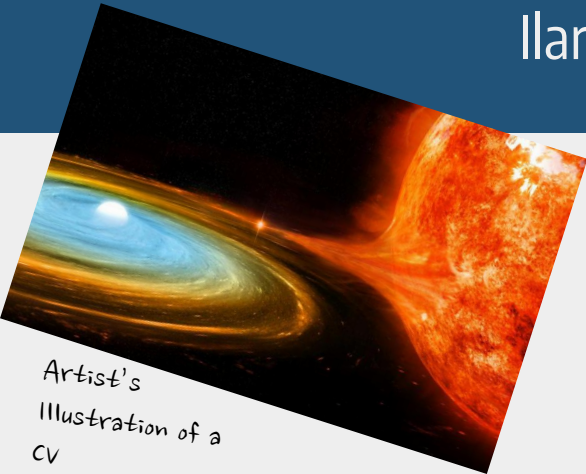# A Search for Short Orbital Period Cataclysmic Variables Using the Zwicky Transient Facility

Collaborators: Jan van Roestel, Michael Rich, Shri Kulkarni, Ilaria Caiazzo, and the ZTF Collaboration

Artist's Illustration of a CV

Zhuofu (Chester) Li
University of Washington
November 15th, 2022 @ UCSB KITP: White Dwarfs from Physics to Astrophysics

A search for 1-2 hour periodic white dwarfs in ZTF

- Science goal: find cataclysmic variable period bouncers
- Sample: Gaia WD Catalog with <u>G < 19.5</u>
- Analyzed 124,819 ZTF WD lightcurves
- Challenges: lightcurves have long term trends and flickering
- Results: 235 periodic stars, 176 new!

Cataclysmic Variables (CVs)

Credit: NASA

CV Evolution
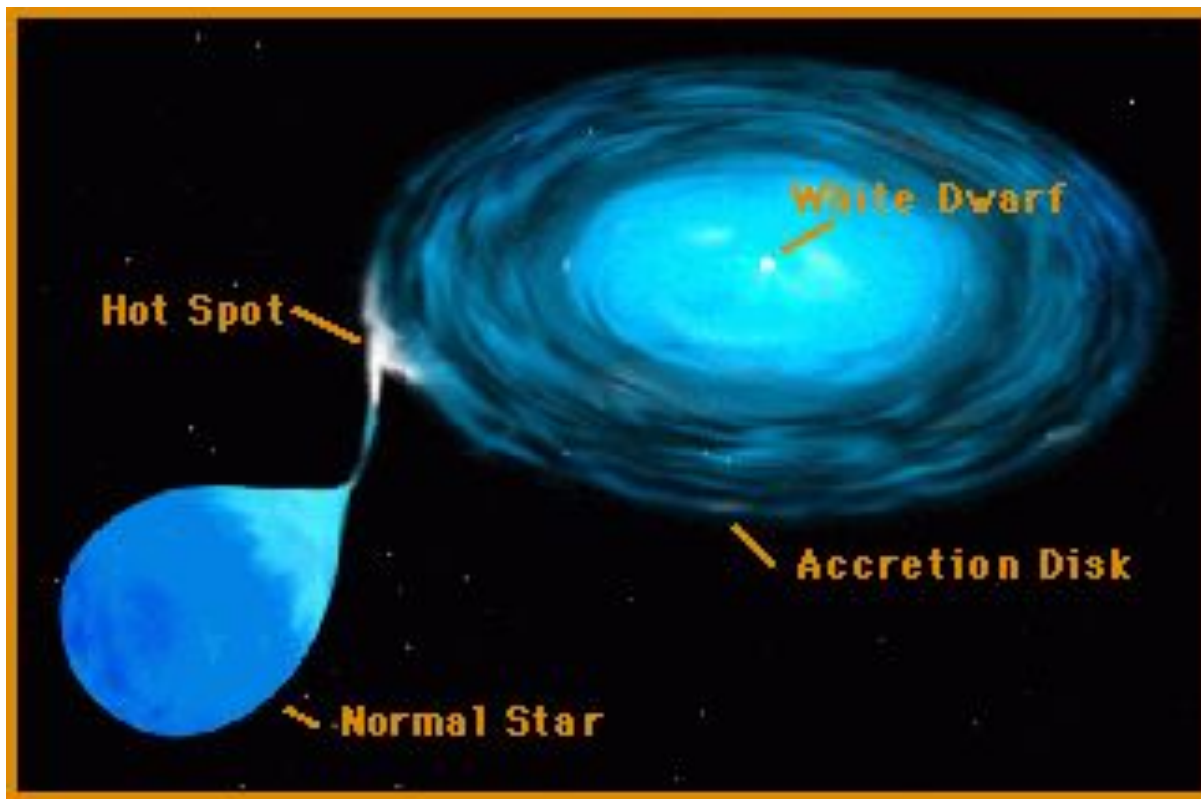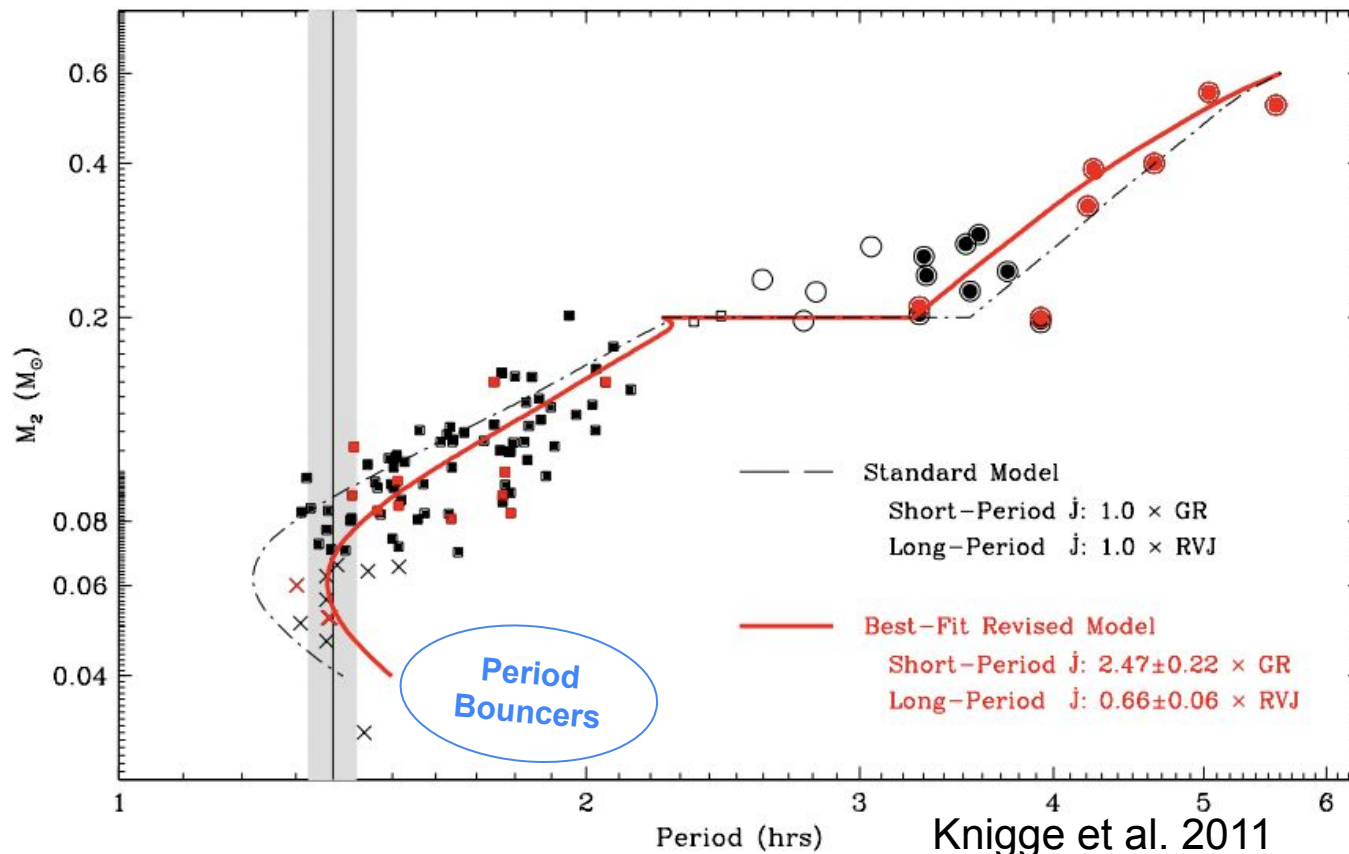
Knigge et al. 2011

CV Period Bouncers

- ## Period Minimum
  - Prediction: ≈ 70 minutes **(Goliasch & Nelson 2015; Kalomeni et al. 2016)**
  - Observation: ≈ 83 minutes **(Gansicke et al. 2009)**
- ## Period Bouncer Population
  - Prediction: 40% **(Goliasch & Nelson 2015)** - 70% **(Kolb 1993; Knigge et al. 2011)**
  - Observation: only a few known **(e.g. Pala et al. 2018)**
- ## Important for understanding CV evolution
- ## Goal: <u>find more period bouncers</u>

Knigge et al. 2011

Data
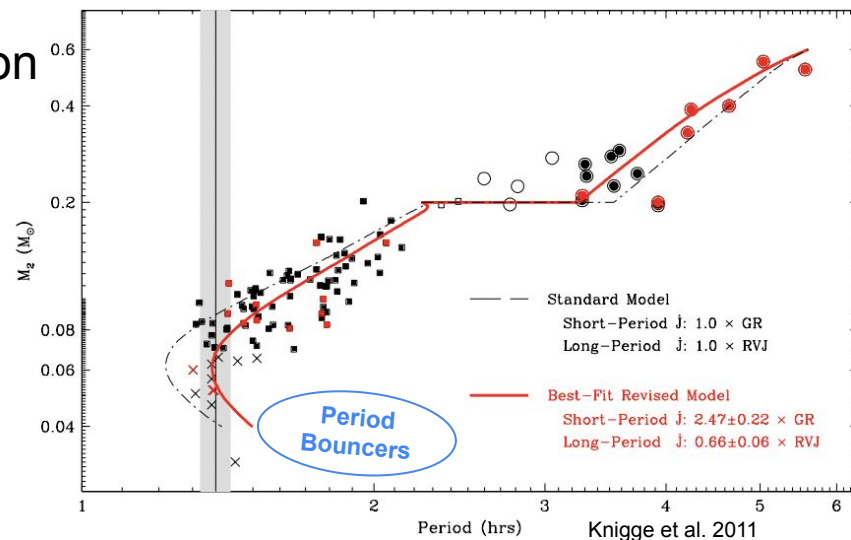
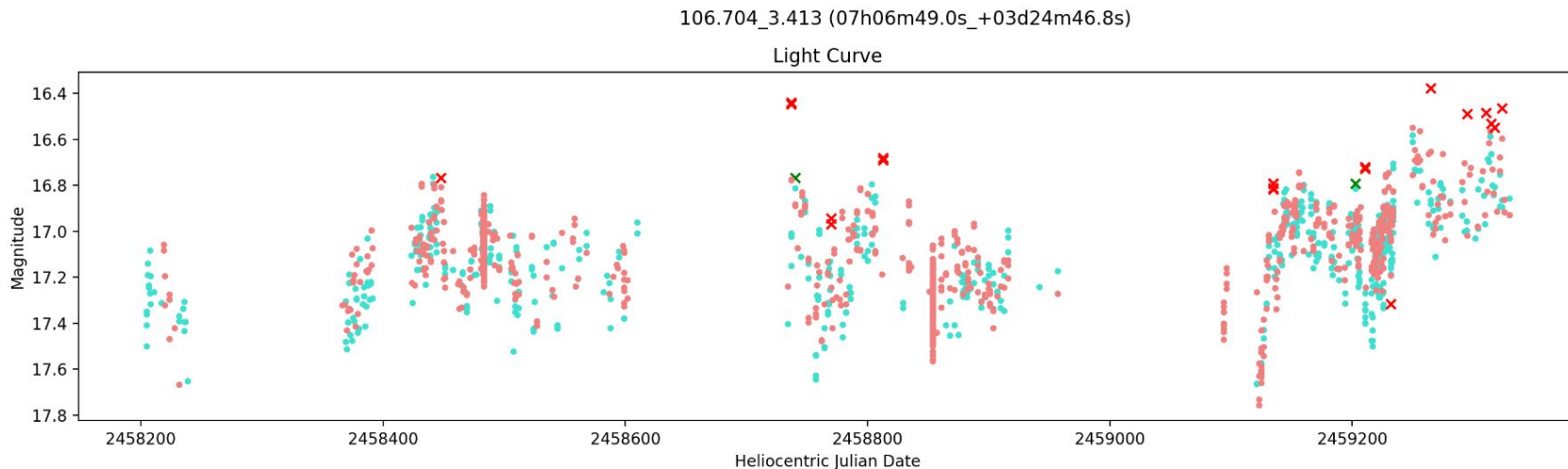ZTF
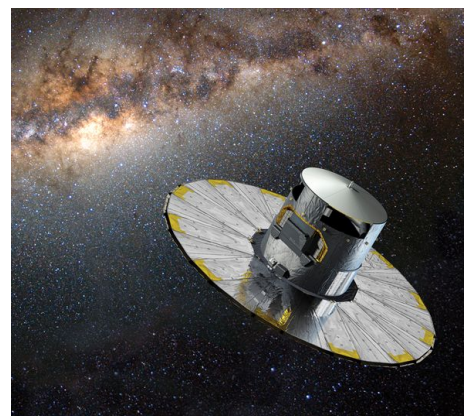
Gaia

- Cross-matched ZTF WD lightcurves with the Gaia WD Catalog with G < 19.5 (Gentile Fusillo et al. 2021)
- Requirement: ZTF epochs > 50
- Total number of lightcurves analyzed: 124,819

Challenges

106.704_3.413 (07h06m49.0s_+03d24m46.8s)

Light Curve

The periodic signal is hidden by:
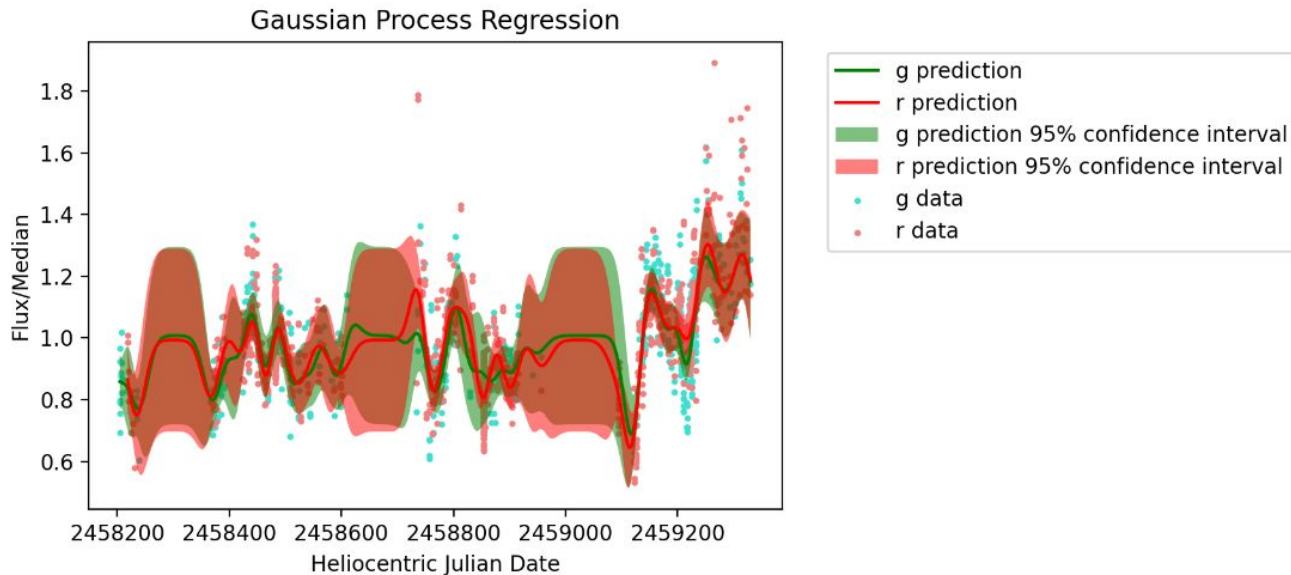- Long term trends
- Flickering

Gaussian Process Regression

- Nonparametric, Bayesian approach
- Uncertainties
- Various usage **(Aigrain and Foreman-Mackey)**
  - Exoplanet transit
  - Eclipse modelling
  - AGN variability
  - Pulsar timing
  - Instrumental systematics

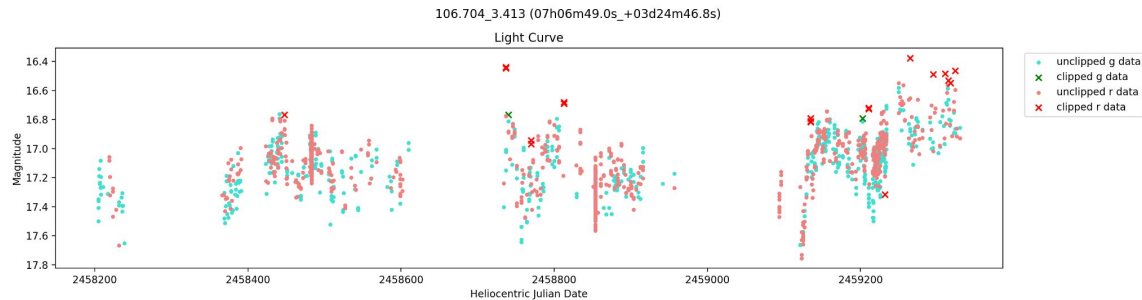

Approximating true function with more data
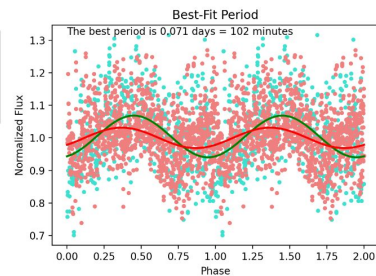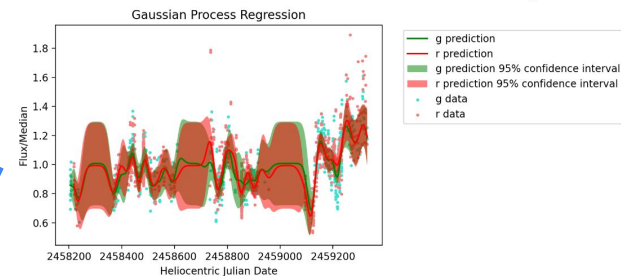
Credit: JIe Wang

Solution
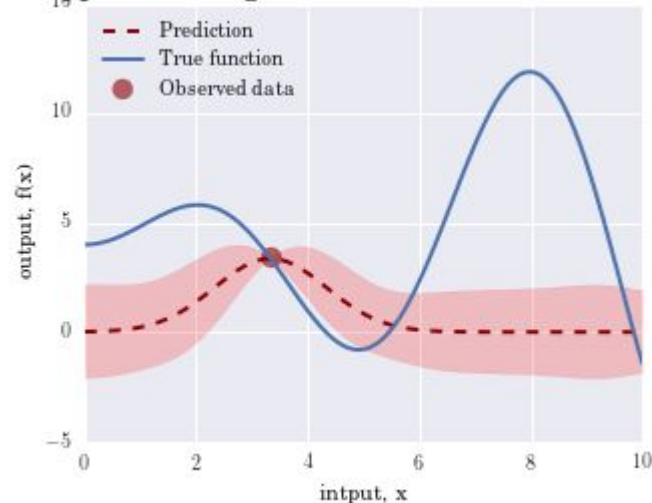
1. Gaussian process regressor (scikit-learn)
2. Sigma clipping (astropy)
3. Lomb-Scargle period finding (gatspy)

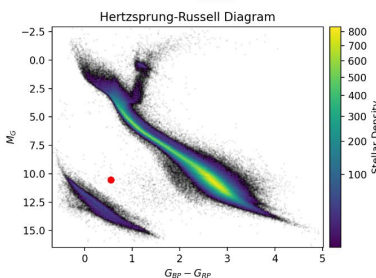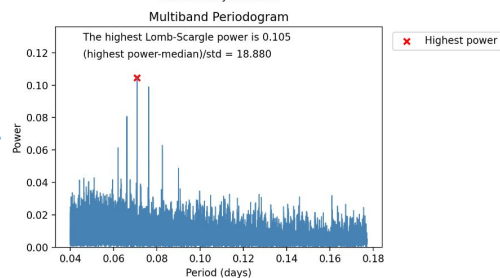# Putting it all together

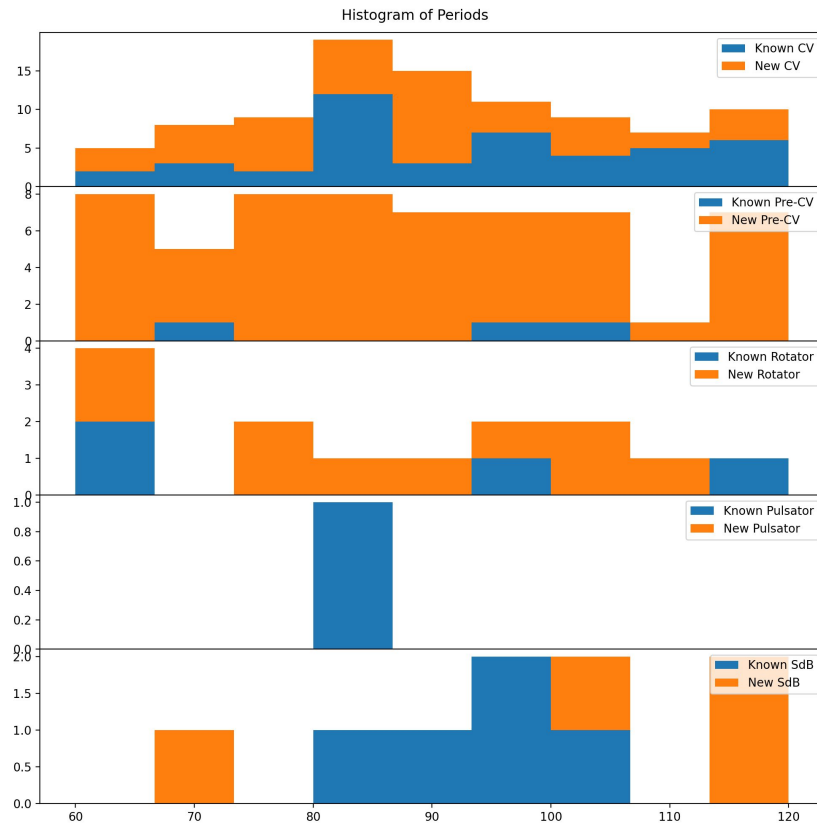Lightcurve With Clipped Data Points
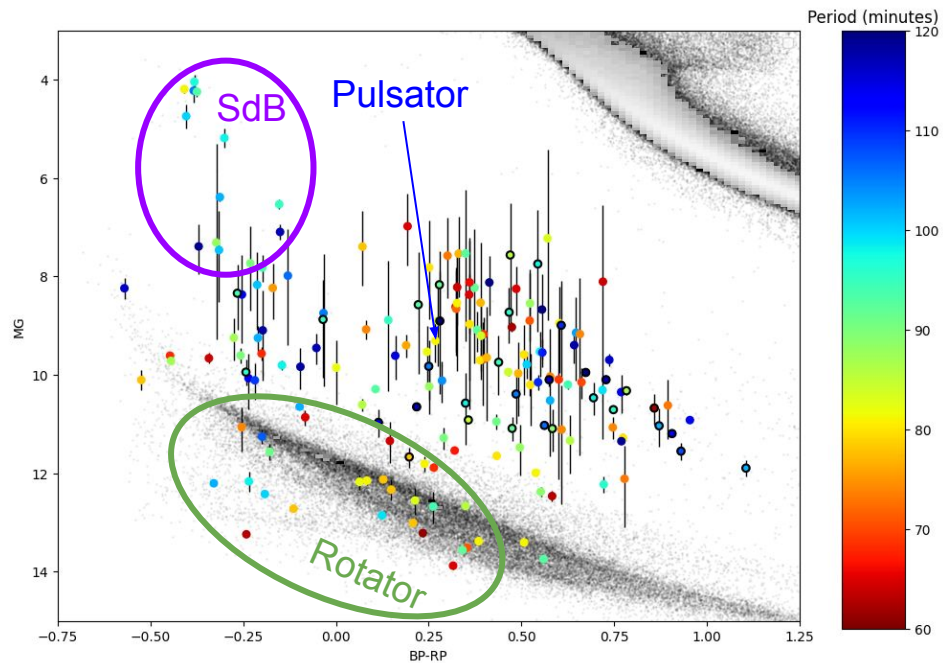
Gaussian Process Regression

Periodogram

Folded Lightcurve

HR Diagram

Results

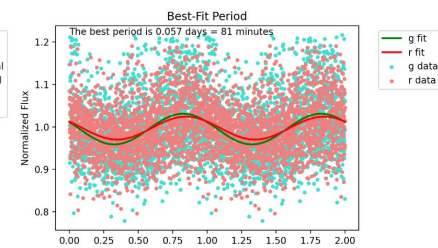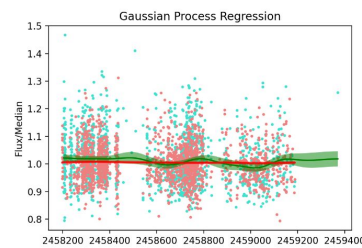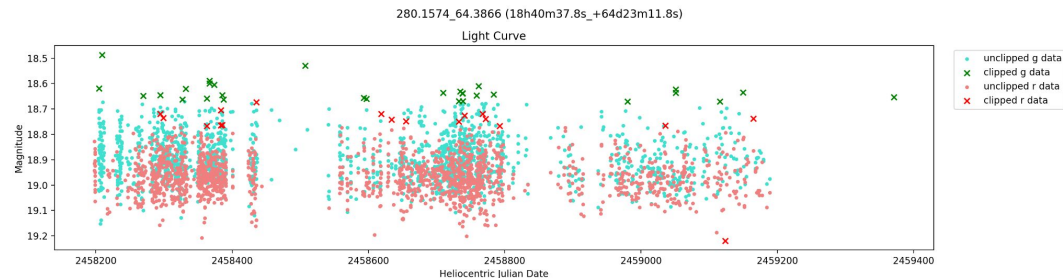|	Total	CV	Pre-CV	Pulsator	Rotator	SdB
Known Classification	59	46	3	1	4	5
New Classification	119	50	56	0	10	3
No Classification	57					
Total	235	96	59	1	14	8

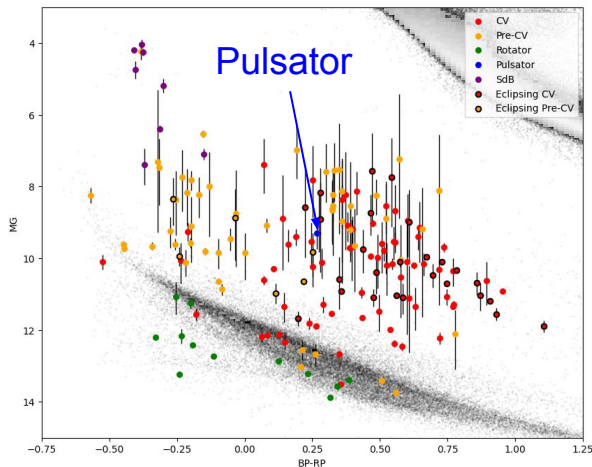Histogram of Periods

Short Periodic Signals
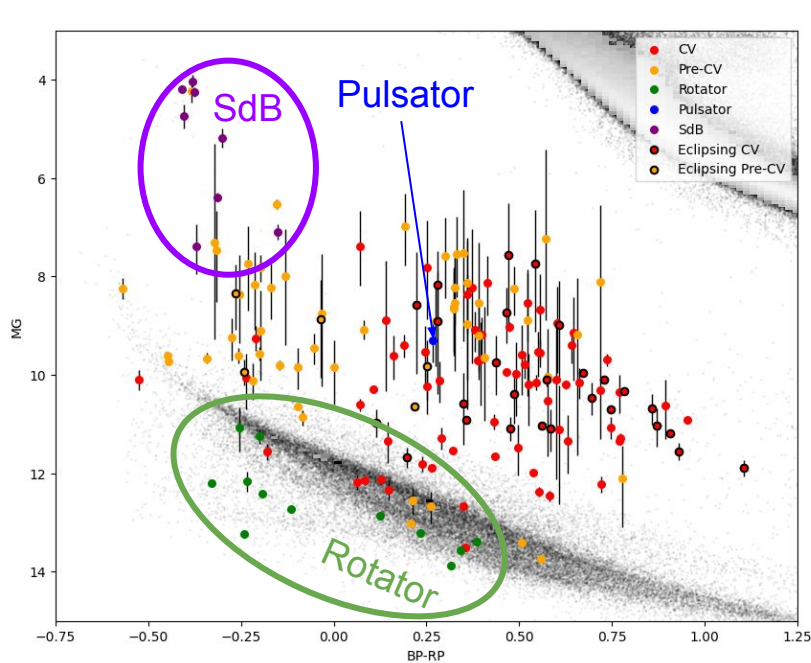
Other Interesting Object: Pulsator

- Extremely low mass
- DA white dwarf
- Multi-periodic
  - 4885 s **(this project)**
  - 4446 s **(Hermes et al. 2018)**
  - 4698 s **(van Grootel et al. 2012)**
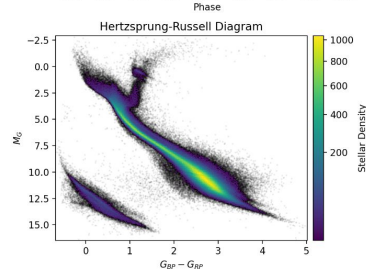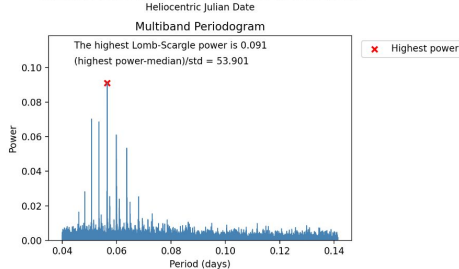
Project Summary

- Applied GPR to 124,819 ZTF WD lightcurves
- Found 235 short periodic signals, 176 new!
- Many new interesting objects with various types

Future Work

- Spectroscopic and photometric follow-ups
- Our code can be applied to other surveys (i.e. LSST)
- GPR is good for finding periods of poorly sampled, imperfect data

Thank you!!

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