

単独白色矮星の サブ分変動探査

檜山和己 (東北大学)

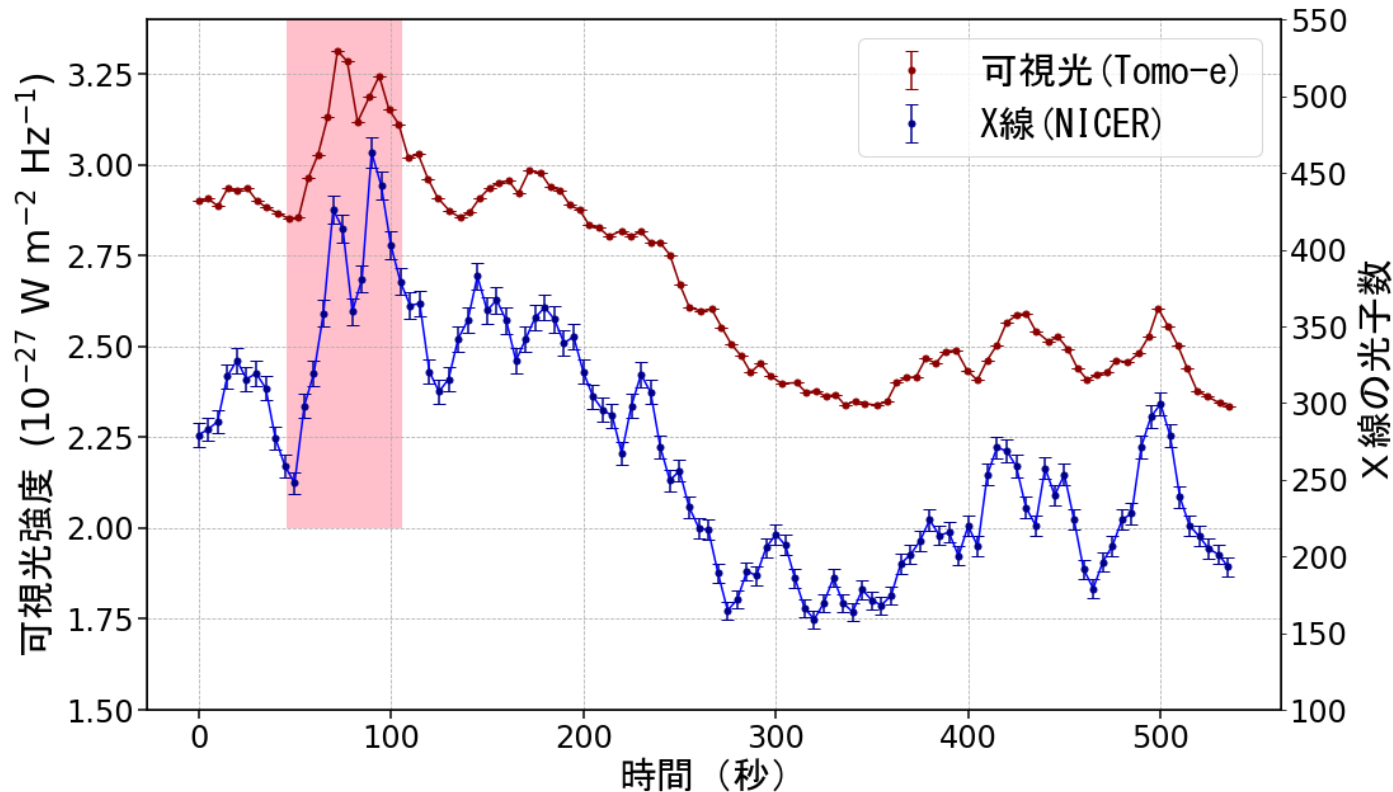
非降着系

~~単独~~白色矮星の
サブ分変動探査

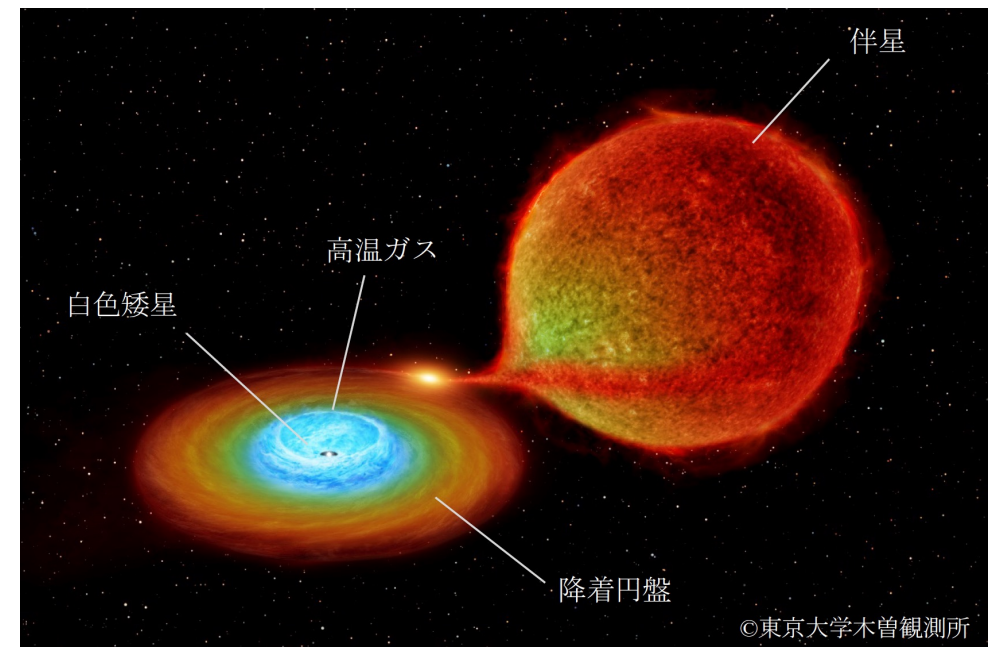
檜山和己 (東北大学)

ガス降着系の面白い話

e.g., detection of highly correlated optical and X-ray variations in SS Cygni with Tomo-e Gozen and NICER



Nishino, Kimura, Sako et al. 2022



See also Taguchi-san's talk

なぜTomo-eで白色矮星か？

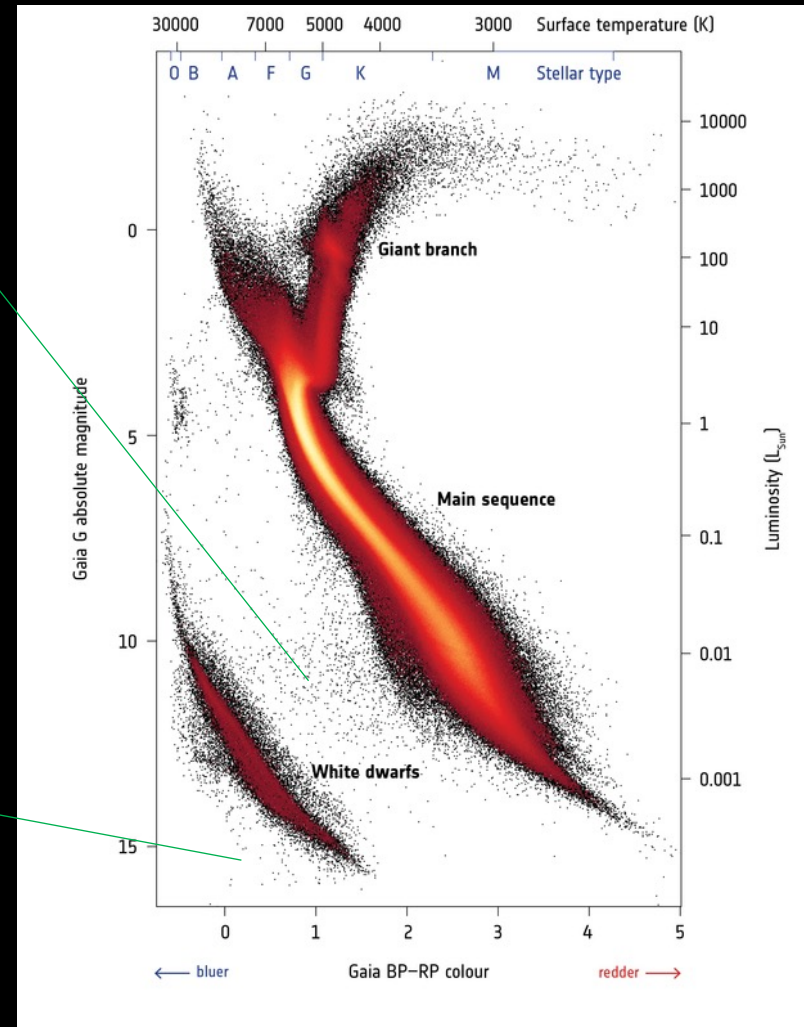
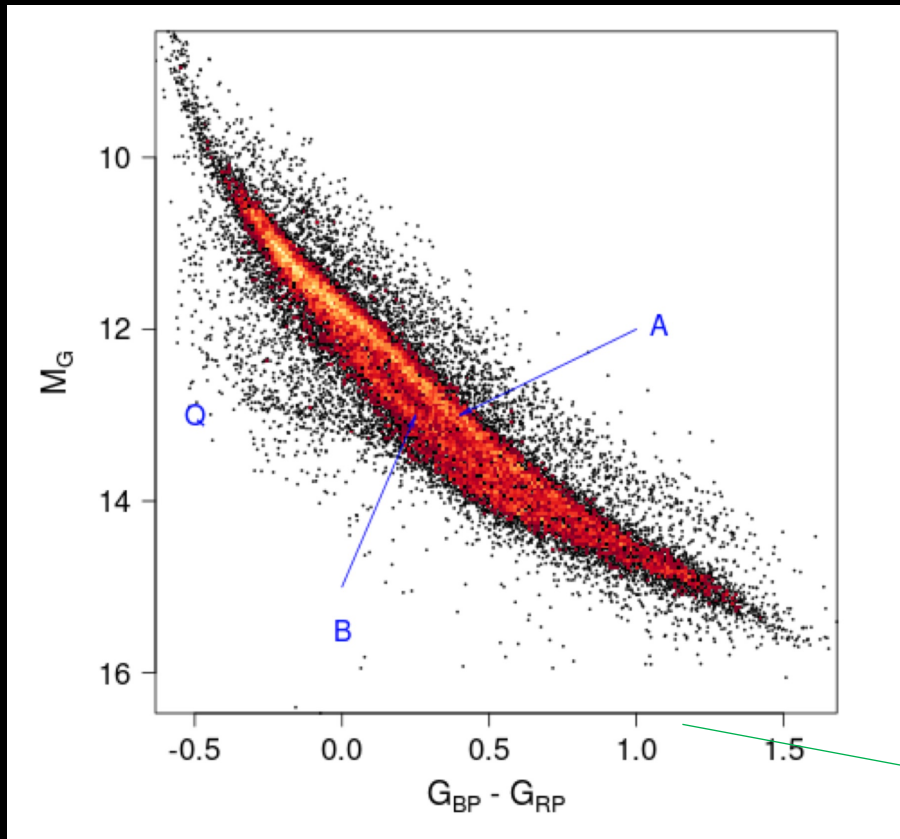


Credit: ESA and NASA

白色矮星は“速い”

$$\left(\frac{R^3}{GM}\right)^{1/2} \sim 0.2 \text{ sec} \left(\frac{M}{M_{\odot}}\right)^{-1/2} \left(\frac{R}{2 \times 10^8 \text{ cm}}\right)^{3/2}$$

白色矮星は“多い”



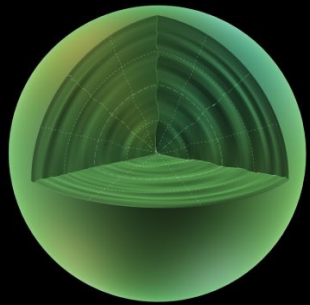
a few 10,000 candidates

Fusillo et al. 18; Jiménez-Esteban et al. 18

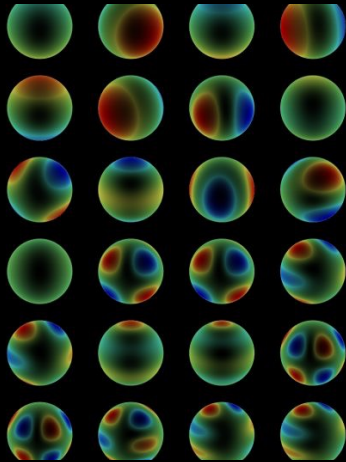


Credit:NASA

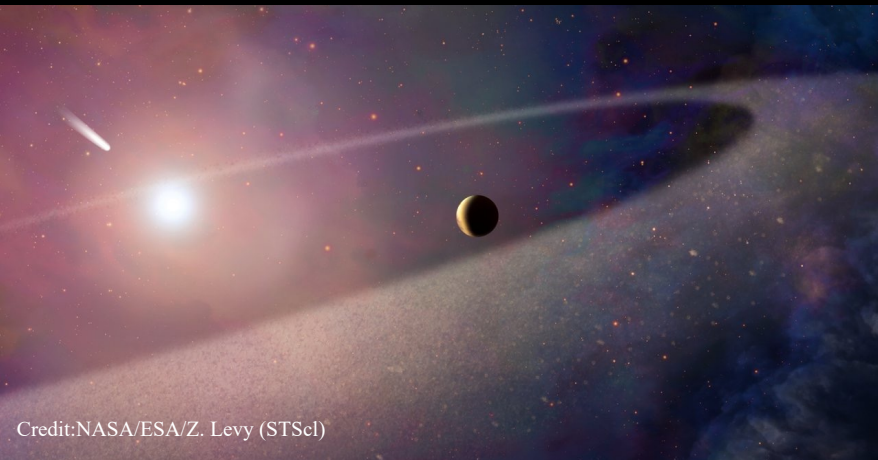
ありそうなのに見つかっていない、
見つかるとうれしいサブ分変動がある



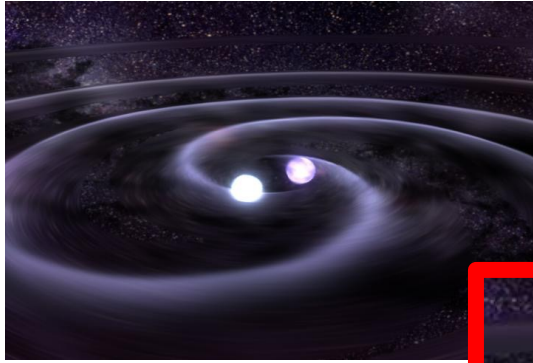
Credits: Stéphane Charpinet



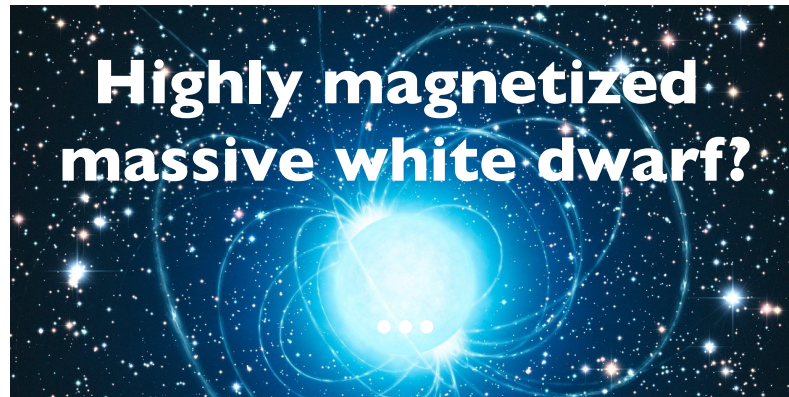
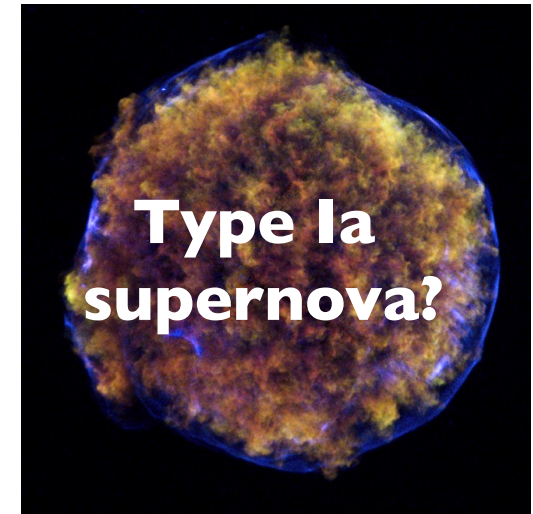
- spin (close to the mass shedding limit)
 - ✓ (magneto)hydrodynamics of formation and merger
 - ✓ a new class of high energy source
- (p-mode) oscillation
 - ✓ new asteroseismology to probe the interior
- tidal disruption (of asteroids)
- transits (of “habitable” planets)
 - ✓ future of our solar system?



Credit:NASA/ESA/Z. Levy (STScI)



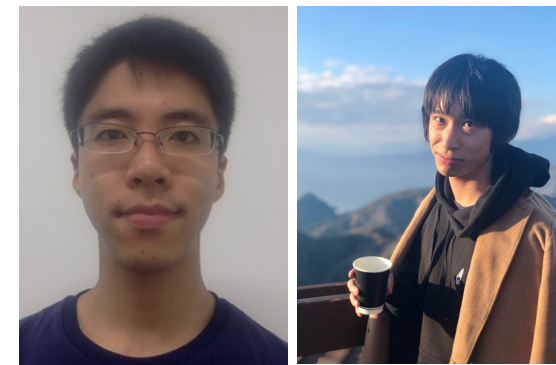
個人的には特にこの文脈でこの辺が知りたい...





HeSO

The Hertz Spinning Object Survey



ありそうなのに見つからない、見つかるとうれしいサブ分変動を見つけるために

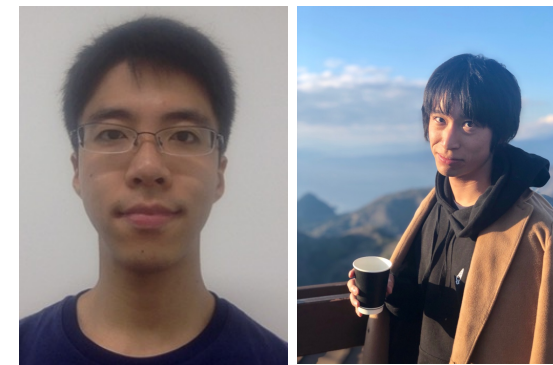
“The goal is ~1 (10 nights x 1000 WDs)”

木曾シュミットシンポジウム 2019のスライドより



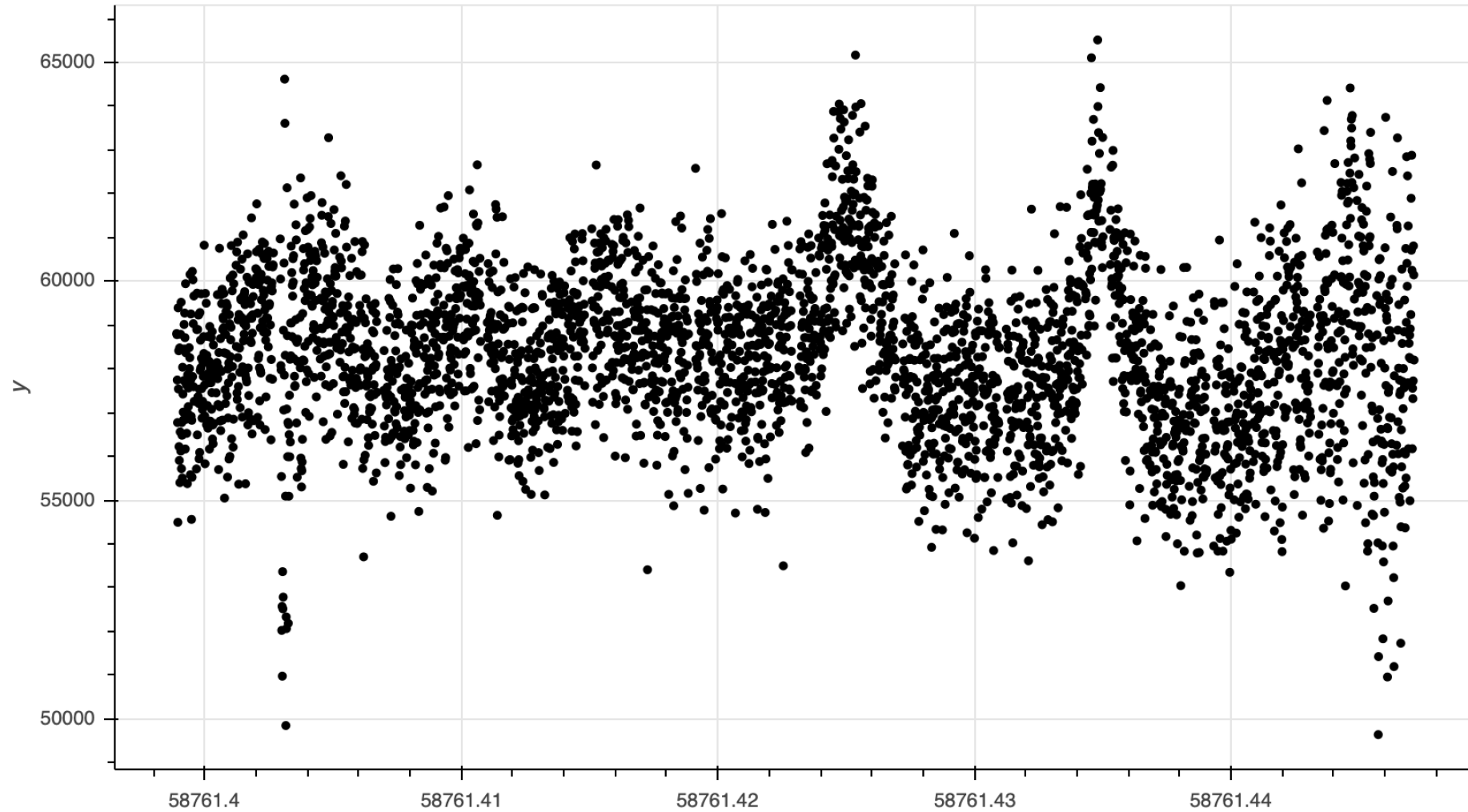
HeSO

**The Hertz Spinning Object Survey
Stellar**



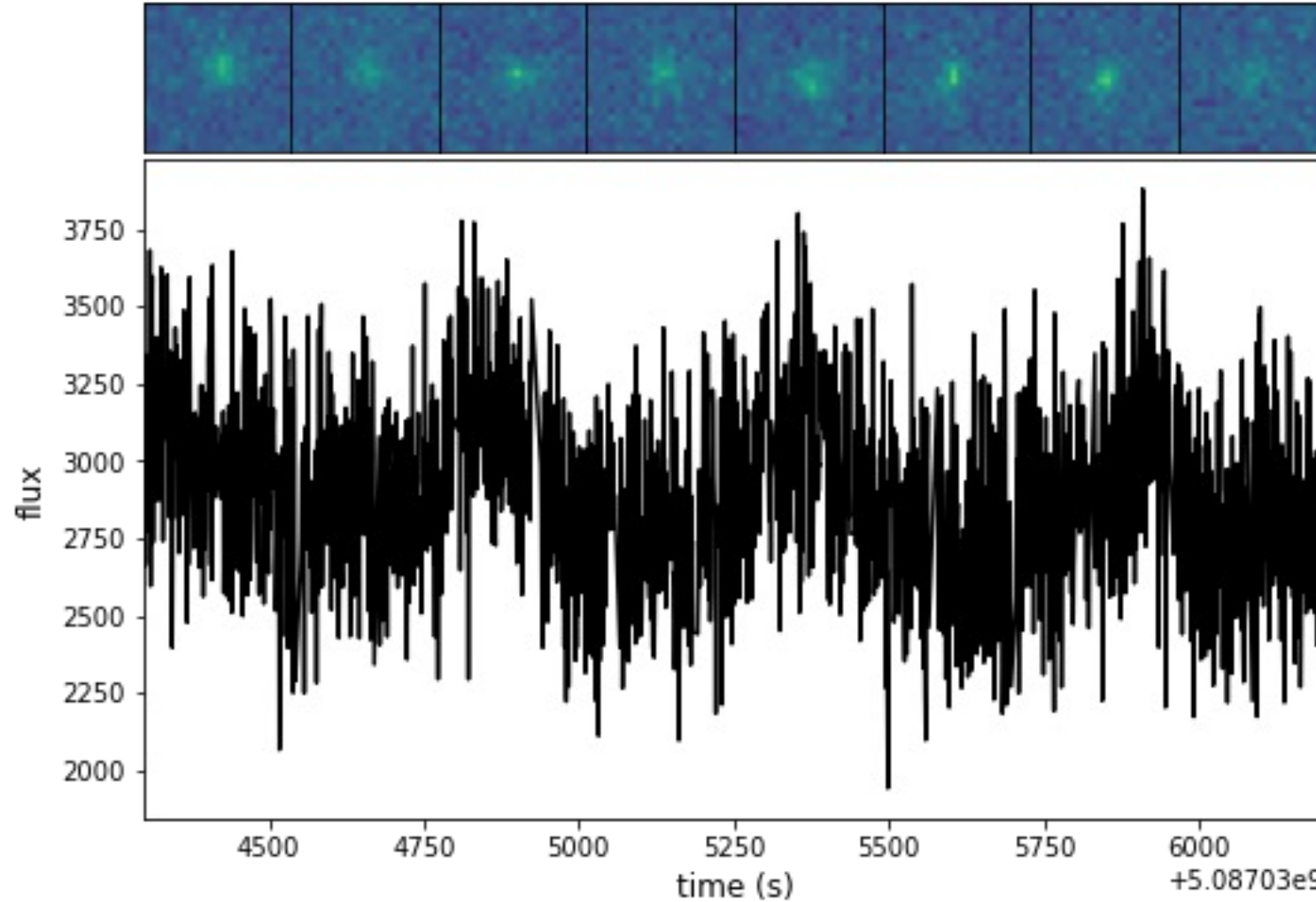
- 現状、total survey time ~ 40 hrs (~ 0.3 nights x 400 WDs) with 1fpsを解析済み
- 有馬さんの地球影のデータも大きなfractionを占める (ありがとうございます)
- Data reduction & analysis pipelineはほぼ整備された (see Aizawa-san's talk)

GD 358



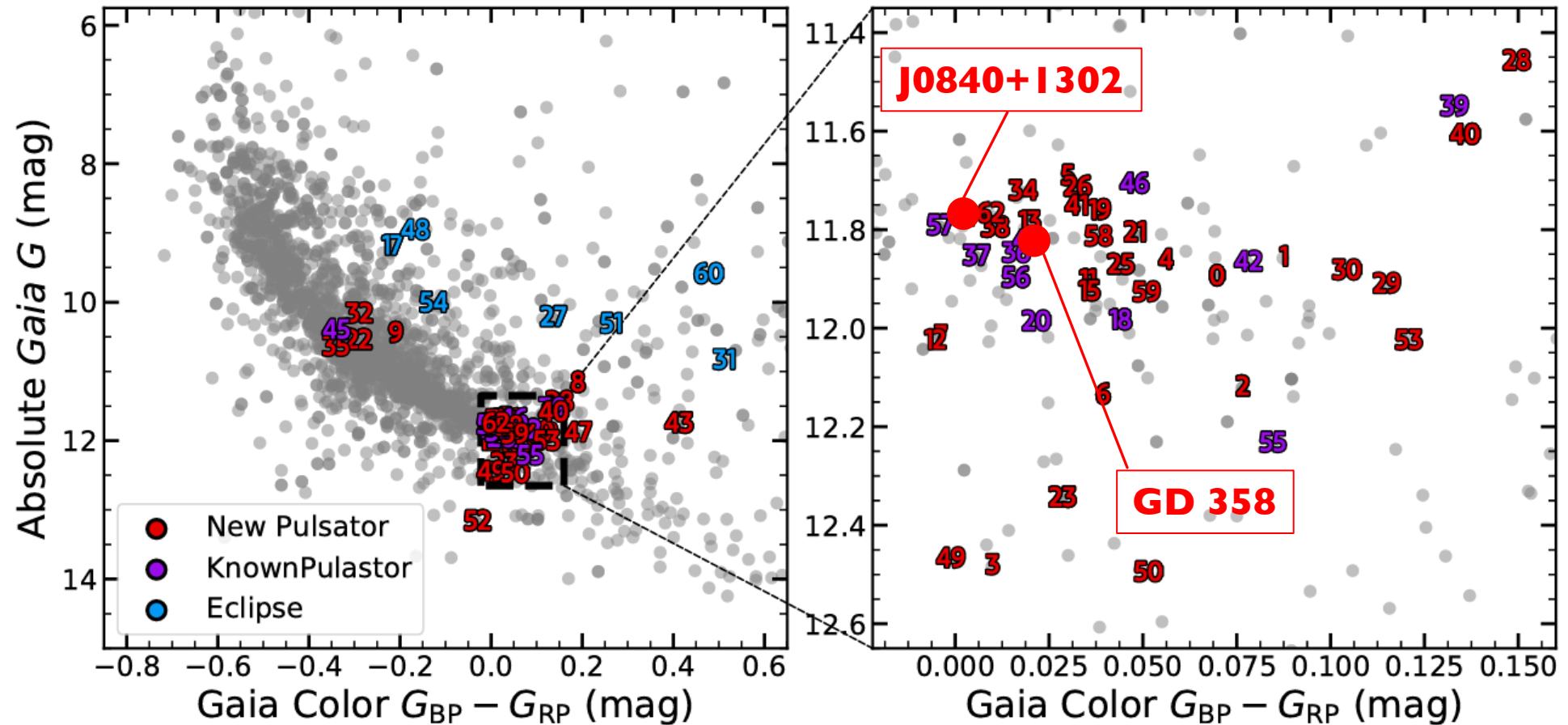
Pulsation with a frequency of ~ 400 - 500 sec and an amplitude of $\sim 10\%$

SDSS J084055.72+130329.5



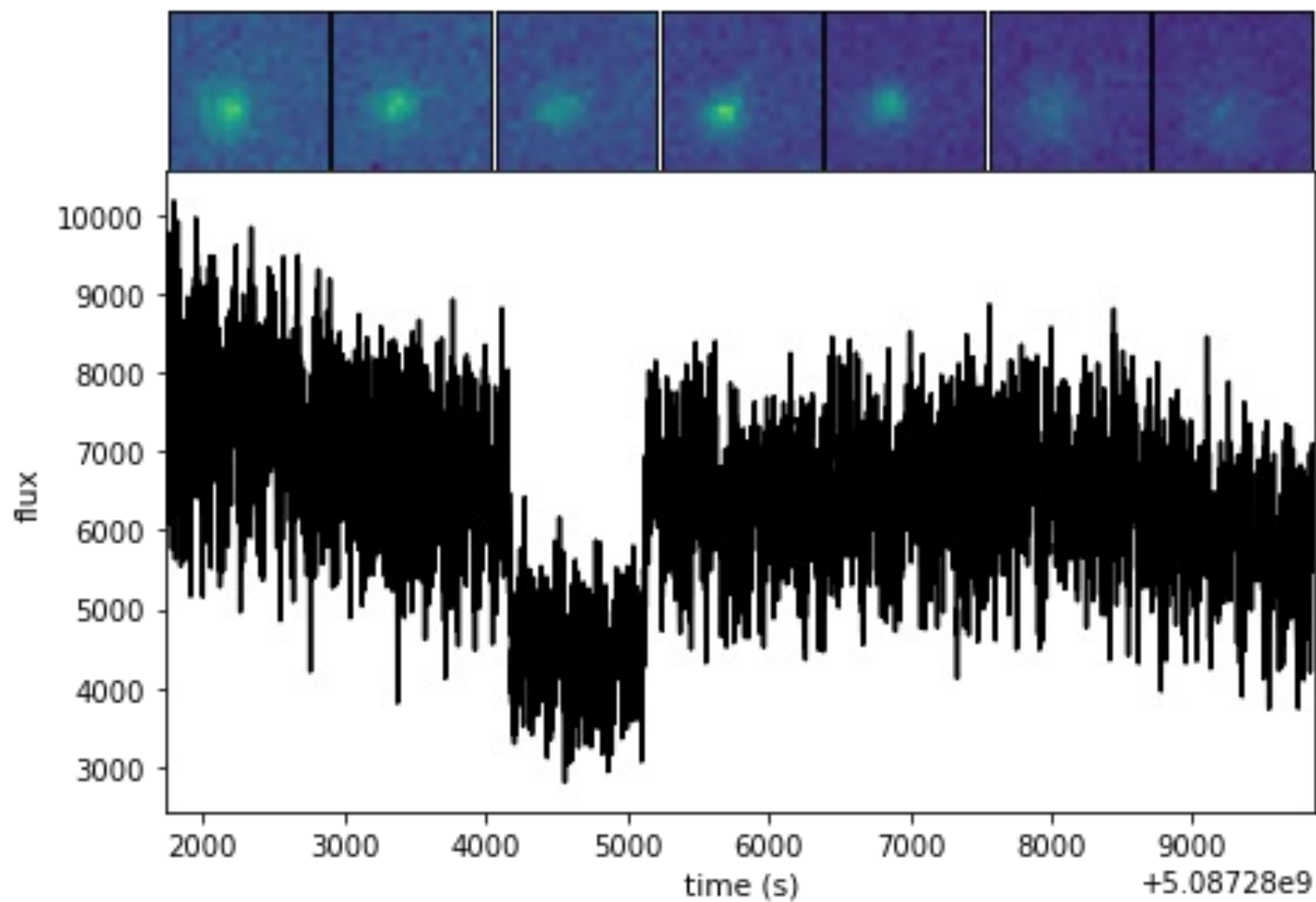
Pulsation with a frequency of $P \sim 500$ sec and an amplitude of $\sim 20\%$

g-mode pulsations of WDs



- *GD 358 is a known DAV.*
- *SDSS J0840+1303 was a newly found DAV by GALEX (Rowan et al. 2019)*

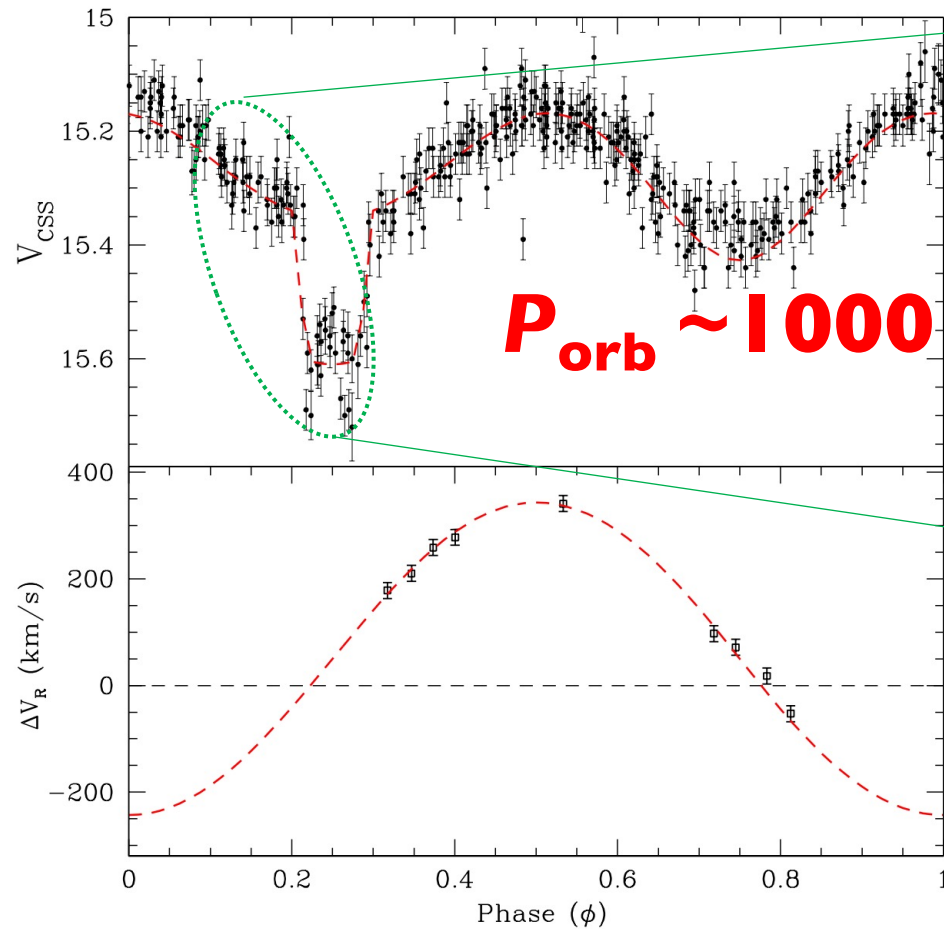
LP 486-53



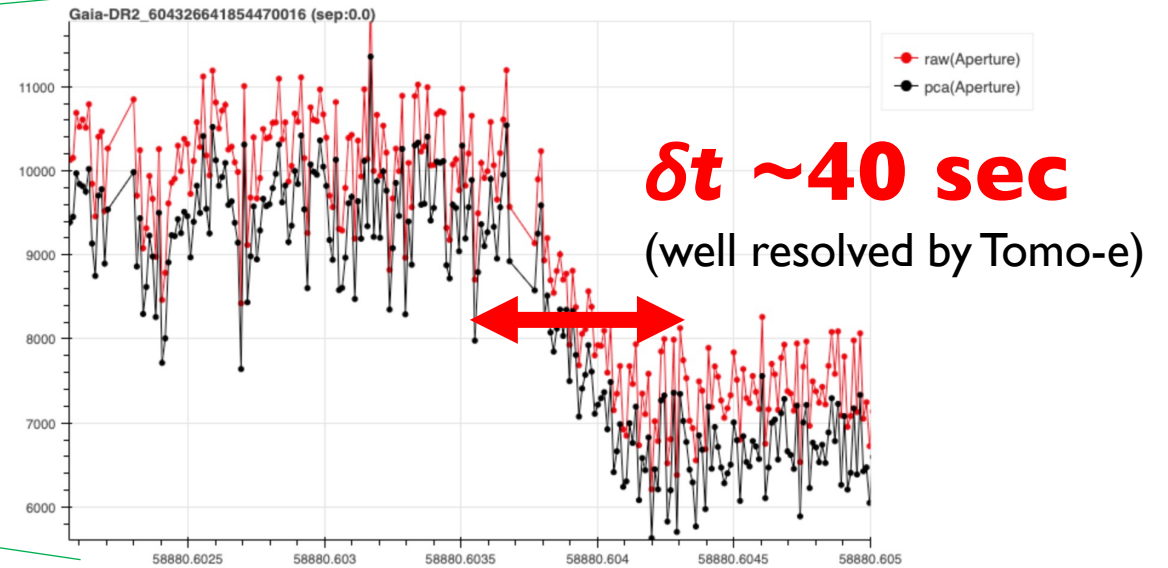
Eclipsing binary (EB) of M dwarf + WD

Eclipsing Binaries including WDs

LP 486-53 was discovered by the Catalina survey (Drake et al. 14)



$P_{\text{orb}} \sim 1000 \text{ sec}$



$\delta t \sim 40 \text{ sec}$
(well resolved by Tomo-e)

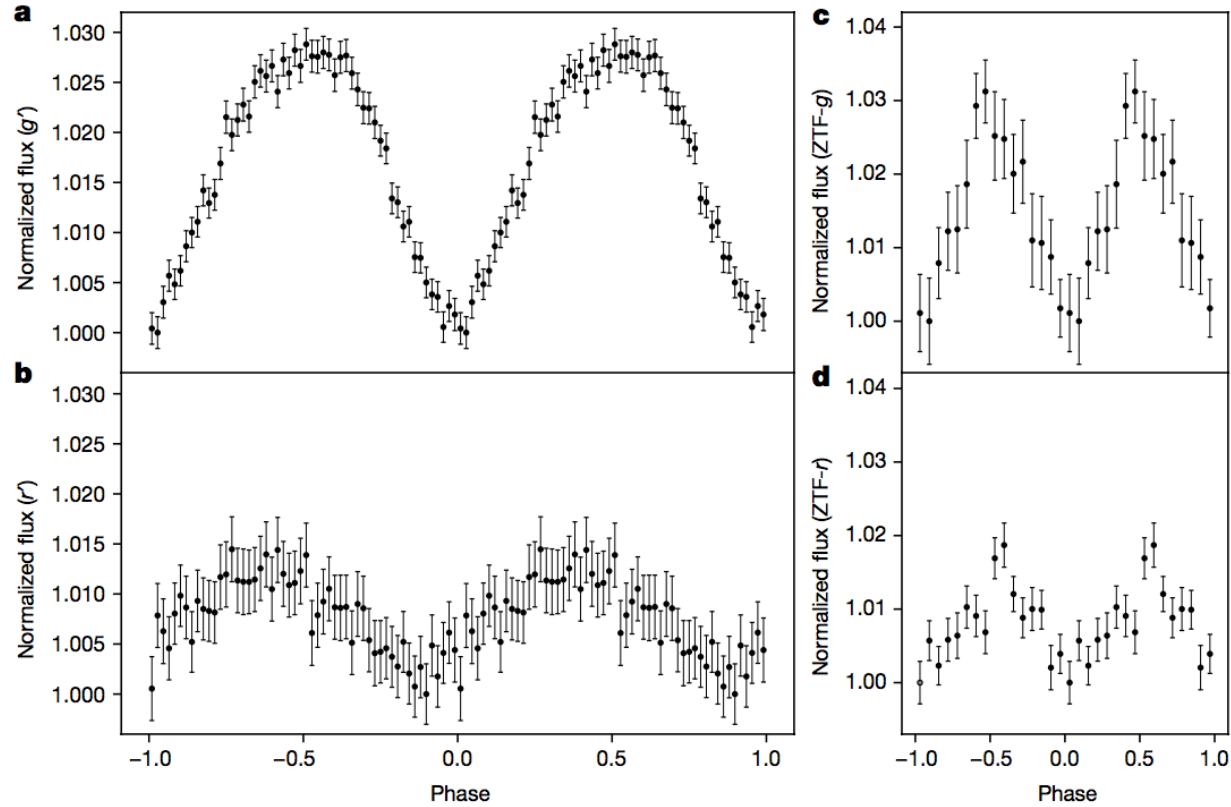
一般に、

$$\delta t \approx P_{\text{orb}} \times \left(\frac{R_{\text{WD}}}{R_*} \right)$$

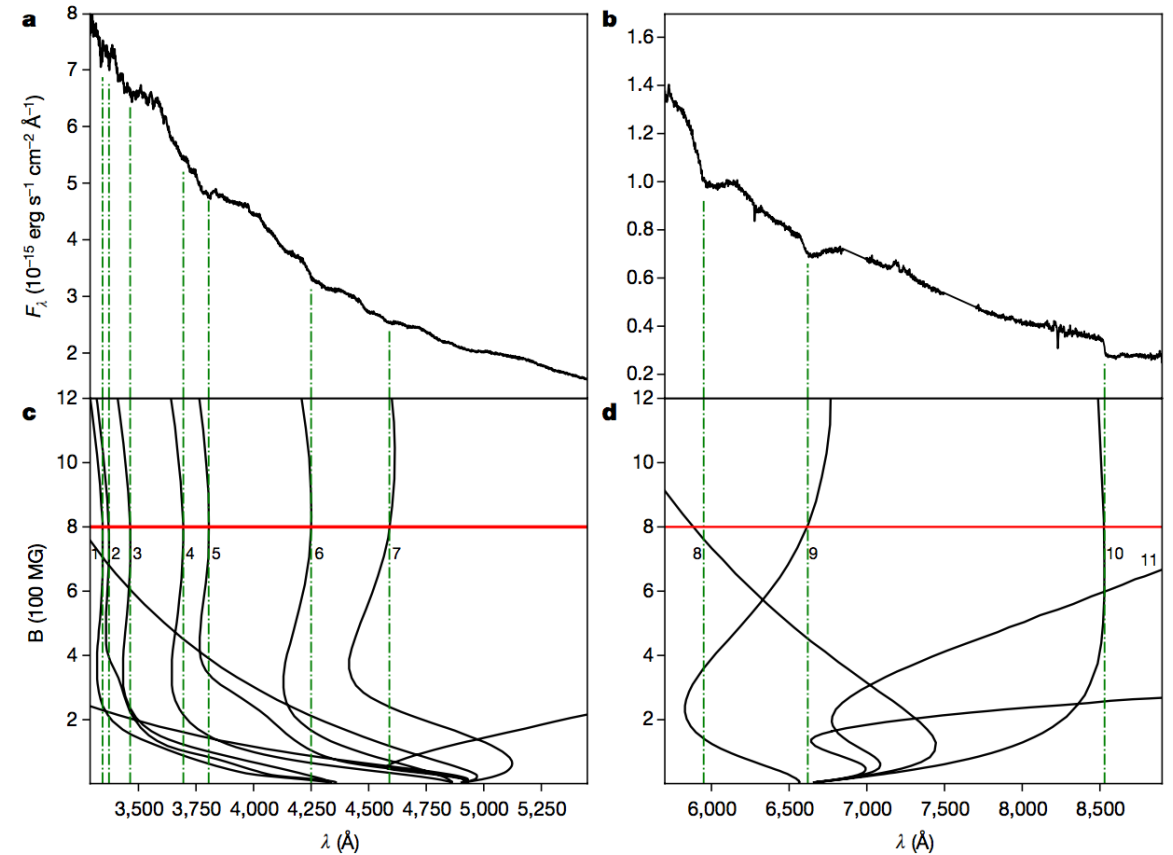
チャンドラセカール質量付近だと $\delta t < 10 \text{ sec}$ もあり得る...

ZTF J190132.9+145808.7

Caiazzo et al. 21



$$P = 6.97 \text{ min}$$

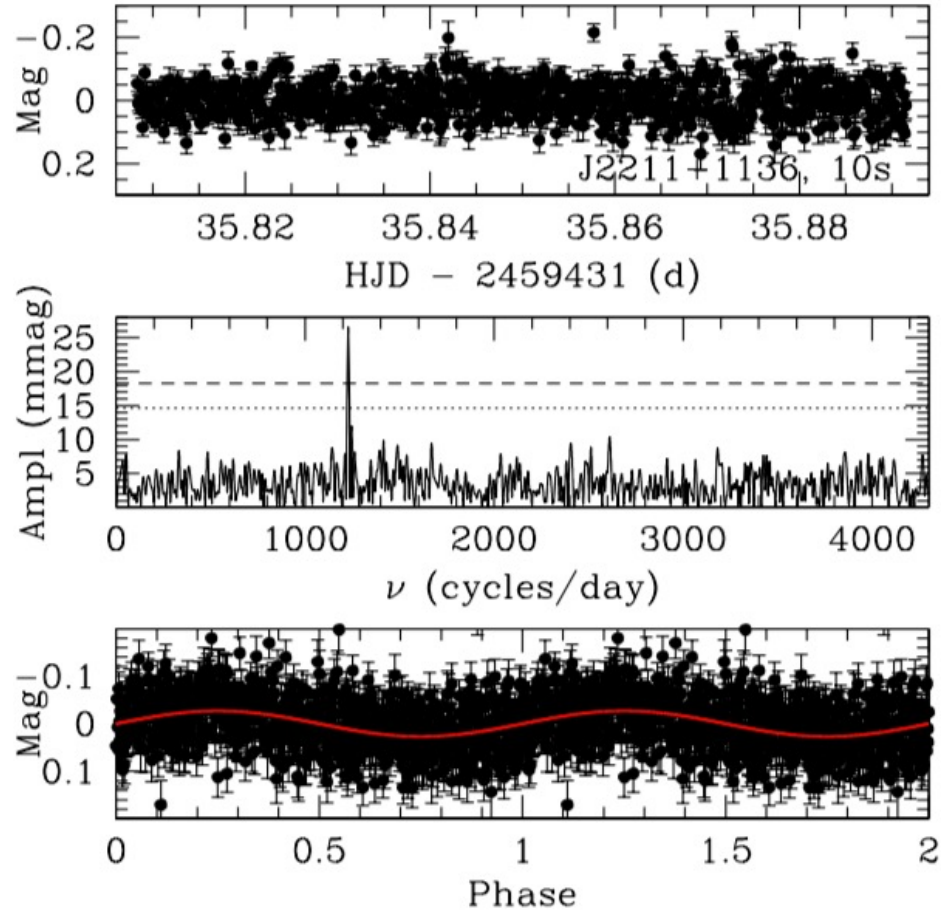


$$B = 6-9 \times 10^8 \text{ G}$$

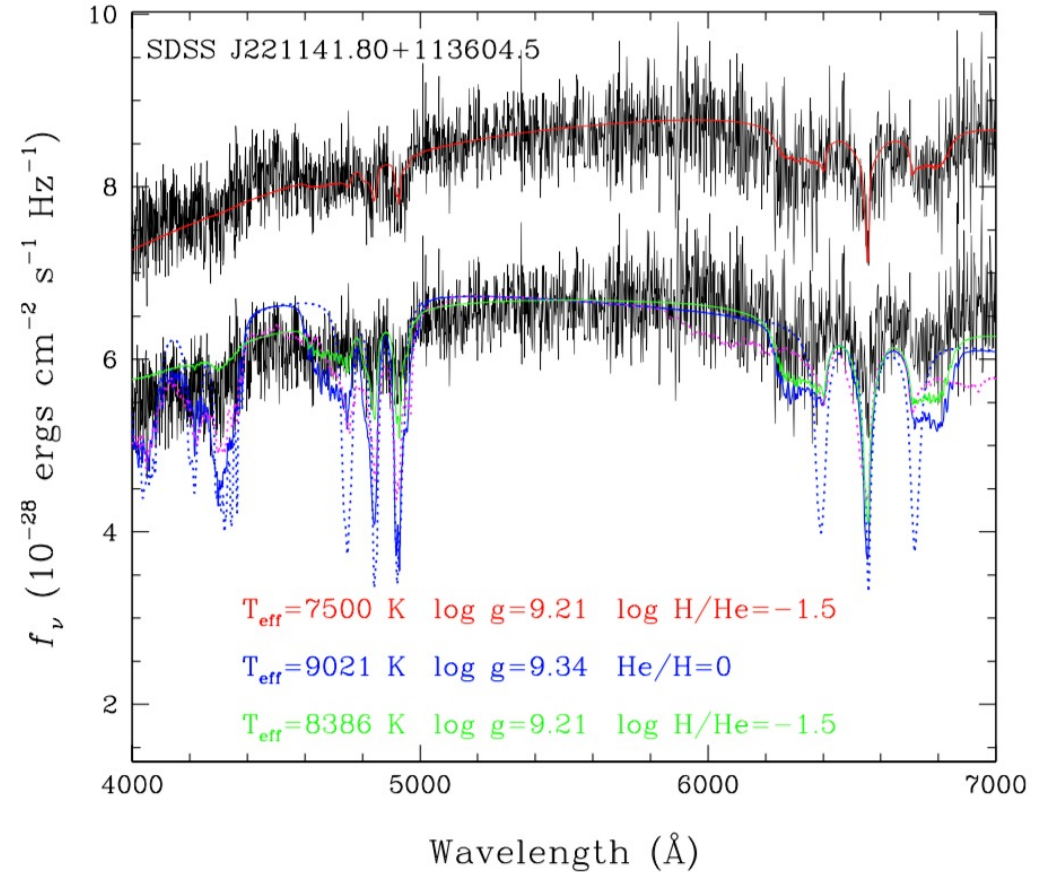
$$M = 1.327-1.365 M_\odot, T_{\text{eff}} = 46,000 \text{ K}$$

SDSS J221141.80+113604.5

Killic et al. 21



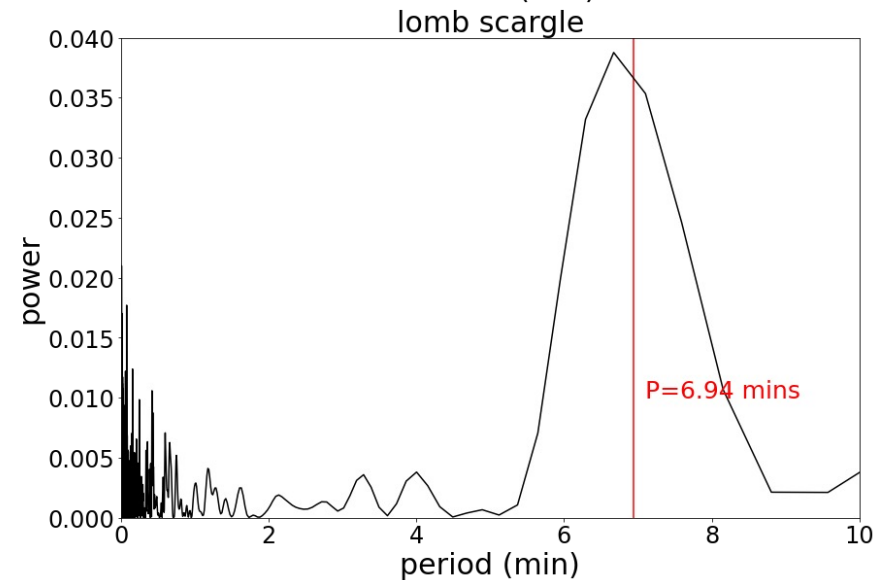
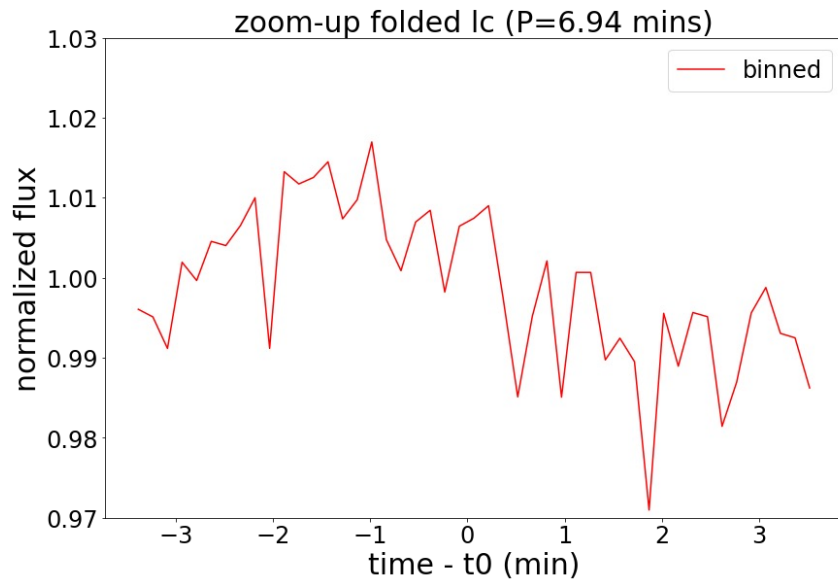
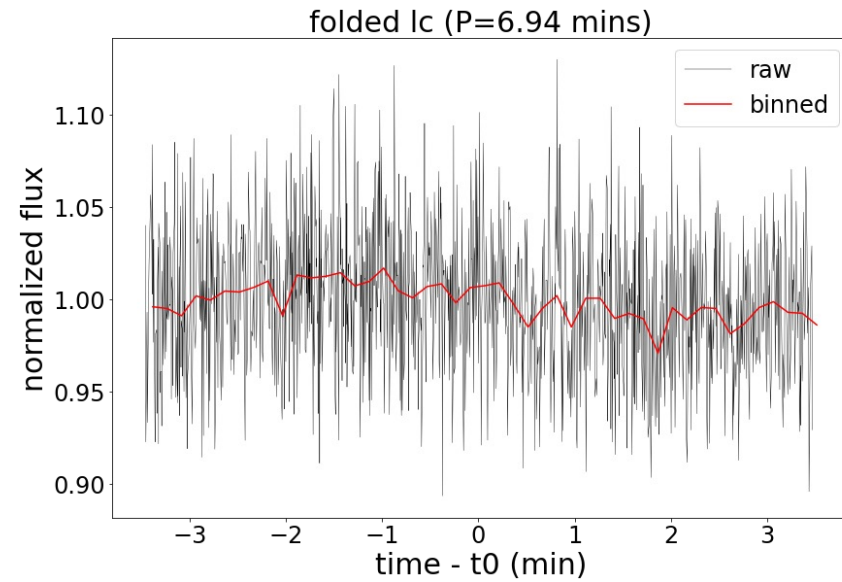
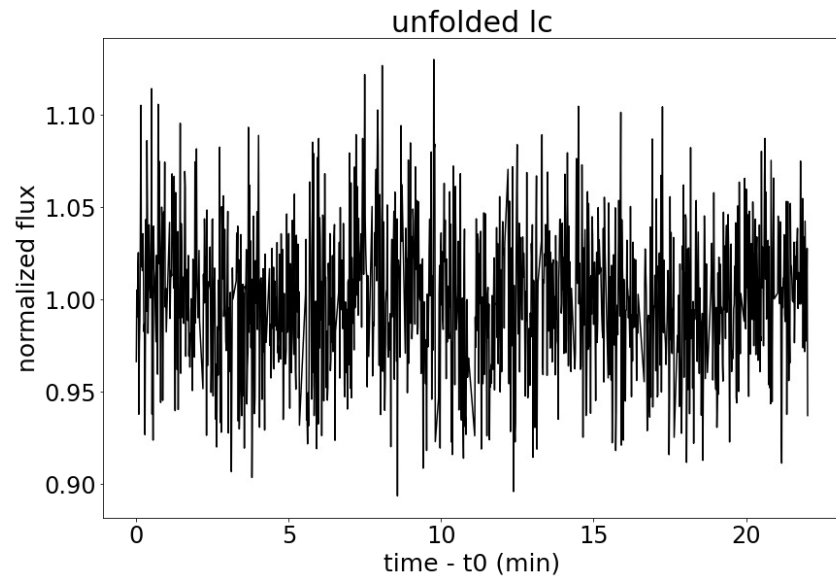
$$P = 76 \text{ sec}$$



$$B = 1.5 \times 10^7 \text{ G}$$

$$M = 1.268 M_\odot, T_{\text{eff}} = 7500\text{-}8390 \text{ K}$$

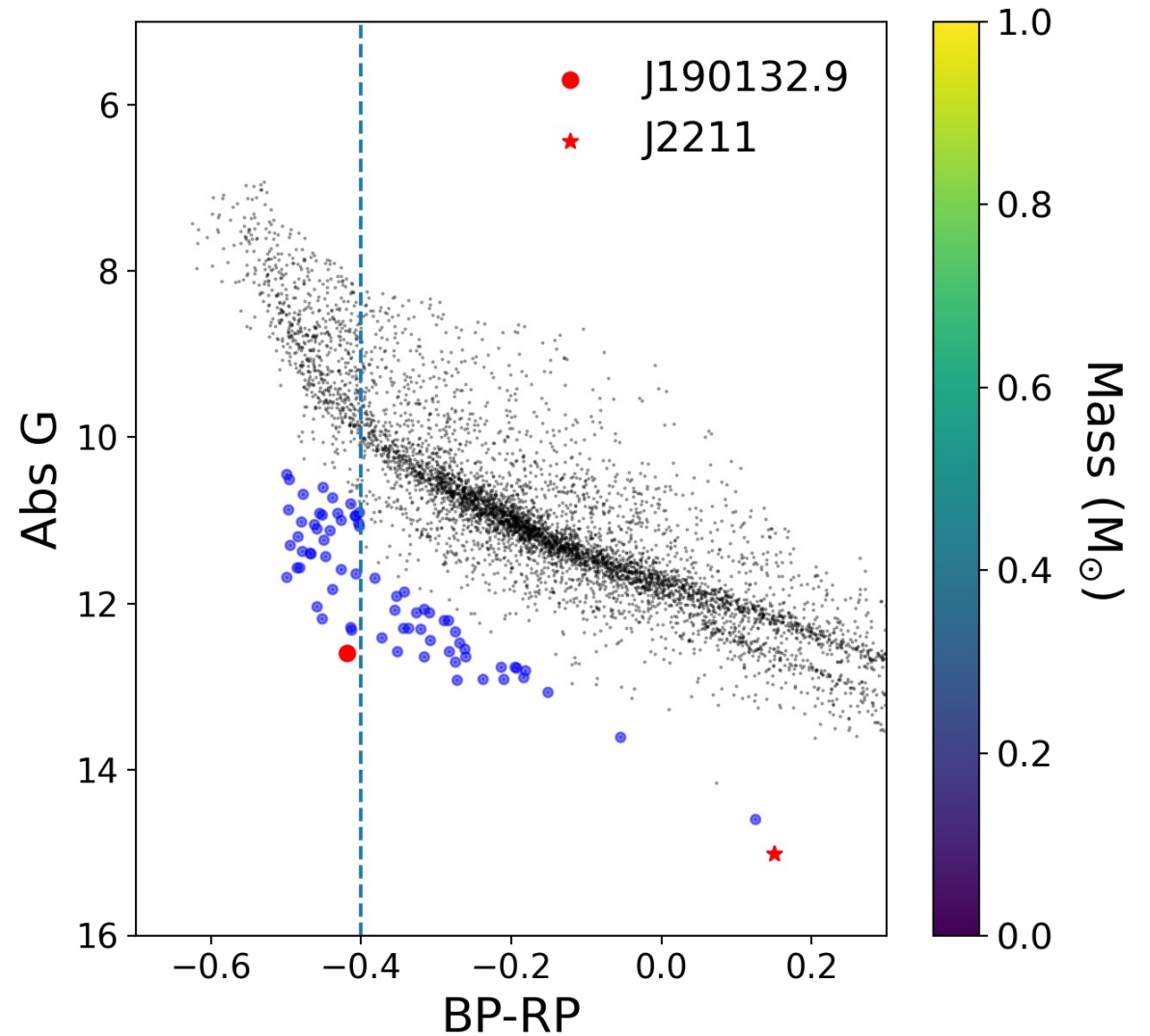
ZTF J190132.9+145808.7 with Tomo-e



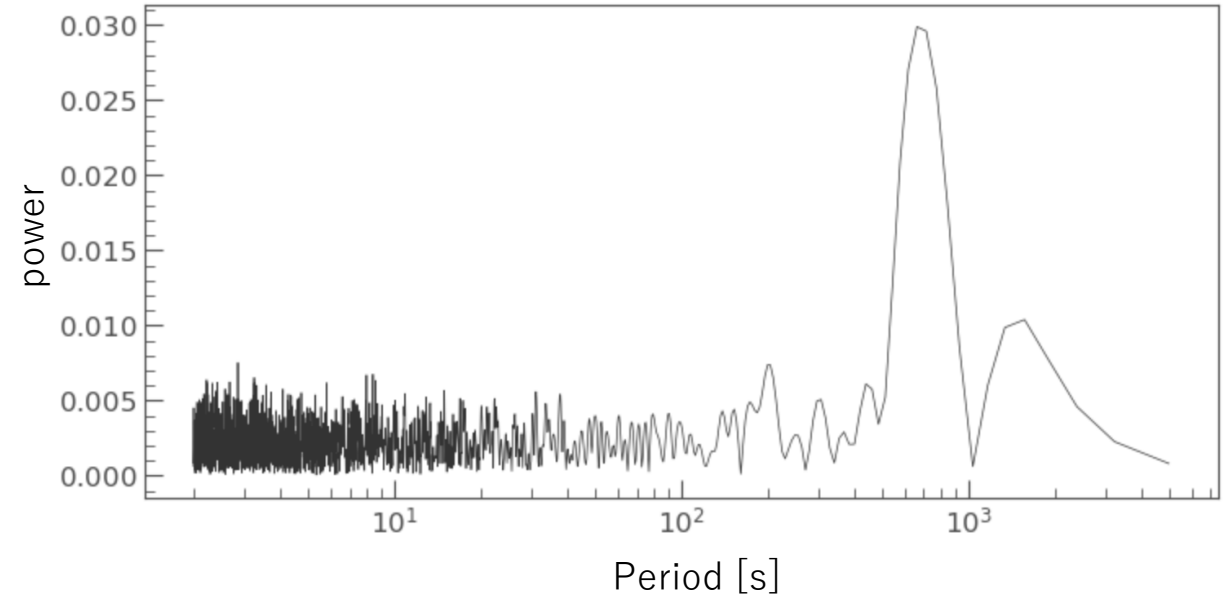
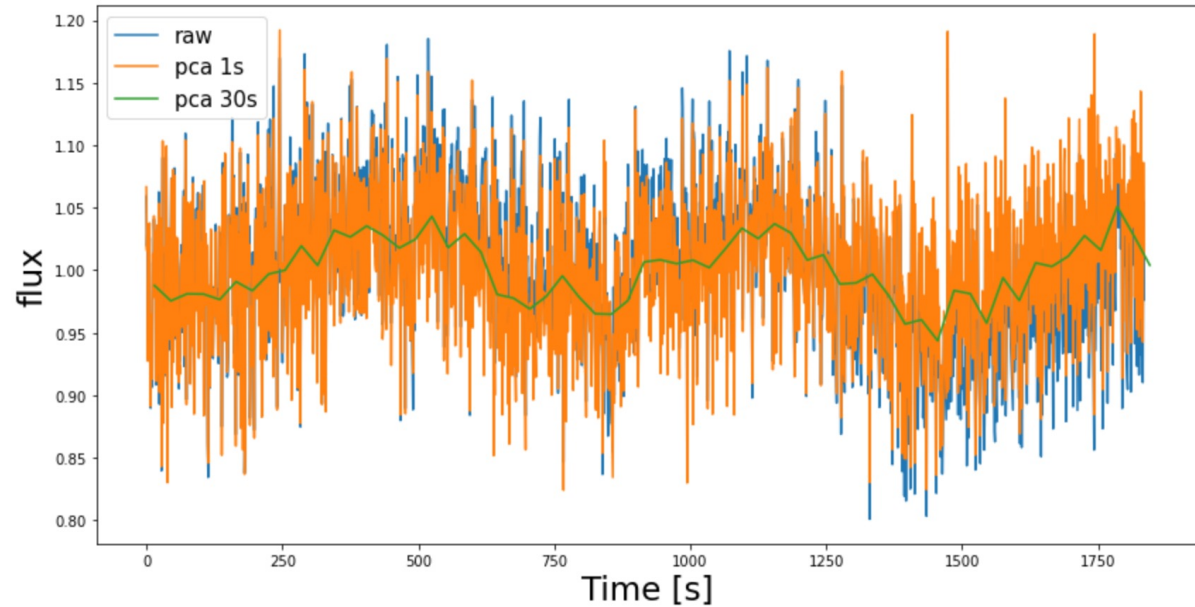
with Seimei TriCCS

targeted observations of
~40 young massive WDs
(not in the unstable stripe)

21B Kashiyama et al. (1/2 night)
22A Aizawa et al. (6 nights)

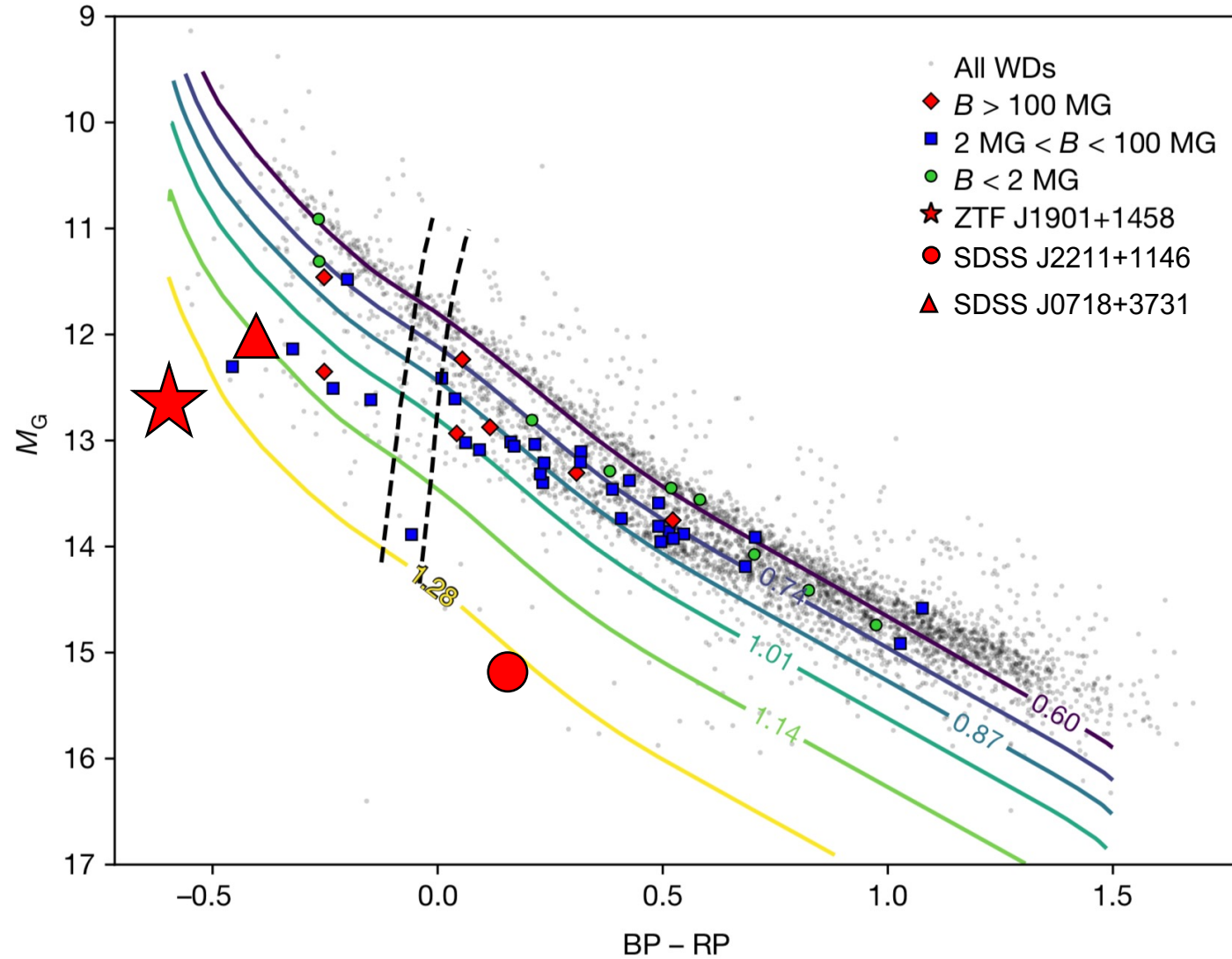


SDSS J071816.41+373139.1 (with TriCCS)

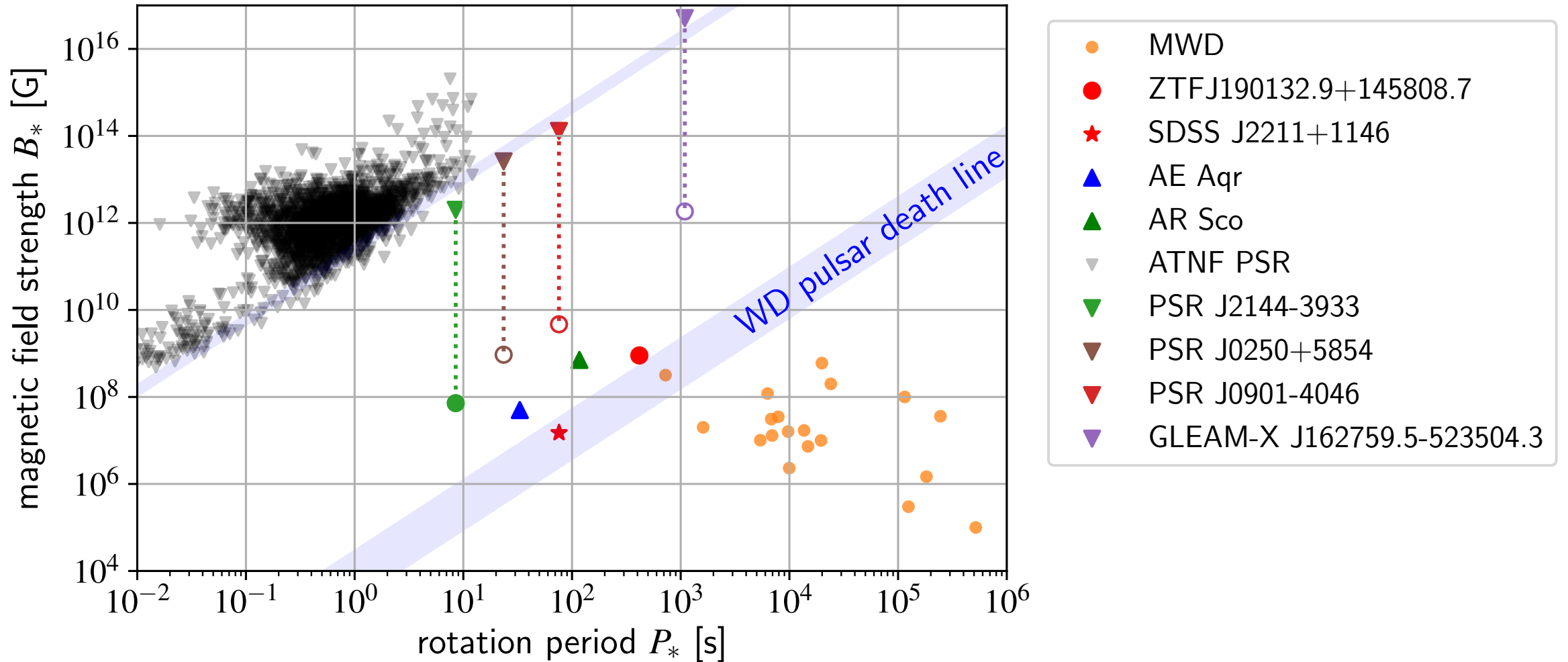


- *Pulsation with a frequency of $P \sim 750$ sec and an amplitude of $\sim 5\%$*
- *Need a spectroscopic follow-up observation*

Fast spinning WDs on the HR diagram



Slowly rotating neutron stars and fast spinning white dwarfs



まとめと議論

- HeSOパイプラインは整備され、既知の~1-10 min変動は各種検出に成功、本丸はサブmin.
- Seimei TriCCSも併用させていただき、特に高速回転白色矮星に関しては本丸に手が届きそうな雰囲気は出てきた...
- が、(わかっちゃいたけど)立ちはだかるZTF他...

- 現状、~0.3 nights x 400 WDs (total survey time ~ 40 hrs)解析済み
- 最終的には、~10 nights x 1000 WDs (total survey time ~ 3000 hrs)分の~1 fpsデータを撮りたいが...