GTC and WHT observations of ultracompact AM CVn binaries

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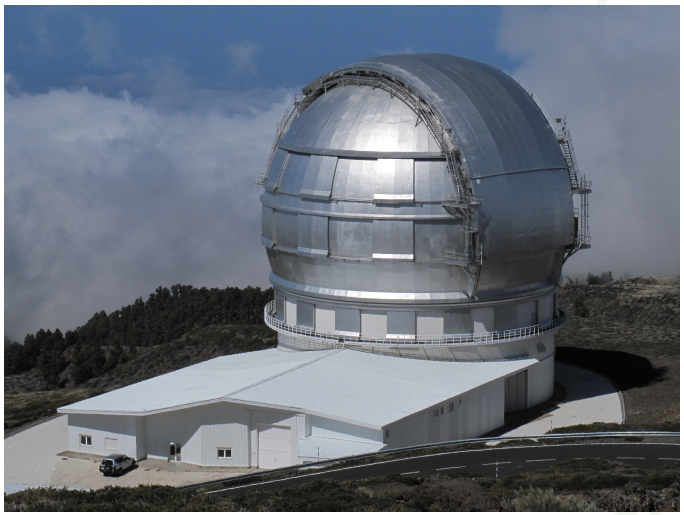

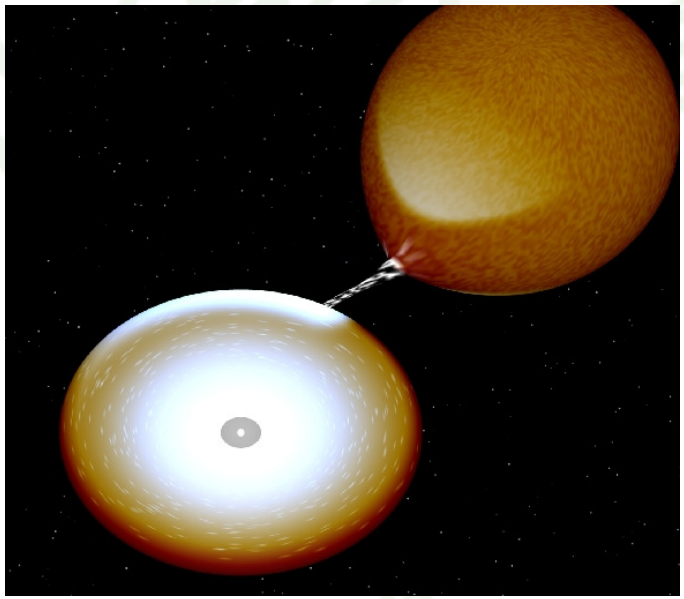

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Danny Steeghs (Warwick), Rene Rutten (Grantecan)

SDSS J1208+3550 - P_{orb}=52.57min

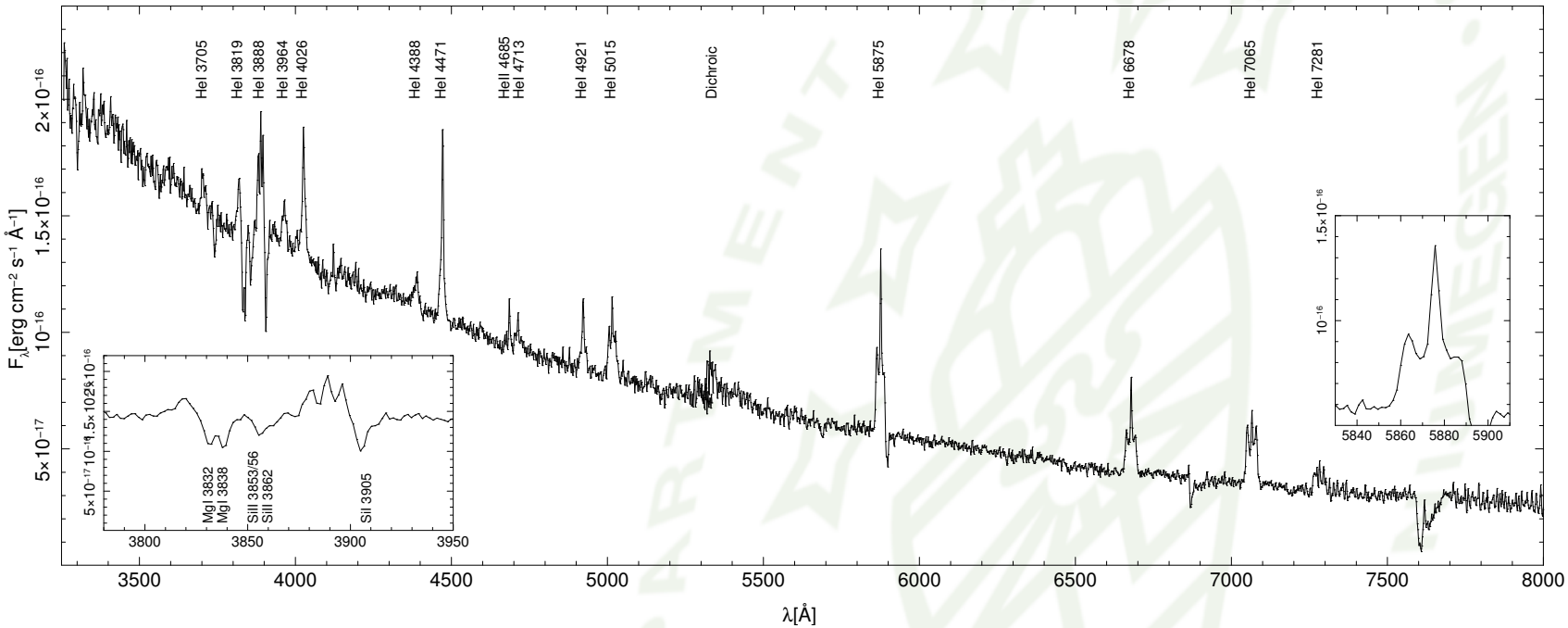
SDSS J1642+1934 - P_{orb}=54.12min

SDSS J1525+3600 - P_{orb}=44.17min

SDSS J0129+3842 - P_{orb}=37.33min

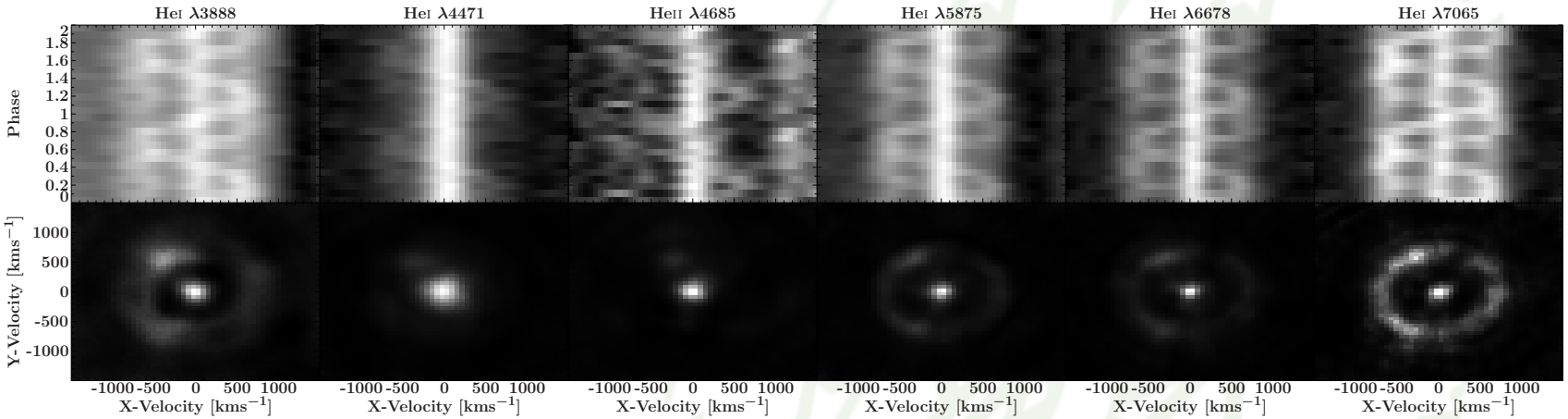
SDSS J1908+3940 - AM CVn or no AM CVn??

SDSS J1208+3550 observed with the WHT



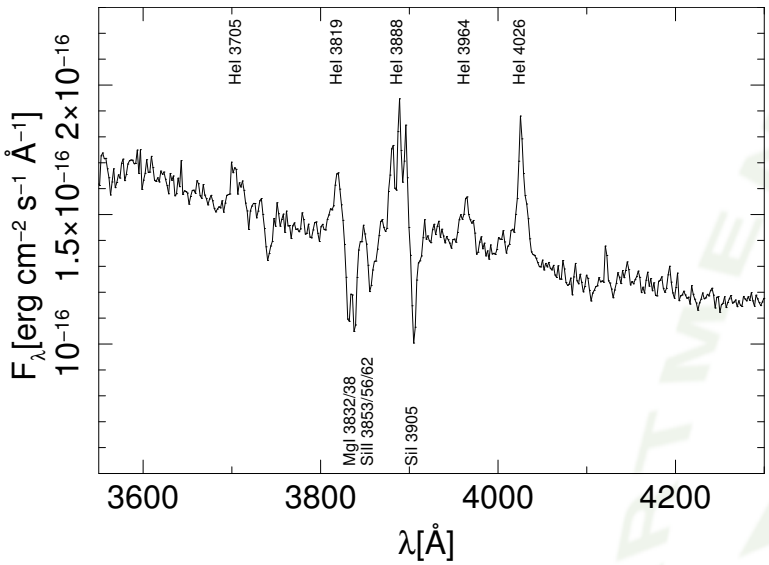
- Typical emission lines for long period system with strong central spike
- Strong absorption features in the blue side of the spectrum

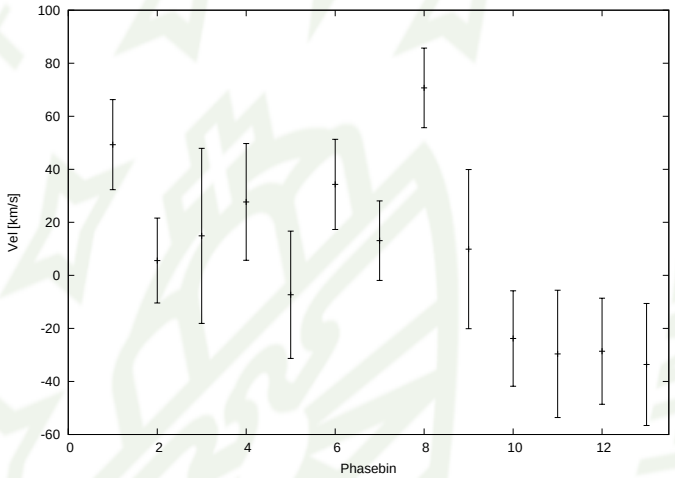
Spectroscopic period of SDSS J1208+3550



- Kinematics analysis gives period of 52.57 min
- Trailed spectra revealed second bright spot
- $\sim$120° offset very similar to SDSS J1240
- Origin unclear

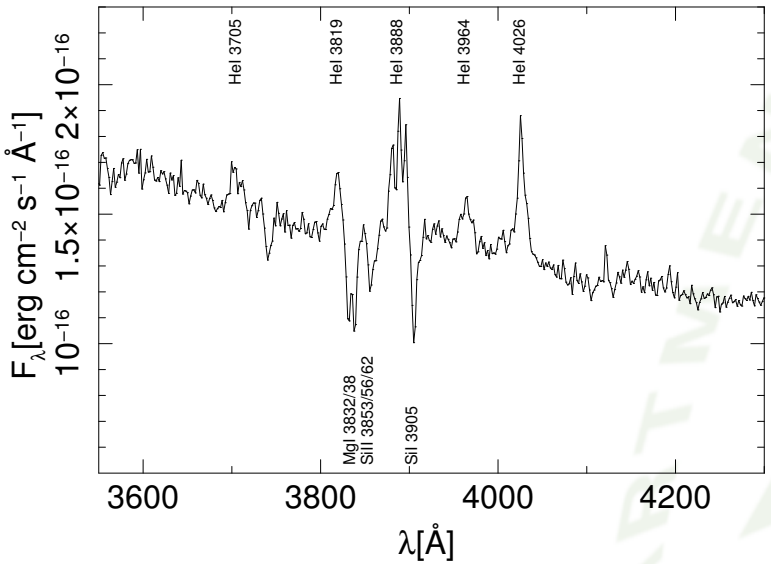
Absorption in SDSS J1208+3550

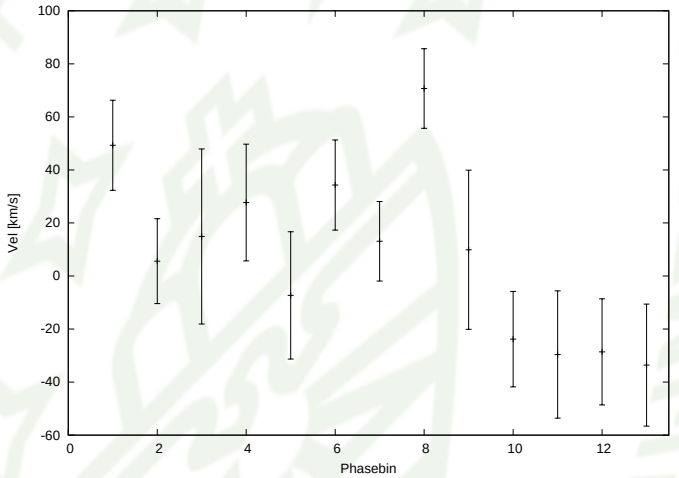




- No periodic velocity shifts detected
  $\Rightarrow$ Originates most likely in the extended photosphere of the accretor
- System much older than settling times of white dwarf
  $\Rightarrow$ Has to be accreted material

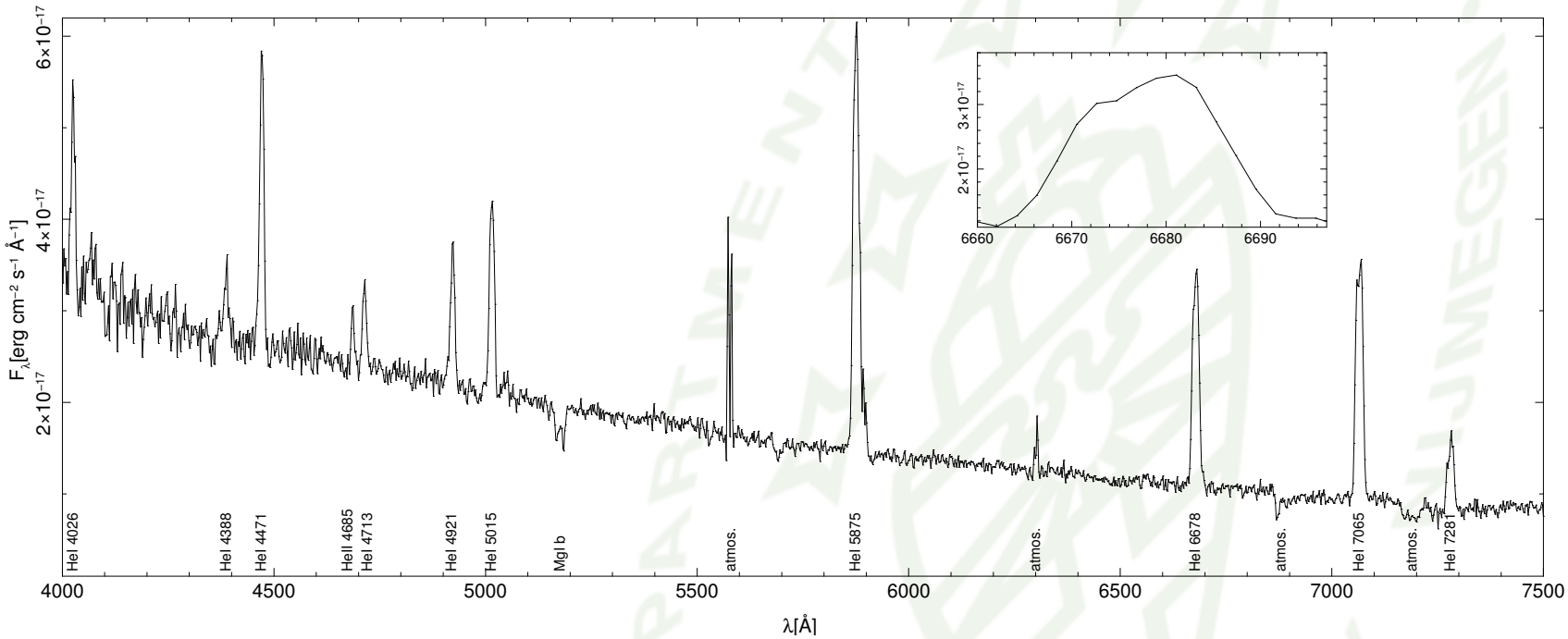
Absorption in SDSS J1208+3550





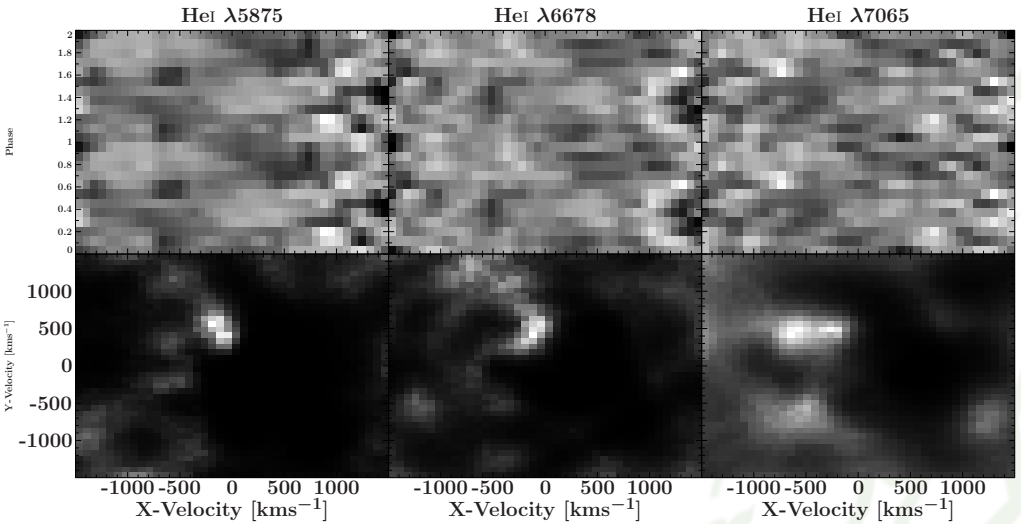
- Absorption lines known from accreting DBZ white dwarfs
  $\Rightarrow$ **BUT** In DBZ white dwarfs Mg always shows up with Ca
- SDSS J1208 shows very strong Mg but no Ca
- Is it the only system with strange abundance ratio??

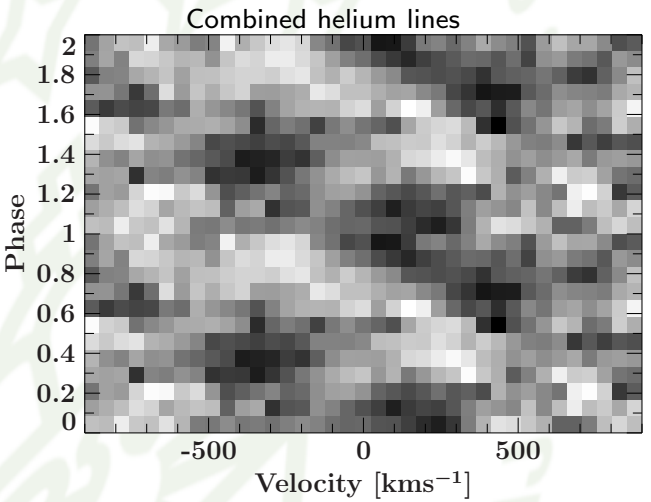
SDSS J1642+1934 observed with the GTC



- Very strong and narrow emission lines
- Narrow double peaked profiles from the disc

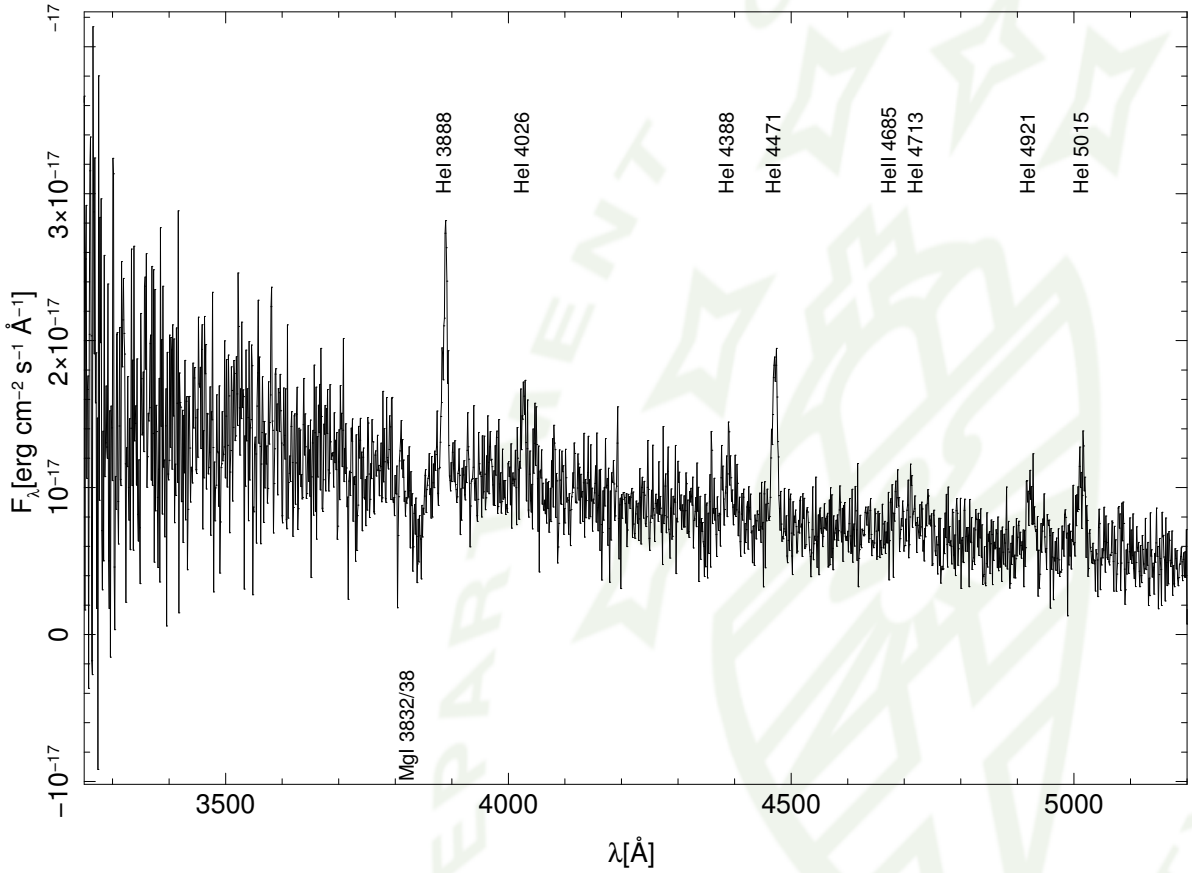
Kinematics of SDSS J1642+1934





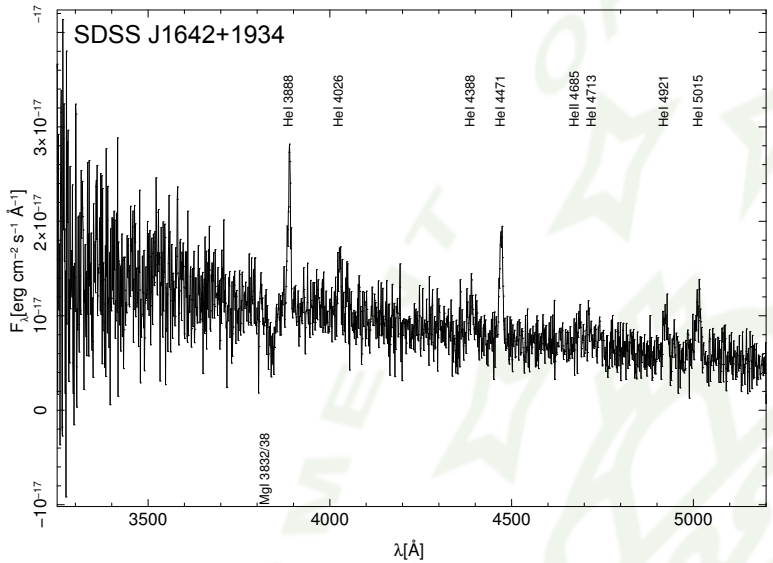
- Very weak bright spot, only trail with combined lines revealed bright spot
- P_{orb}=54.12min $\Rightarrow$ Third longest known orbital period
- Dimming of bright spot, also seen in AM CVn and SDSS J0804
- Fairly low velocity amplitude $<$400 kms^{-1}

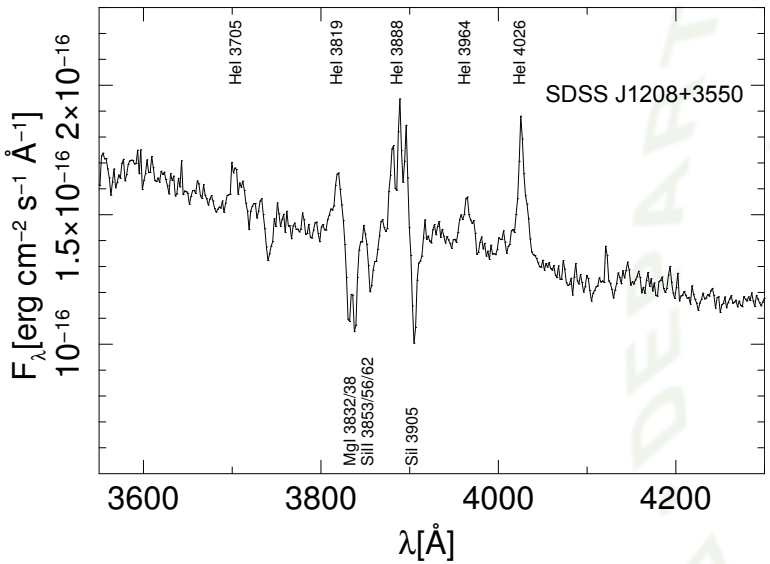
Metal lines in SDSS J1642+1934

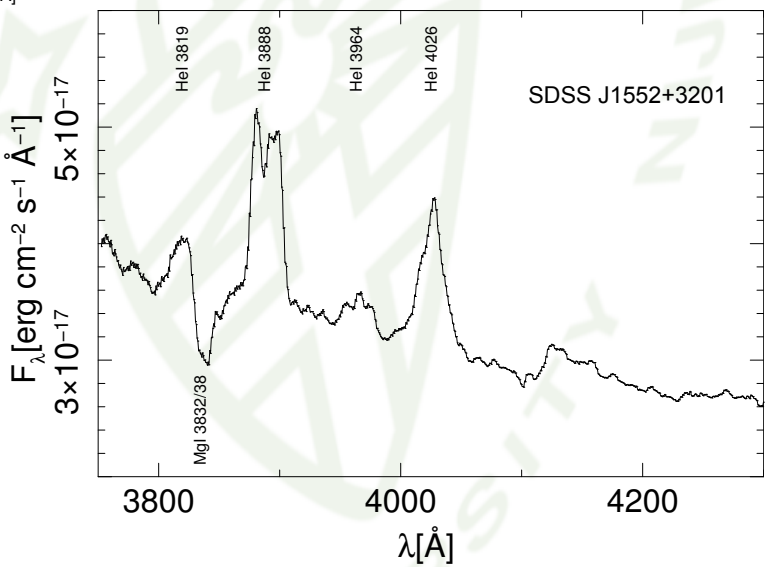


- GTC does not go that far blue
  $\Rightarrow$ Identification spectrum with Palomar 200" telescope
- Like SDSS J1208, strong Mg absorption but no Ca

SDSS J1208, SDSS J1642 and SDSS J1552

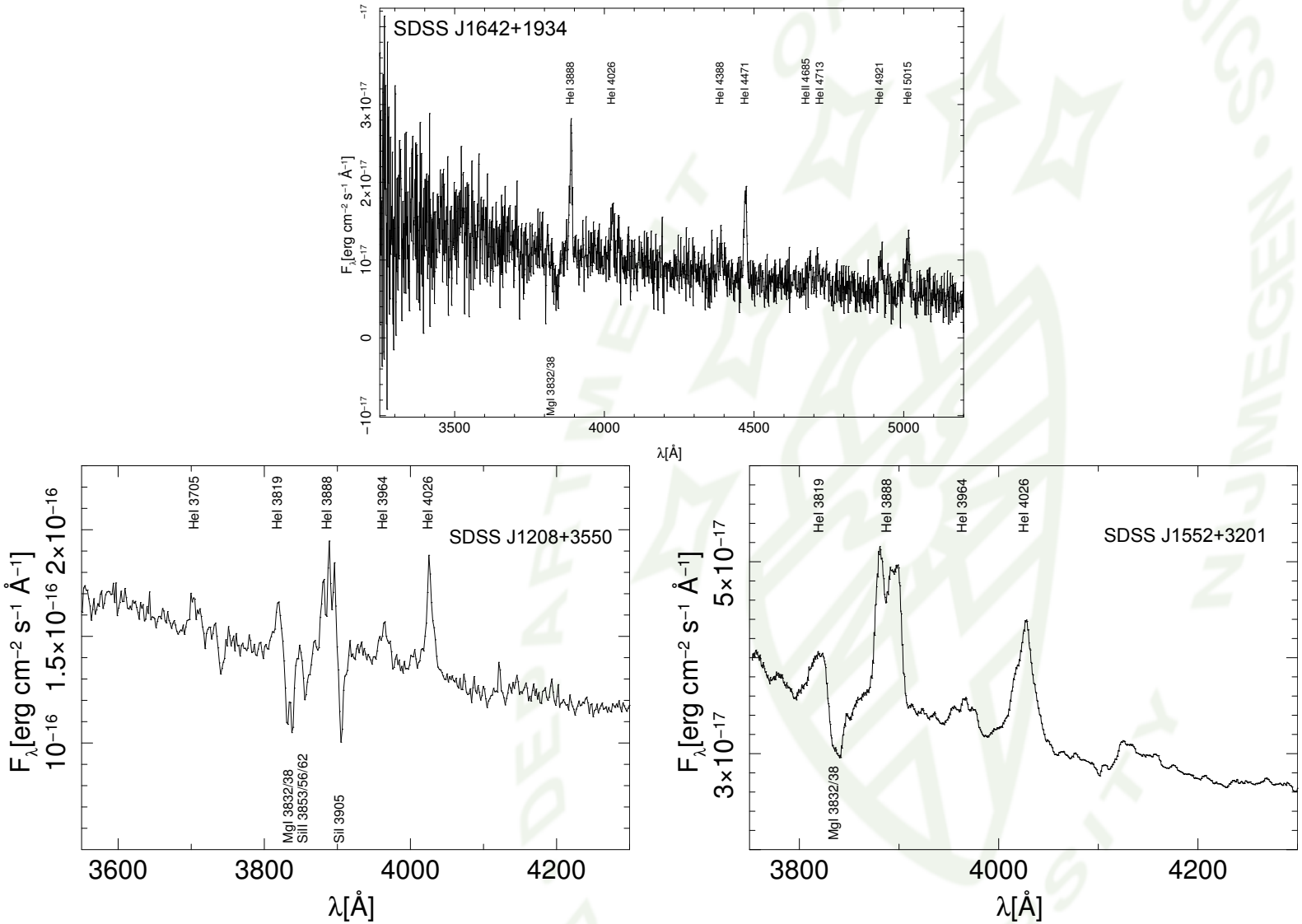






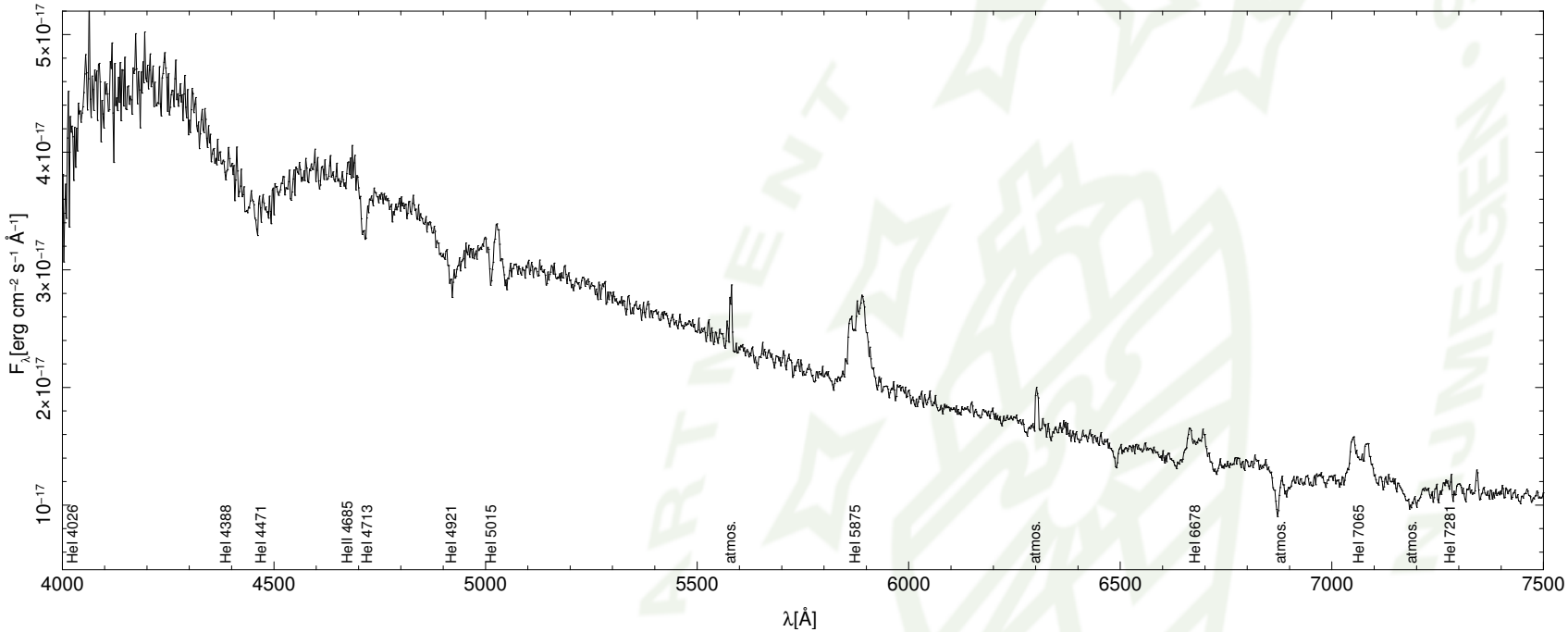
- All three systems show Mg but no Ca
- Lines in all spectra not resolved

SDSS J1208, SDSS J1642 and SDSS J1552



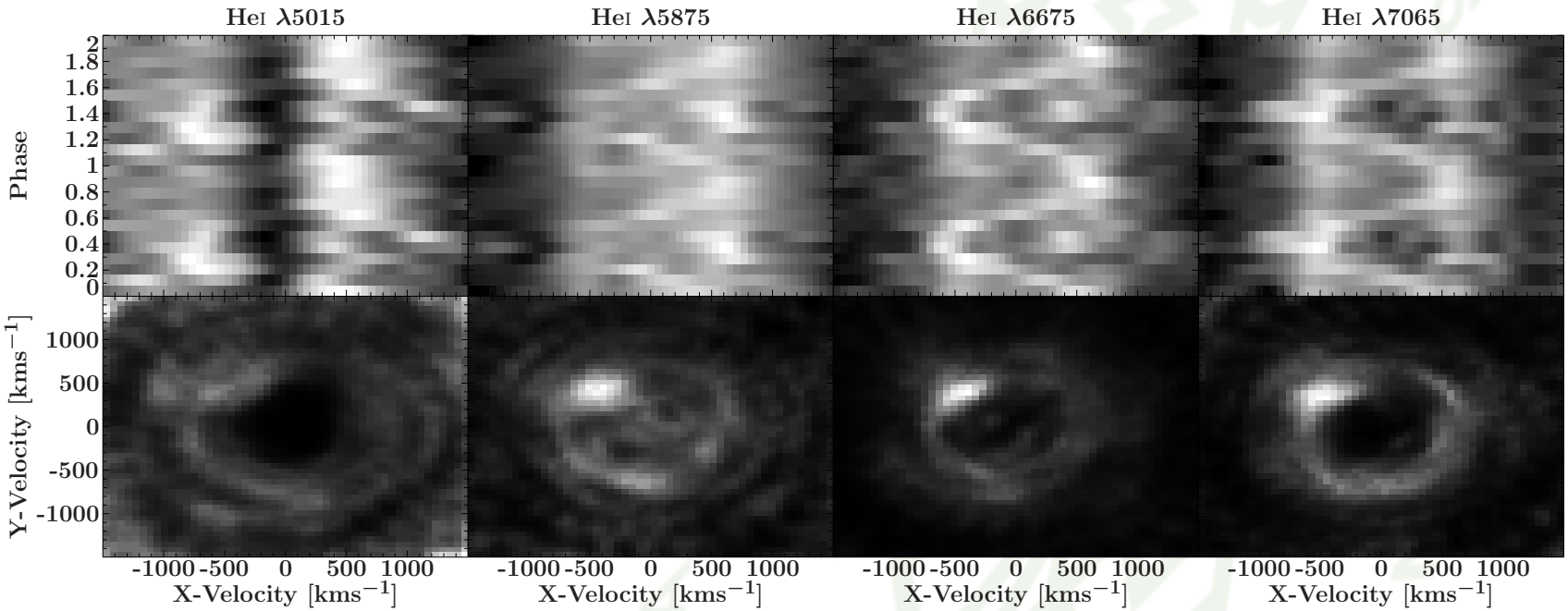
- Where exactly do these lines originate??
- How can we explain absence of Ca but strong Mg??

SDSS J1525+3600 observed with the GTC



- Strong emission features from the disc and absorption lines from accreting white dwarf
  $\Rightarrow$ Temperature of white dwarf still high ($\sim$ 20 000 K)
  $\Rightarrow$ Expected $P_{\rm orb} < 40$ min

Kinematics of SDSS J1525+3600

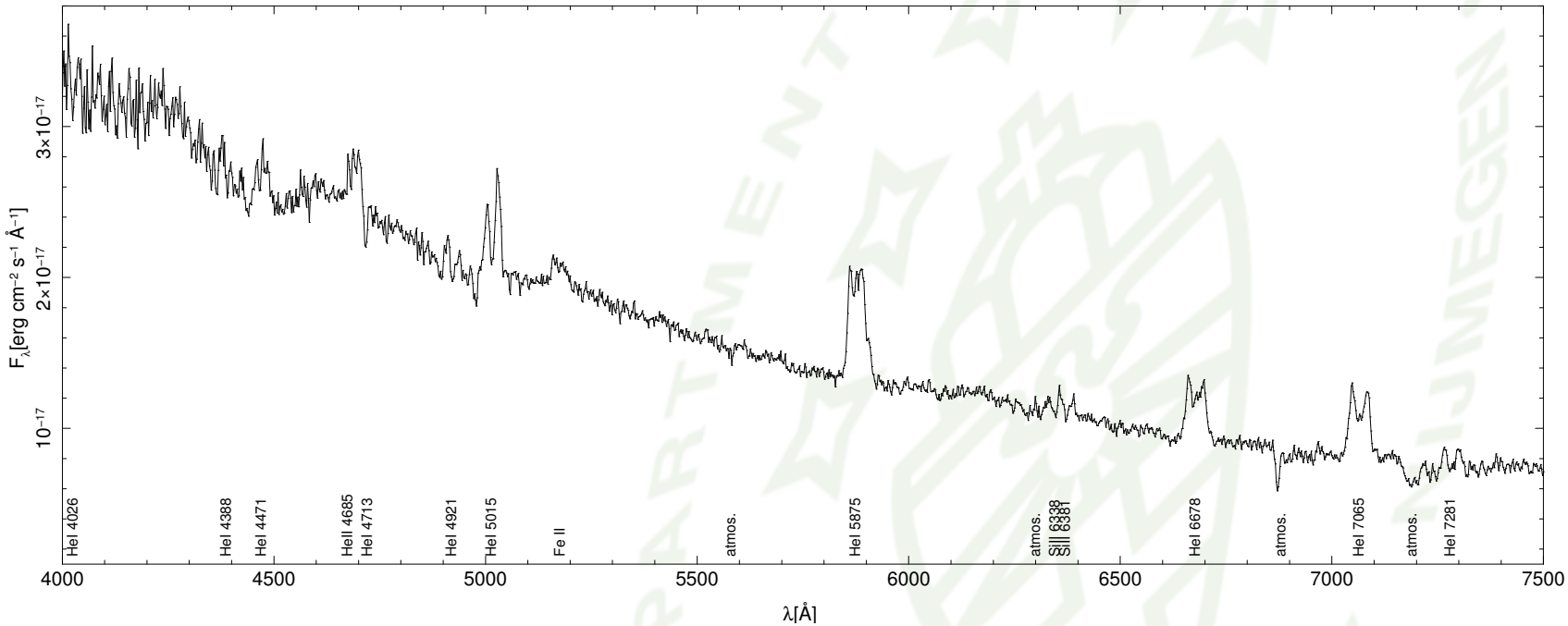


- Kinematic analysis gives an orbital period of 44.17 min
- System is as an AM CVn already several billion years old

(Bildsten et al. (2006))

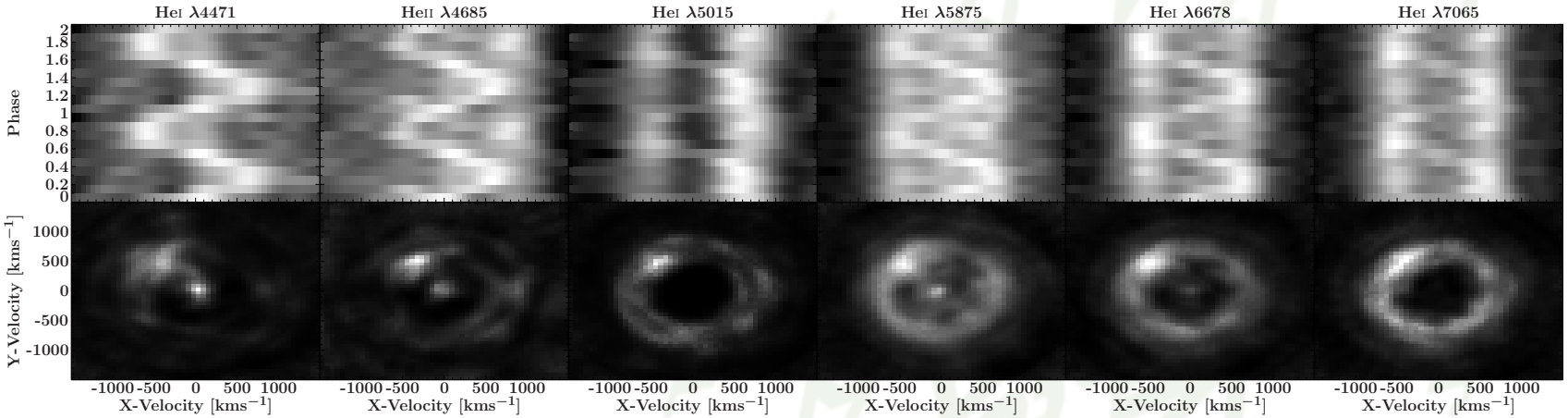
$\Rightarrow$ What keeps accreting white dwarf so hot??

SDSS J0129+3842 observed with the GTC



- Beside helium, emission of Iron and Silicon from the disc
- Weak absorption lines from accreting white dwarf

Kinematics of SDSS J0129+3842



- Kinematics analysis gives period of 37.33 min
- Shears et al. (2011) obtained a superhump period of 37.9 min
  $\Rightarrow$ Results in period excess ϵ=0.015
  $\Rightarrow$ With equation from Patterson et al. (2005) mass ratio q=0.074

Bringing all together

- Periods of four systems confirmed
- SDSSJ1208 shows second bright spot
- All three systems between 50 – 60 min period show strange line ratios between Magnesium and Calcium
- SDSSJ1525 is first system showing the accretor and has a period well above 40min

Upcoming runs

- 16 hours in total on the GTC for SDSS J1427-0123, SDSS J1721+2733 and SDSS J1730+5545
- 3 nights on the WHT on SDSSJ1730+5545

SDSS J1908+3940

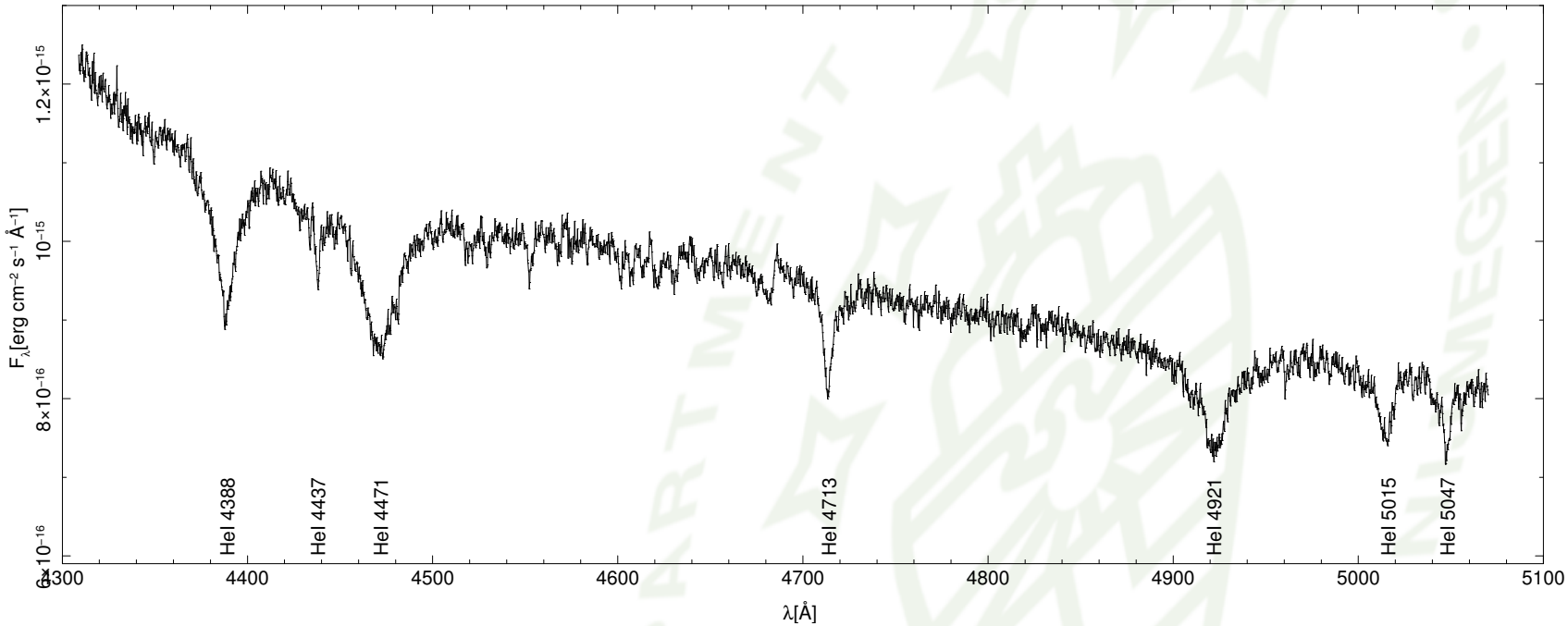
- AM CVn candidate found by the Kepler satellite
- Two photometric periods detected in the Kepler data (P_{sh}=15.89min and P_{orb}=15.64min)
- Strong helium absorption lines typical for a high state system
- Spectrum could not be modelled with normal DB models

  (Fontaine et al. (2011))

  BUT

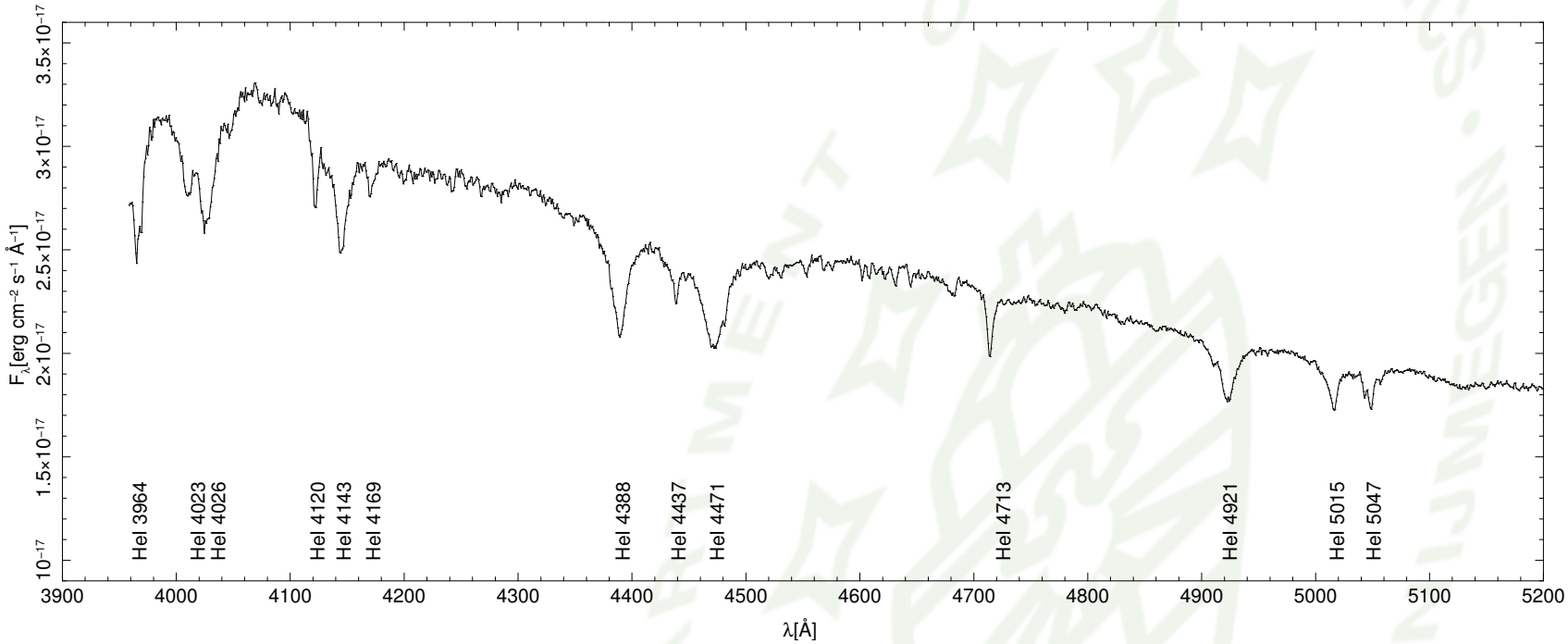
  Follow up observations to proof the AM CVn nature necessary

SDSS J1908+3940 observed with the WHT



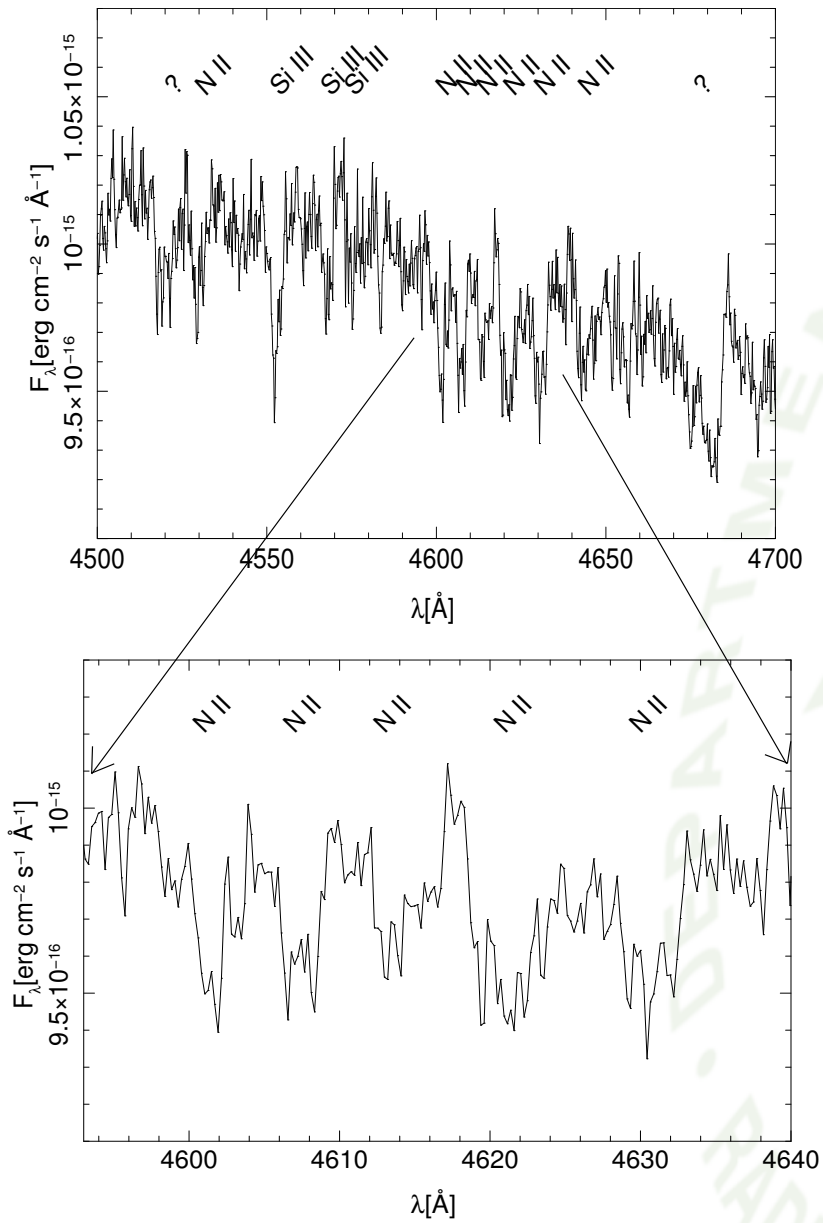
- Phase resolved spectroscopy with the WHT over 5 nights
  $\Rightarrow$ Resulting in 1876 spectra with SNR=1-4 per spectrum
- Average spectrum shows He absorption and weak metal lines

SDSS J1908+3940 observed with the GTC



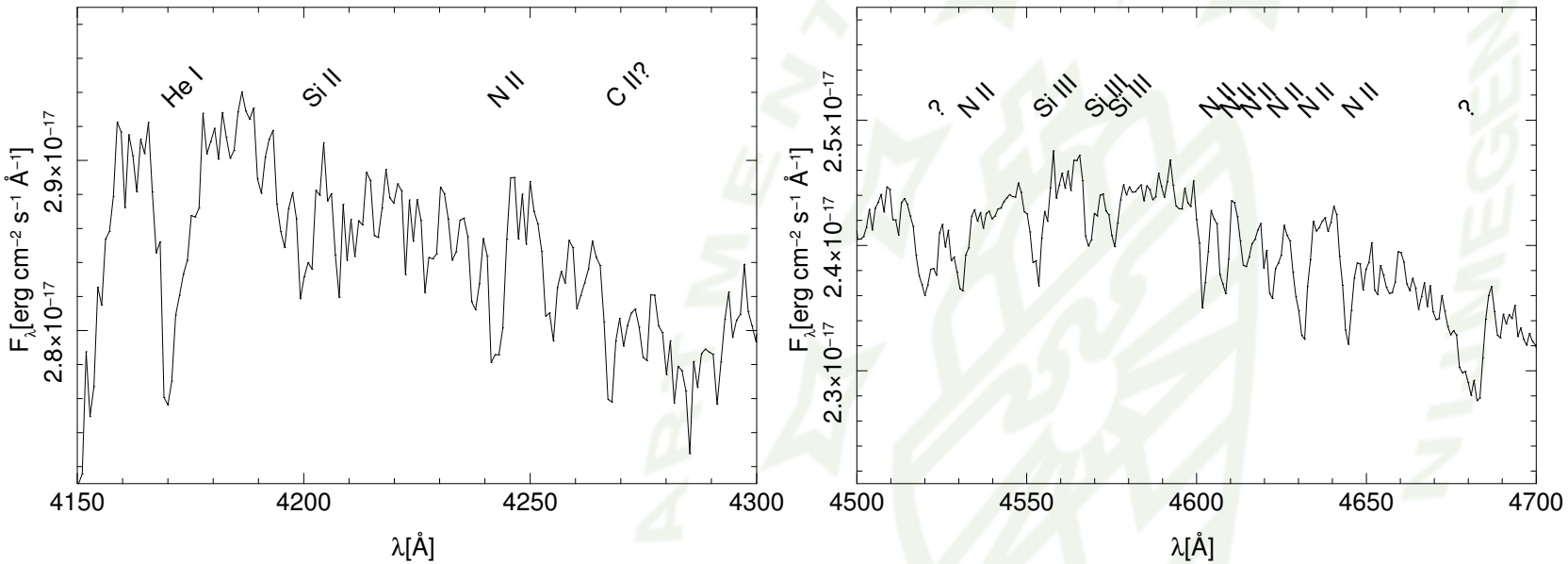
- Phase resolved spectroscopy with the GTC over 3 nights
  $\Rightarrow$ Resulting in 222 spectra
- Lower resolution but greater wavelength coverage than in WHT data
- Average spectrum (SNR$\sim$200) shows even more weak metal lines

Weak metal lines in SDSS J1908+3940 from WHT data



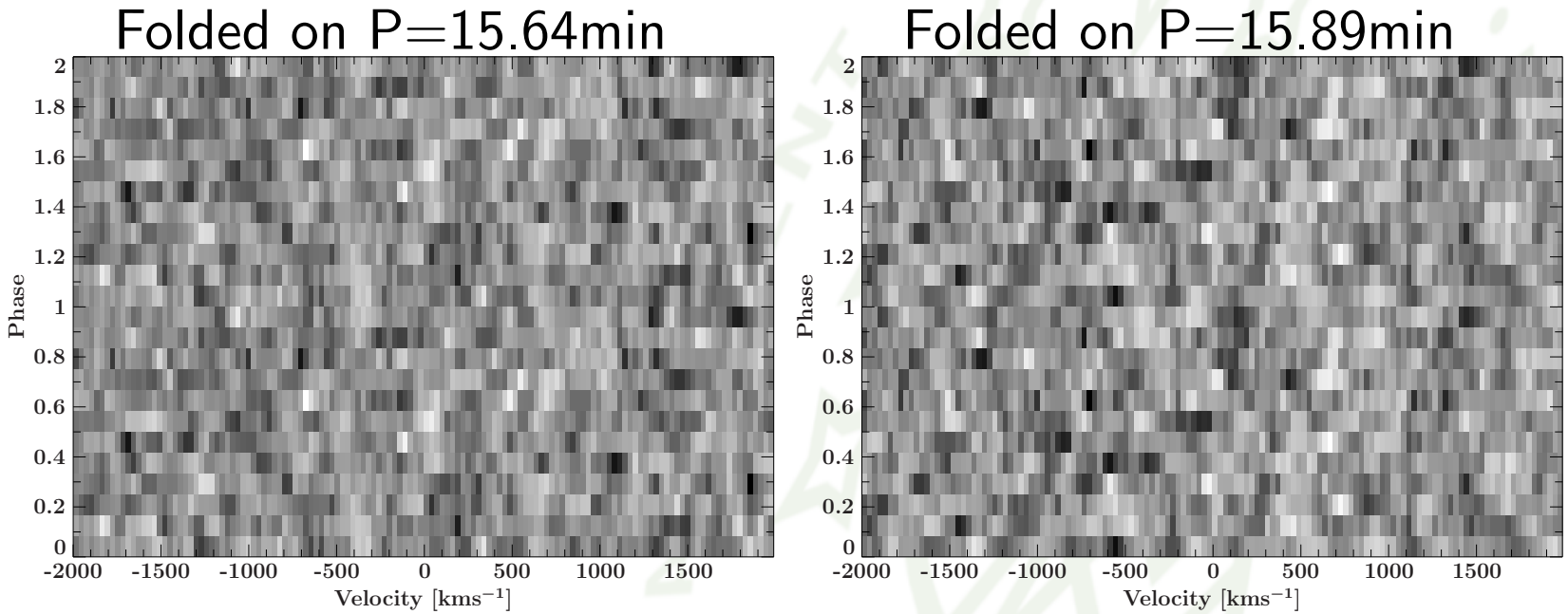
- Weak metal lines of NII, SiII/III and MgII
- Lines well resolved
- FHWM of nitrogen lines $\sim$ 200 kms^{-1}

Weak metal lines in SDSS J1908+3940 from GTC data



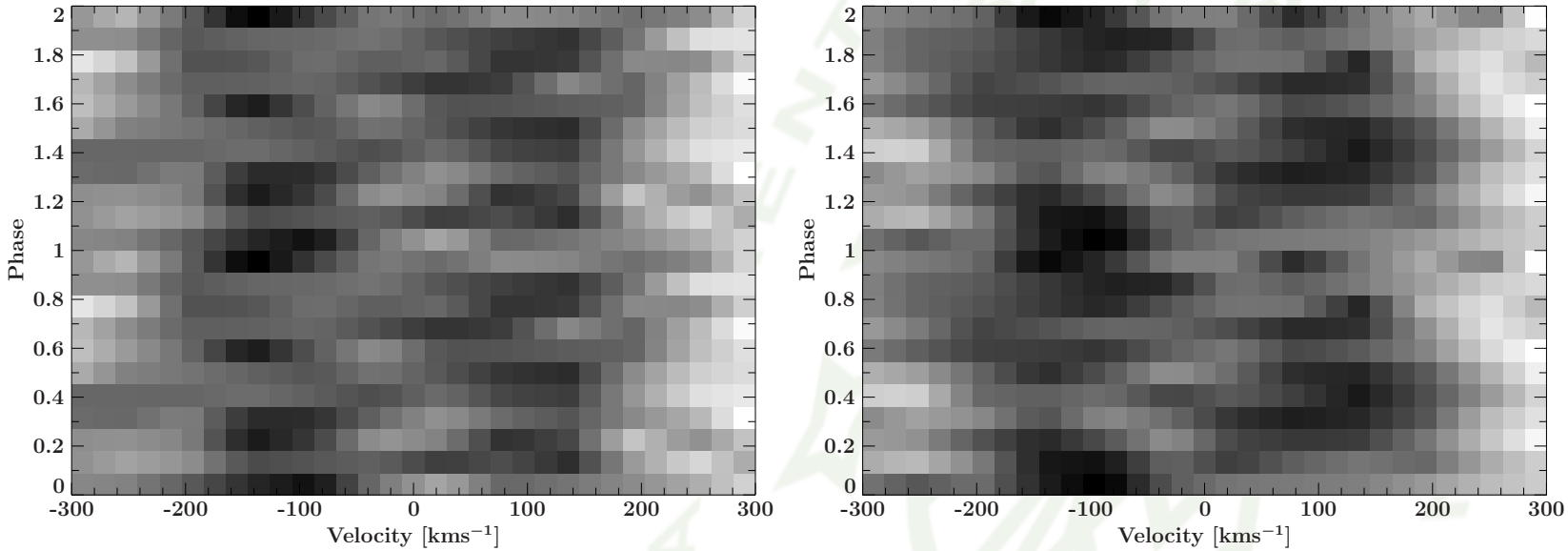
- Large sample of metal lines from different species
  $\Rightarrow$ NII, SiII/III, MgII and possibly CII and OII

Kinematics in SDSS J1908+3940



- Every spectrum divided by the average spectrum
- Folded on the photometric periods
- No velocity variations detected

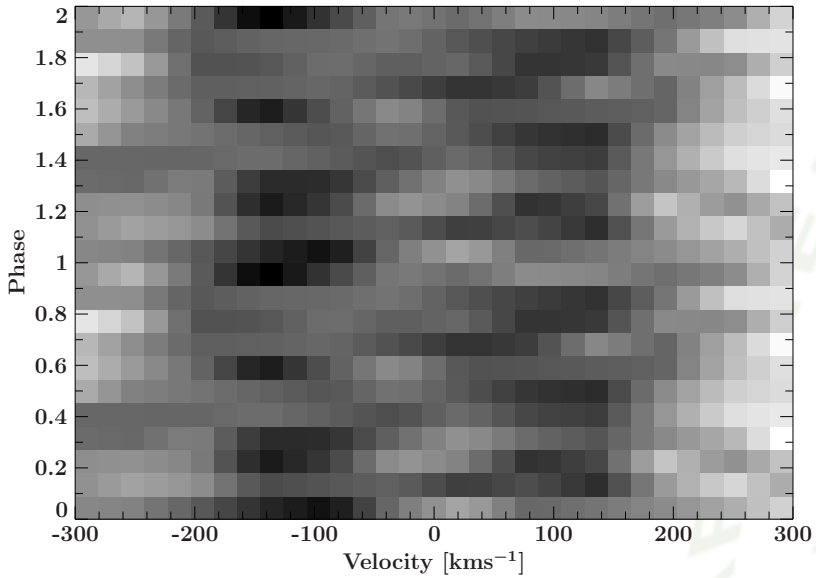
Bright spot in SDSS J1908+3940??



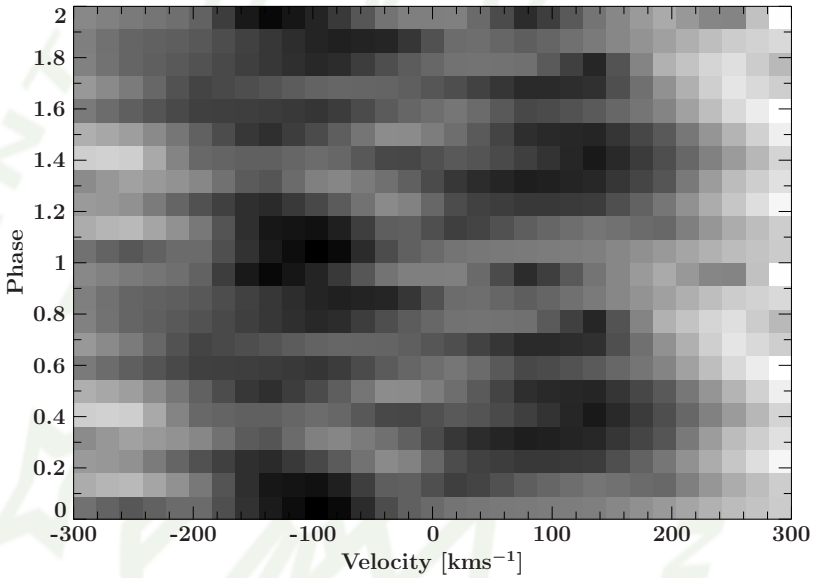
- Core of the HeI 4471 absorption line folded on the photometric periods
- Periodic variations?? Which one is the orbital period??

Bright spot in SDSS J1908+3940??

Folded on P=15.64min



Folded on P=15.89min



- Core of the HeI 4471 absorption line folded on the photometric periods
- Periodic variations?? Which one is the orbital period??
- 2 nights in July on Keck/ESI (R=27 000) will hopefully solve the question

Open questions

- What can we learn from the metal lines appearing all over the place??
- How can we explain the strange line ratios in the 50min period systems??
- Why is the accretor in SDSS J1525+3600 still so hot??
- What is the orbital period of SDSS J1908+3940??

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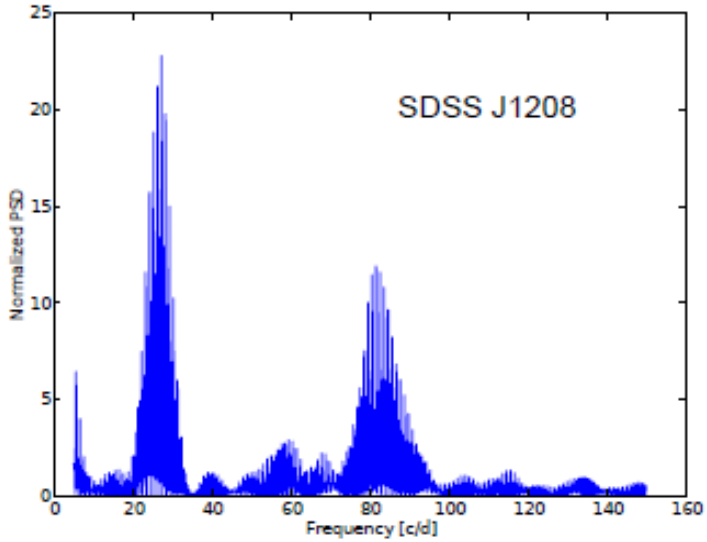
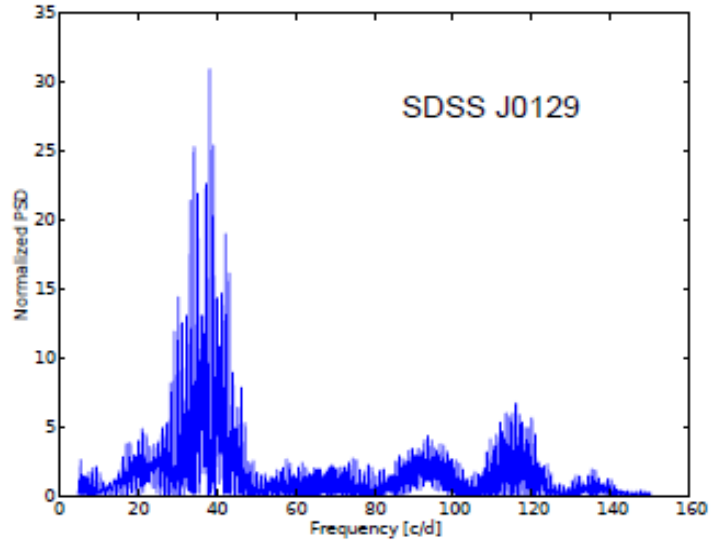
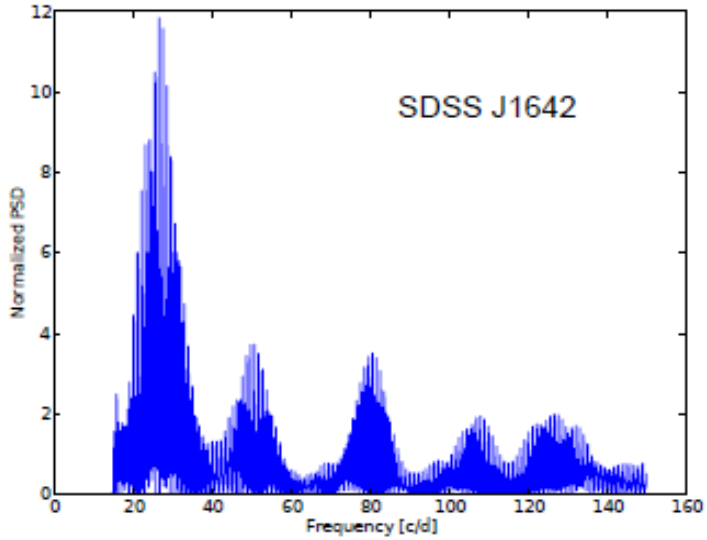
Table 2. Measured equivalent widths in [Å] and limits of disc emission and photospheric absorption lines

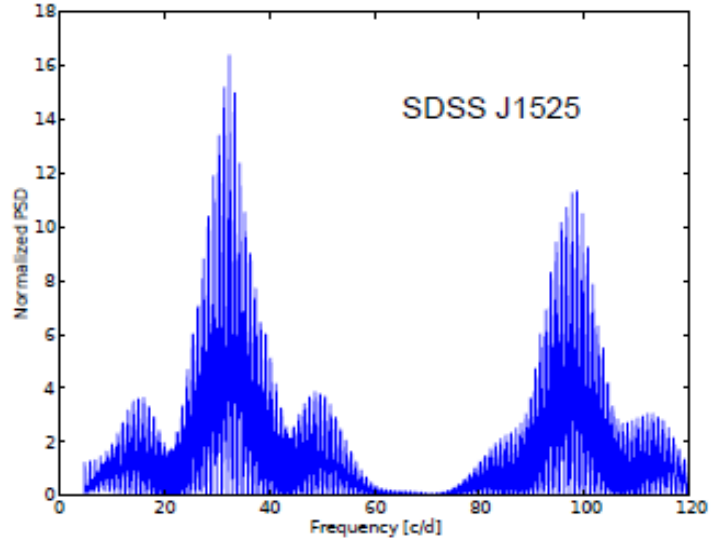
Line	SDSS J1208	SDSS J0129[a]	SDSS J1642	SDSS J1525[a]
Disc emission				
HeI 3888	-4.8 ± 0.2	-	-7.2 ± 0.3	-
HeI 3964	-1.9 ± 0.2	-	-0.3 ± 0.2	-
HeI 4026	-4.6 ± 0.3	-	-4.2 ± 0.4	-
HeI 4388	-2.3 ± 0.3	-	-1.8 ± 0.3	-
HeI 4471	-7.0 ± 0.2	-	-13.0 ± 0.5	-
HeII 4685	-1.0 ± 0.2	-3.5 ± 0.3	-1.5 ± 0.4	-0.8 ± 0.2
HeI 4713	-1.2 ± 0.2	-	-3.8 ± 0.4	-
HeI 4921	-4.0 ± 0.2	-	-7.8 ± 0.5	-
HeI 5015	-7.1 ± 0.3	-7.9 ± 0.4	-13.2 ± 0.5	-
HeI 5875	-19.8 ± 0,4	-24.4 ± 0.4	-56.8 ± 0.7	-16.0 ± 0.3
HeI 6678	-15.8 ± 0.5	-18.8 ± 0.5	-39.4 ± 0.7	-6.7 ± 0.3
HeI 7065	-24.0 ± 0.5	-25.4 ± 0.5	-54.7 ± 0.7	-11.8 ± 0.4
HeI 7281	-7.9 ± 0.4	-2.8 ± 0.4	-14.7 ± 0.7	-
FeII 5169	-	-2.4 ± 0.4	-	-
SiII 6347/6371	-	-3.1 ± 0.4	-	-
Absorption lines				
MgI 3832/3838	3.2 ± 0.2	-		-
CaII 3933[b]	<0.3	-		-
SiII 3853/58/62	1.3 ± 0.2	-		-
SiII 3905	1.6 ± 0.2	-	-	-
MgI b	1.2 ± 0.2	-	4.0 ± 0.5	-

[a] Note that lines which are blended by stark broadened absorption from the accretor are excluded
[b] CaII λ3968 was excluded because of an HeI blend


SDSS J1208
Normalized PSD
Frequency [c/d]


SDSS J0129
Normalized PSD
Frequency [c/d]


SDSS J1642
Normalized PSD
Frequency [c/d]


SDSS J1525
Normalized PSD
Frequency [c/d]