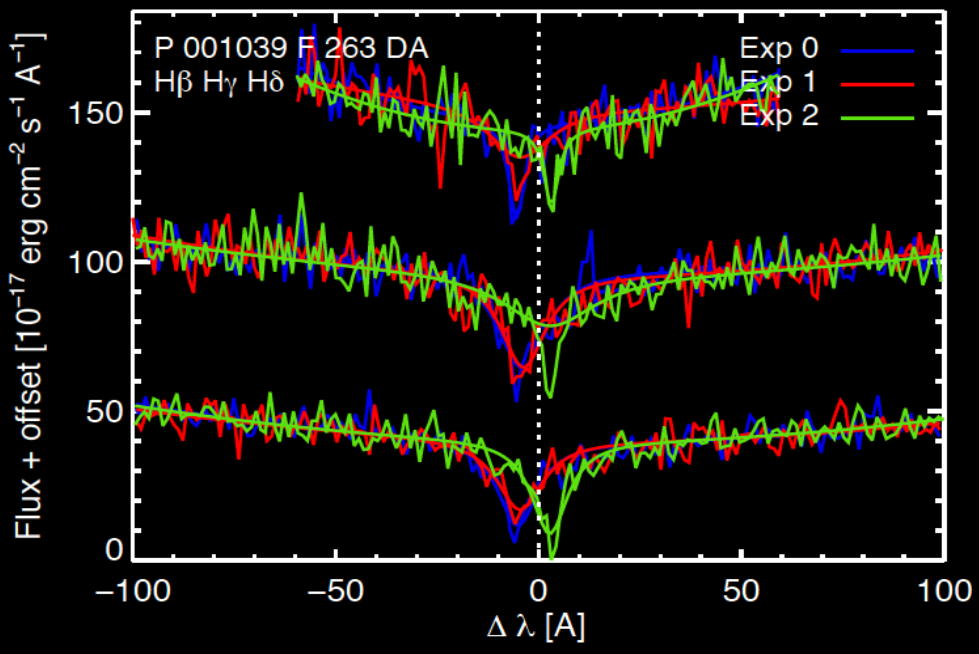

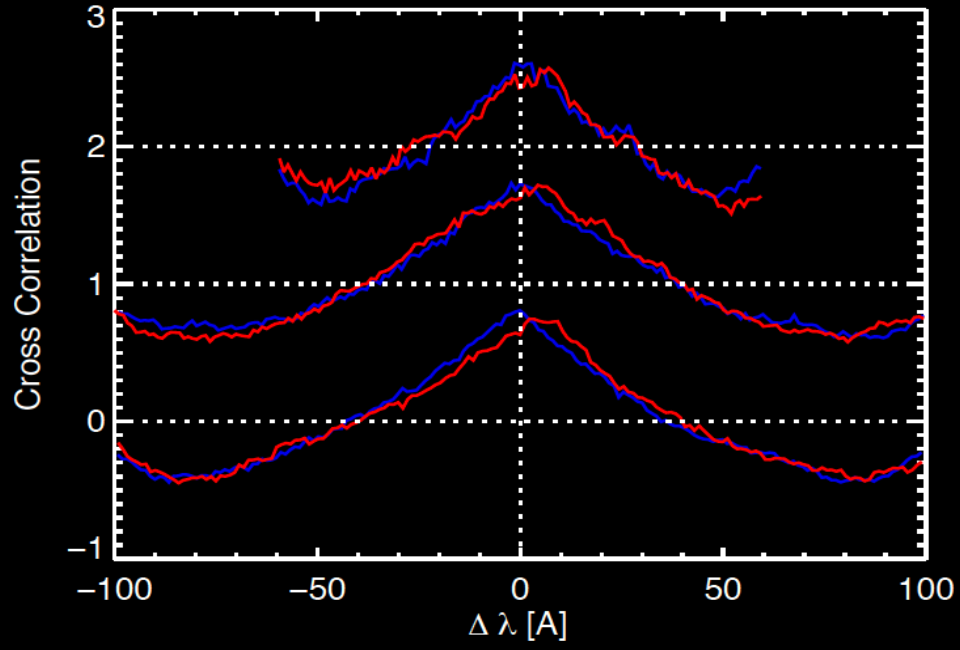

P 001039 F 263 DA
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gMag=16.84 SNR=30.11 Teff= 8570. logg=9.00
nExposures= 3 Δt [hr]=
0.29667 24.19278

- Classified as DA by E06; M_g=16.8.
- RV shift of ~8 Å (~490 km s^{-1}) between esposures 0, 1 (taken 10/03/2003) and 2 (taken 10/04).

Follow-up of SDSS 1257+5428: Orbit

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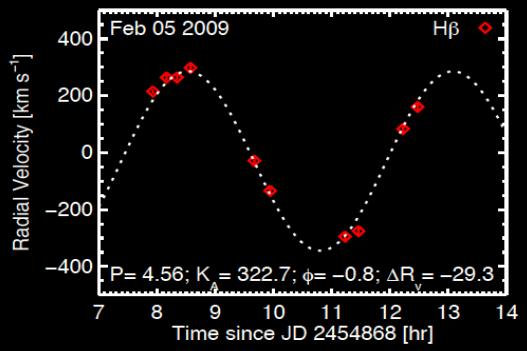

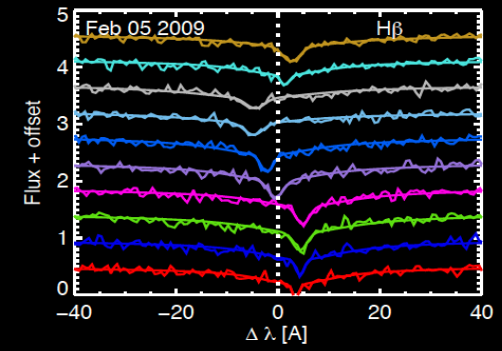

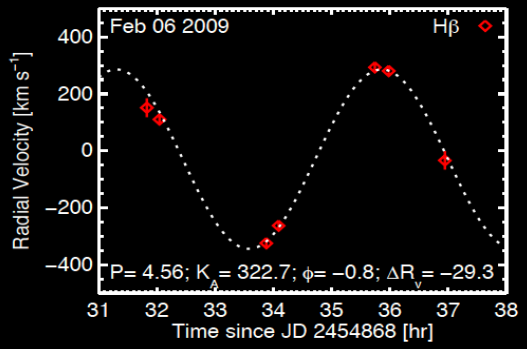

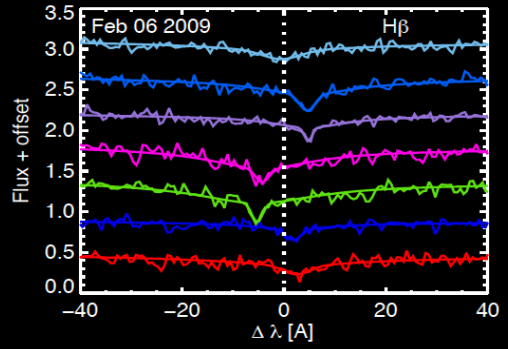

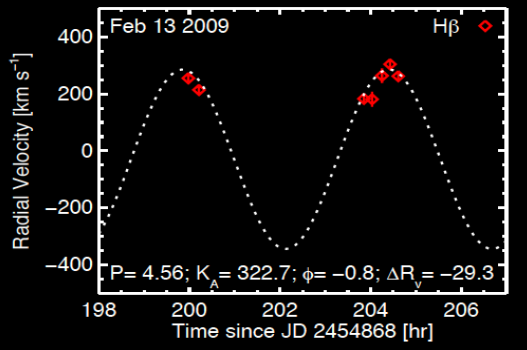

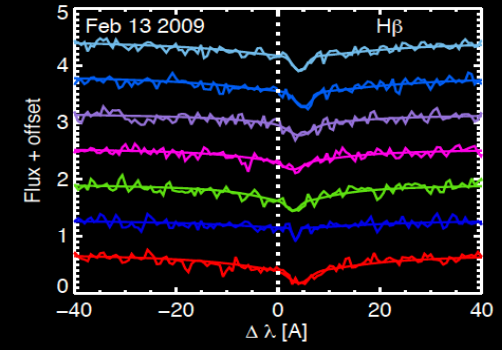

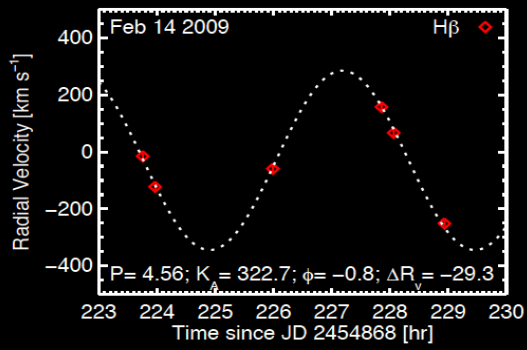

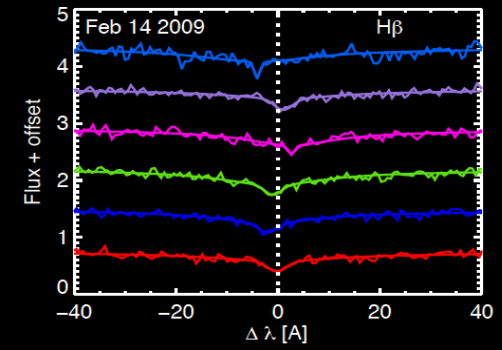

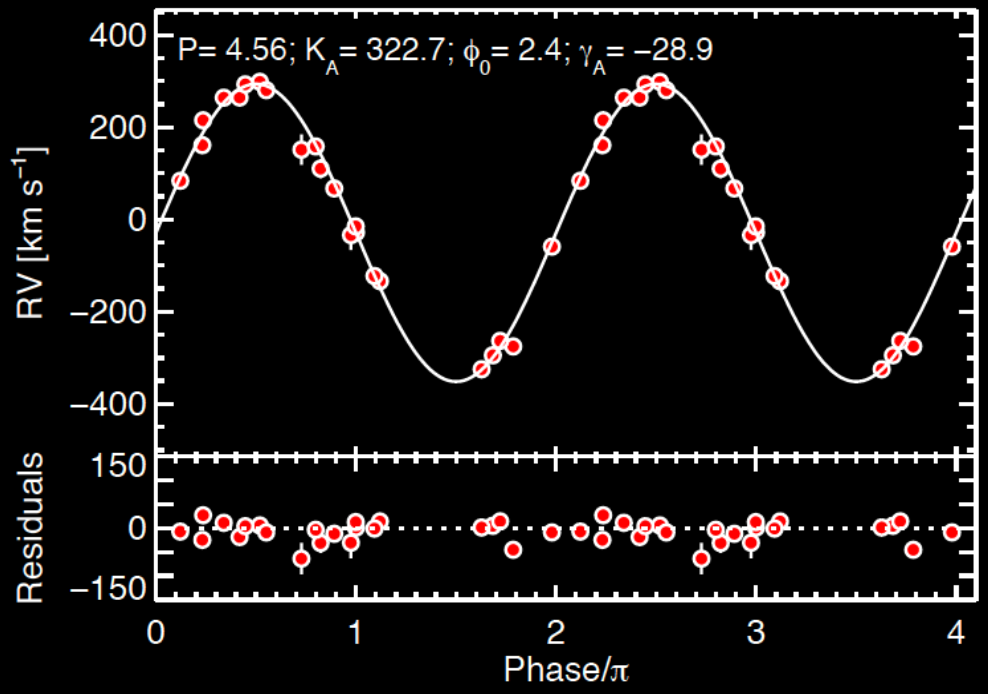

- Follow-up observations: APO ARC 3.5m telescope on 02/2009.
- RV curve is well fit by a circular orbit with P=4.5550±0.0007 hr; K_A=322.7±6.3 km s^{-1}.
- System must be tight and/or have massive components.

Follow-up of SDSS 1257+5428: Spectrum

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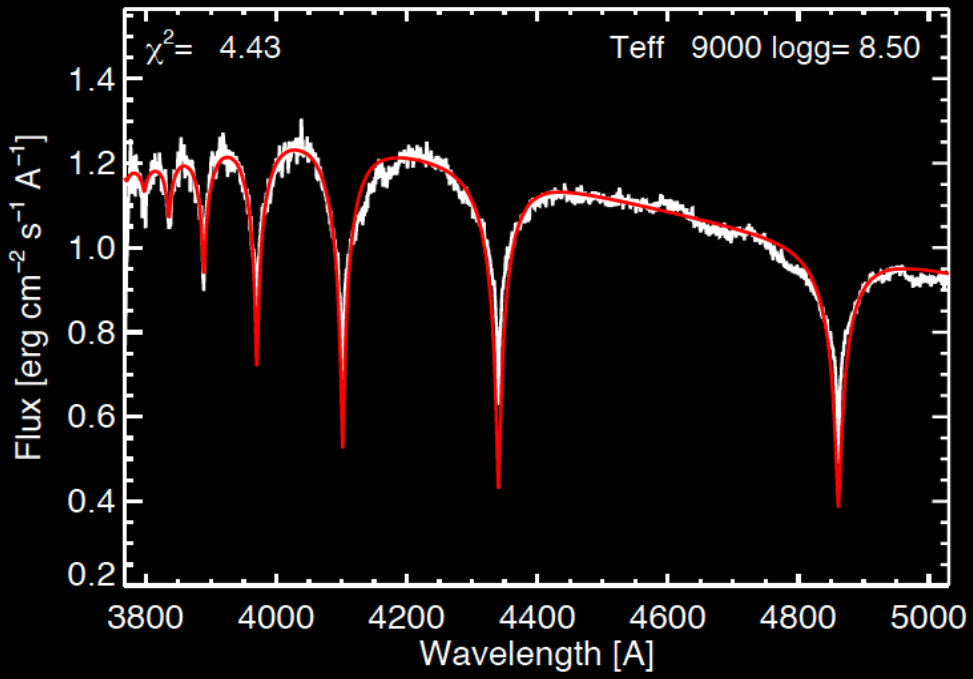
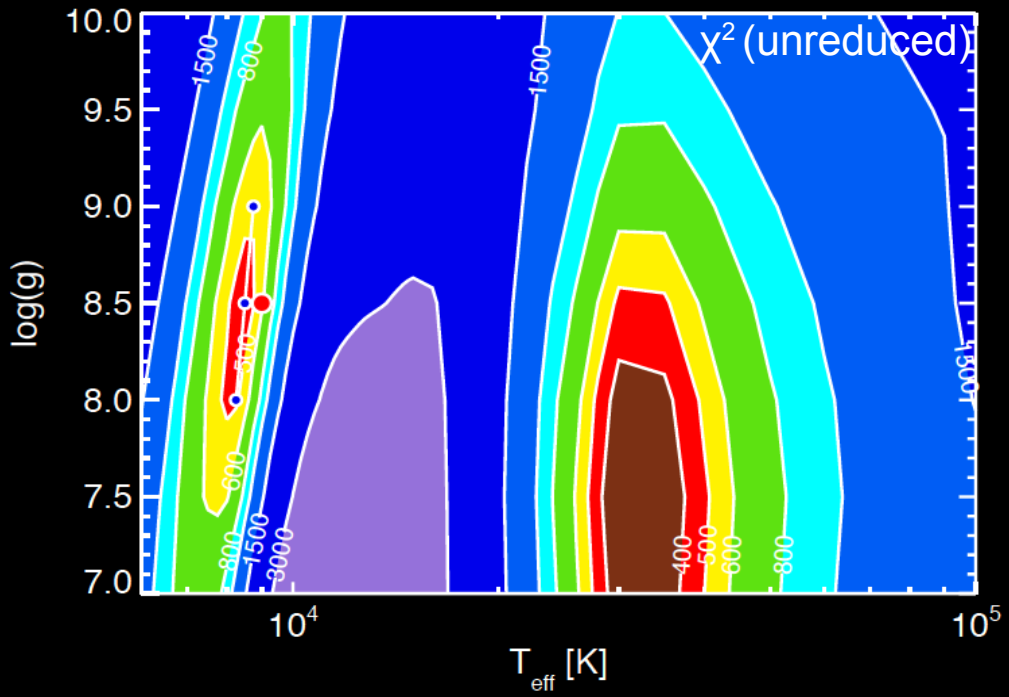
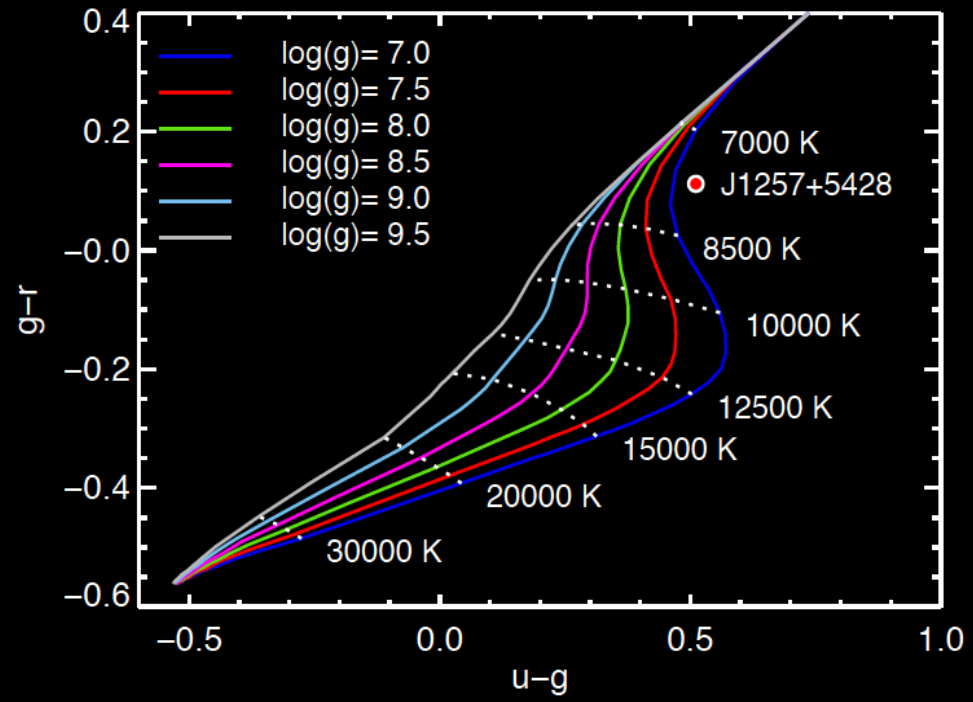
- Co-added APO spectrum has S/N=160.
- χ^2 statistic has two minima, but hot solutions are ruled out by the SDSS photometry.
- Best model: T_{eff}=9,000 K; log(g)=8.5, but fit is not very good.







The companion of SDSS 1257+5428

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- WD models [Finley et al. 97, ApJ 323, 129] are known to have problems around 9,000 K [Koester et al. 08, arXiv:0812.0491]. We can make a conservative mass estimate from high-order Balmer lines:

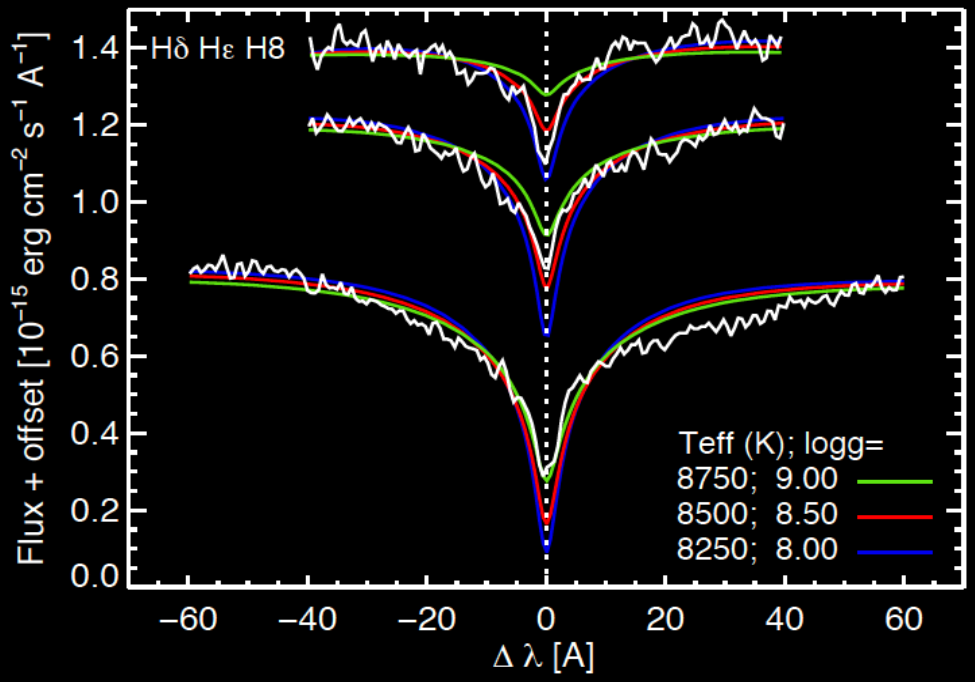
$$M_A = 0.92 \pm 0.32\ M_\odot$$

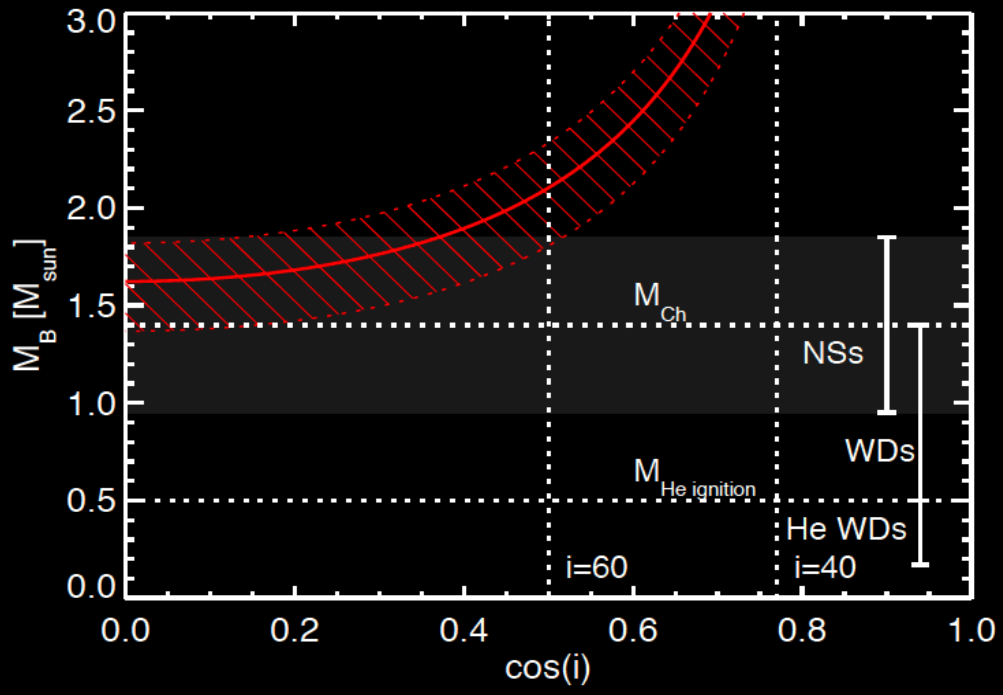
- Together with the orbital parameters, this yields:

$$M_B \sin(i) = 1.62 \pm 0.25\ M_\odot$$

- **The companion is too massive to be another WD** ⇒ probably a **neutron star** or **black hole**. At 29≤D≤58 pc, it might be the closest stellar remnant of a SN explosion.

- More details: Badenes et al. 09, ApJ submitted.





SDSS 1436+5010: A Short Period DDWD

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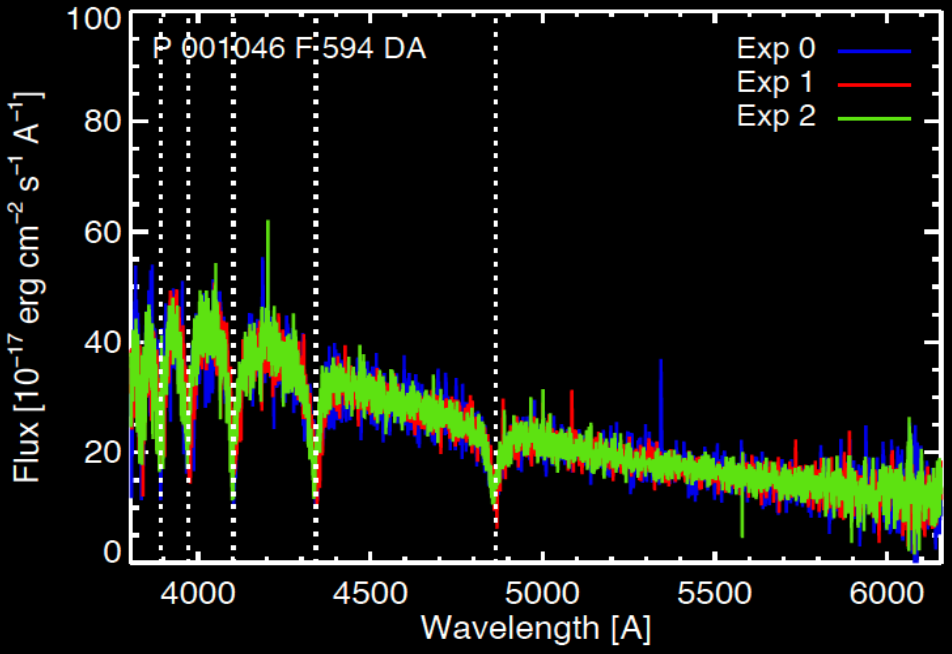

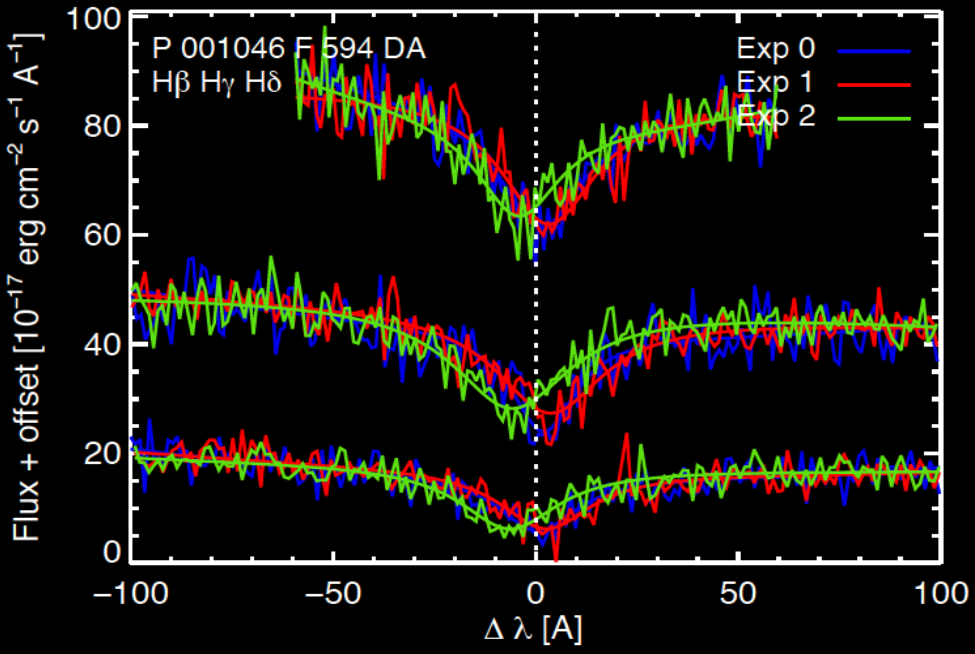

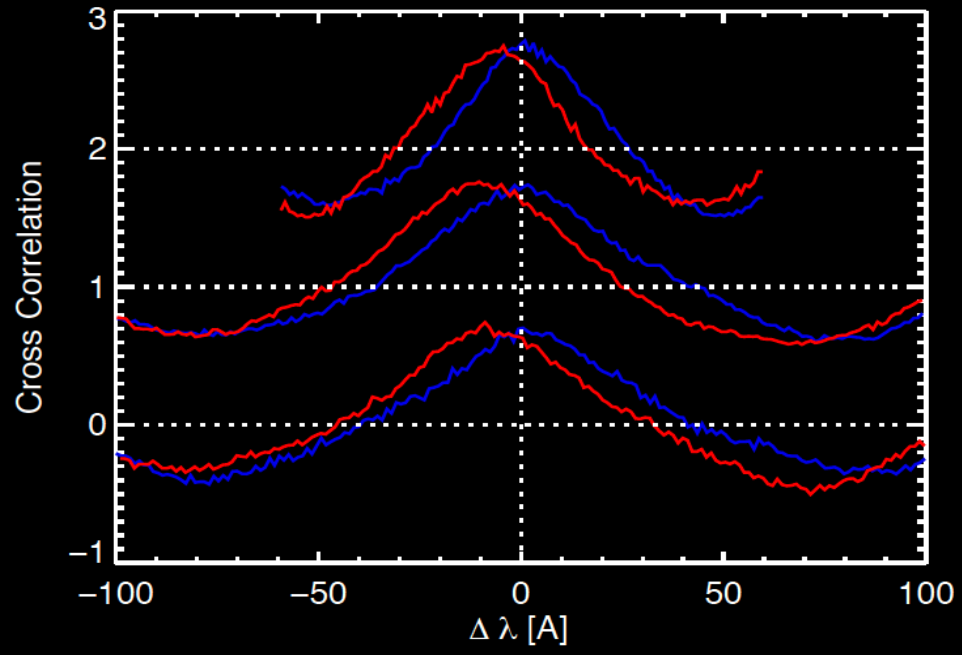

P 001046 F 594 DA
SDSS_J143633.29+501026.8
gMag=18.23 SNR=17.64 Teff= 16993. logg=6.58
nExposures= 3 Δt [hr]=
0.29333 0.37917

- Classified as DA by E06; M_g=18.2.
- RV shifts can be detected between consecutive SDSS exposures!

SDSS 1053+5200: A Short Period DDWD

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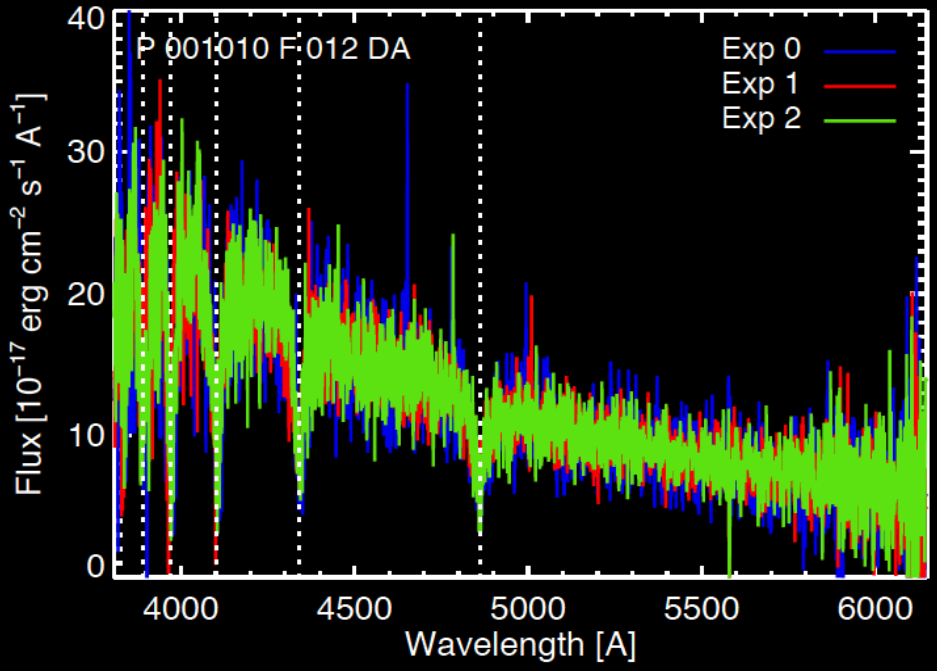

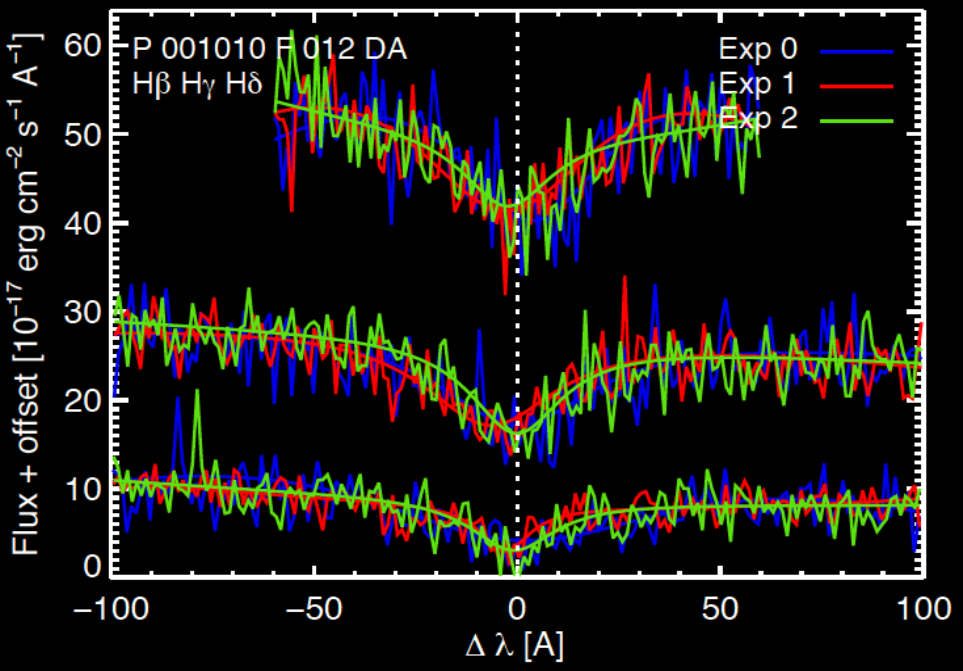

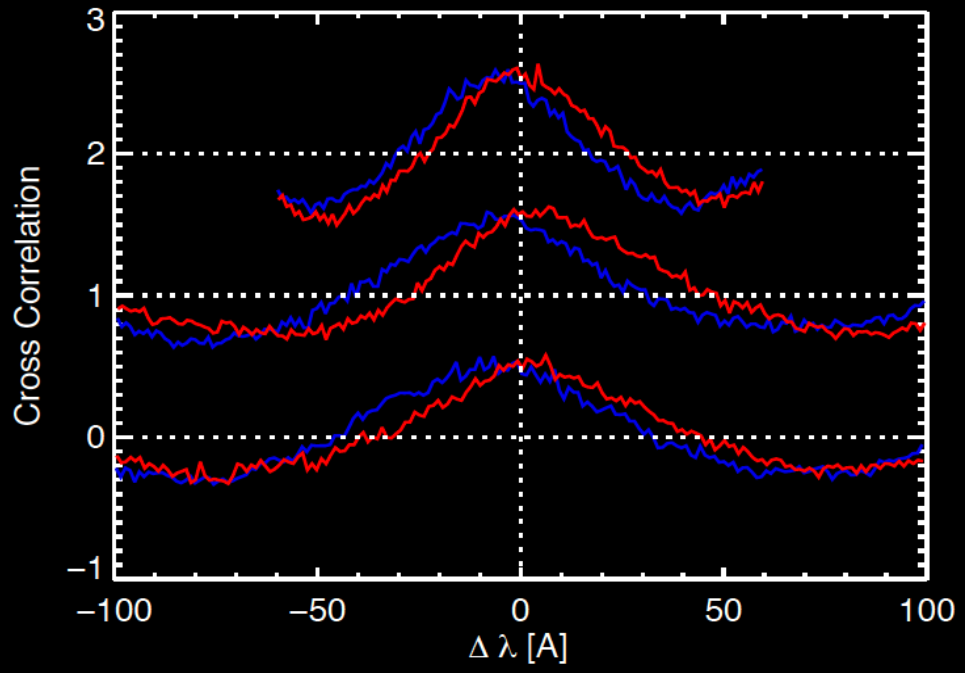

P 001010 F 012 DA
SDSS_J105353.89+520031.0
gMag=18.93 SNR=10.67 Teff= 15399. logg=6.28
nExposures= 3 Δt [hr]=
0.29639 0.35333

- Classified as DA by E06; M_g=18.9.
- RV shifts can be detected between consecutive SDSS exposures!

The Two Shortest Period DDWDs

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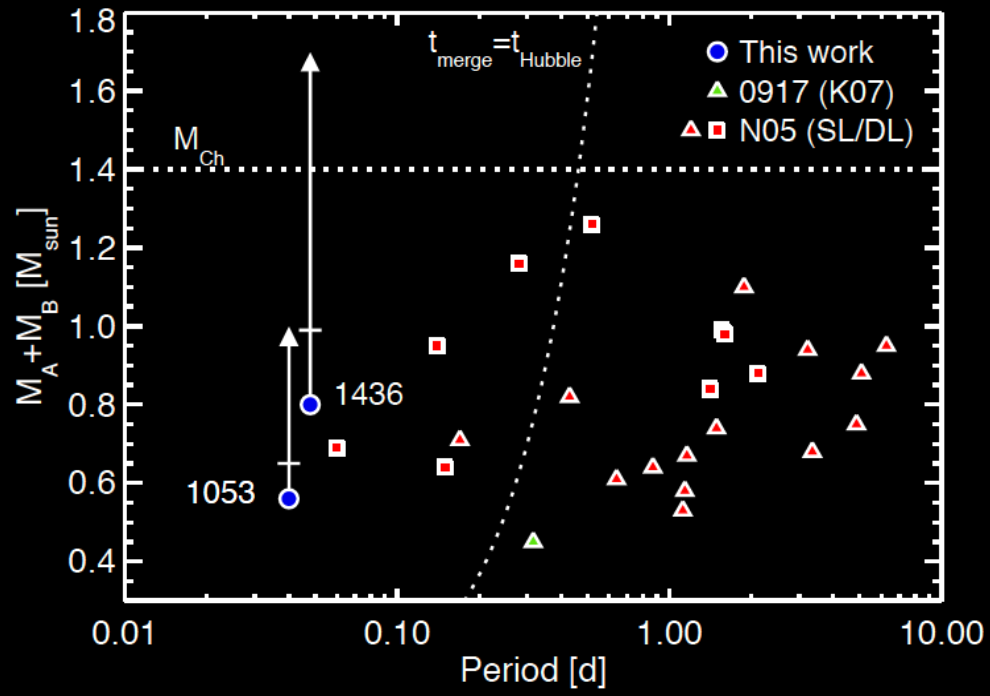
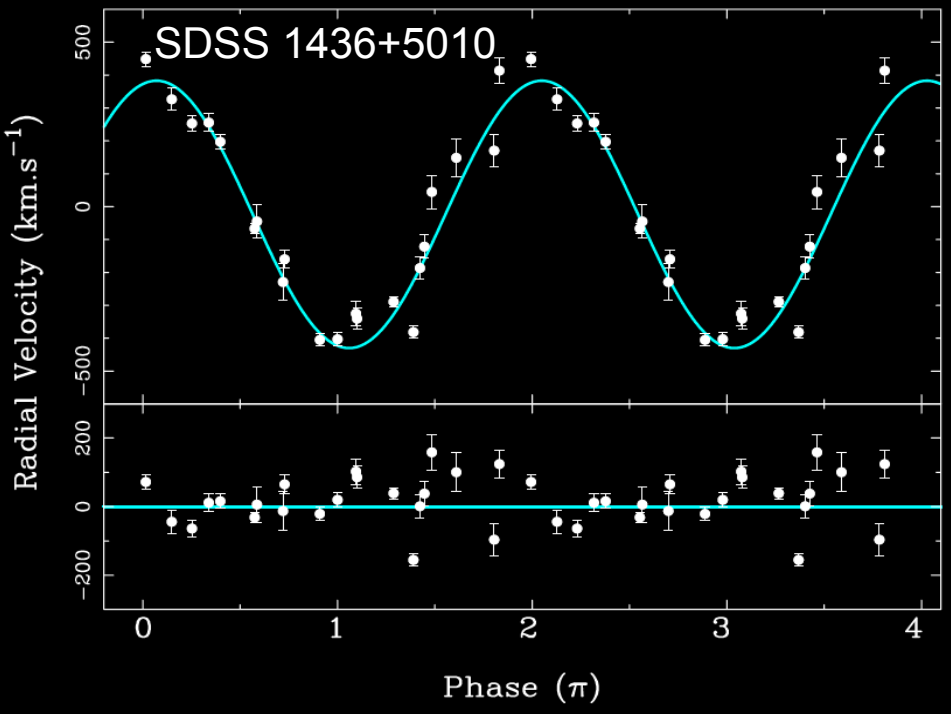
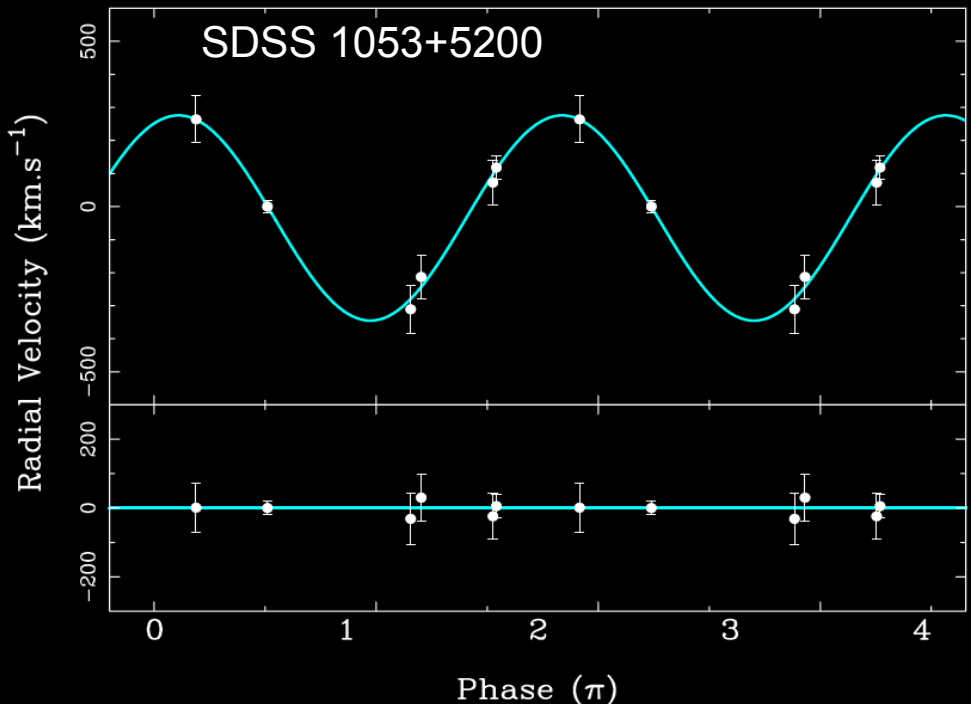
- SDSS 1436+5010 and 1053+5200 are the two detached DDWDs with the shortest periods known (1.15 and 0.96 hr). Their potential binarity had ben noted previously from their low masses (~0.19 $M_\odot$) [Kilic et al. 07, ApJ 660, 1451].

- More details: Mullally et al. 09, in prep. (see poster outside).







Future Prospects for SWARMS

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- **SWARMS** complements and improves on the **SPY** survey [Napiwotzki et al. 01, Ast. Nach. 322, 411]. No control over original observations ⇒ luck is involved and completeness is hard to establish.

- Results so far: Closest NS/BH (?); Two shortest period DDWDs. Important theoretical implications for the theory of binary systems. We anticipate more exciting discoveries, so stay tuned!

- Great prospects for time resolved spectroscopy of stellar spectra in SDSS [Pourbaix et al. 05, A&A 444, 643].

	SPY	**SWARMS**
Location	S (Paranal, Chile)	N (APO, NM)
$N_{objects}$	~1,000	~10,000 (DR4 alone)
Resolution	18,500 (~2 km s^{-1})	1,800 (~120 km s^{-1} w/cc)
Limiting mag.	B≤16.5	g≲19
Best suited for	Systematic study of DDWDs	Finding pre-mergers and SN Ia progenitors

A Variable Magnetic WD

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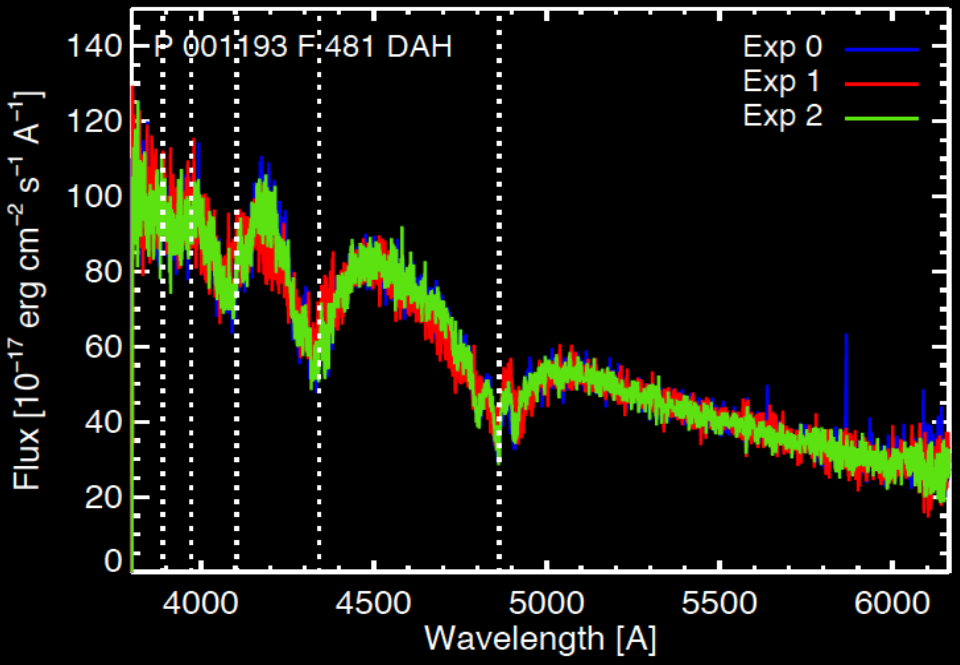

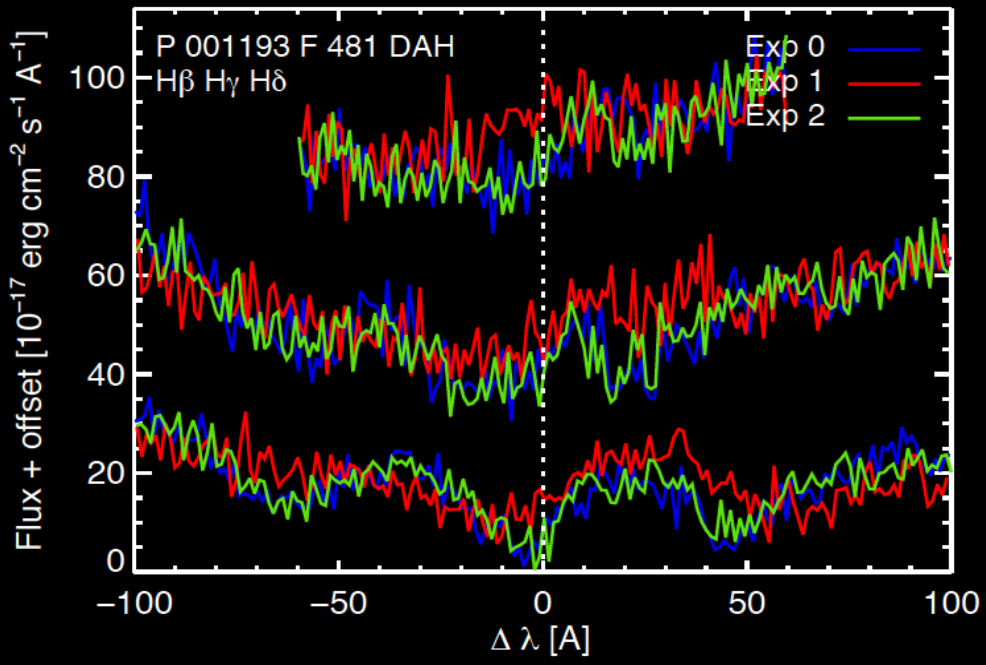

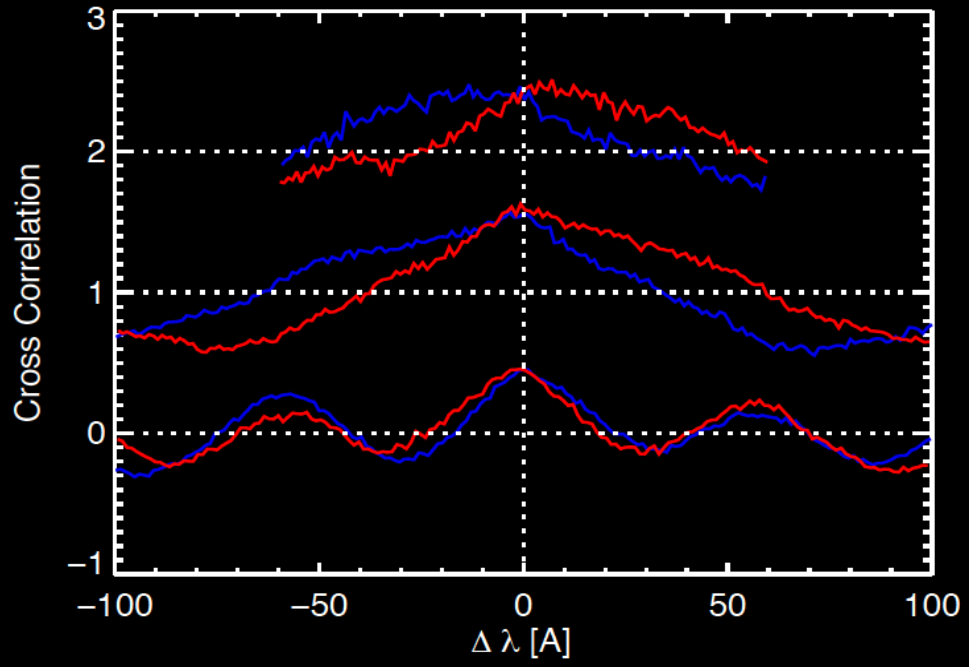

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nExposures= 3 Δt [hr]=
46.33361 0.38250

A Flaring M Star Around a WD

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