

Non-evolutionary effects on Period change in Magellanic Cepheids

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Collaborators: G. Hajdu, P. Karczmarek, O. Ziółkowska,
V. Hócdé, I. Soszyński, A. Udalski



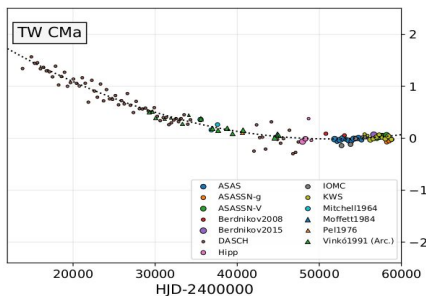
Based on: Rathour et al. 2024 (a) [under review]
Rathour et al. 2024 (b) [in prep.]

Taxonomy of Period Change (PC)

Evolutionary

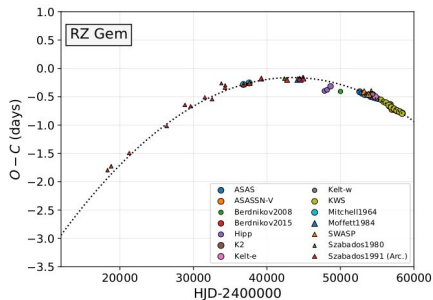
($\sim 10^4 - 10^7$ yr)

Positive



G. Csörnyei et al. (2021)

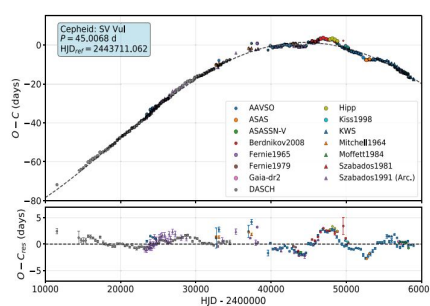
Negative



Non-evolutionary

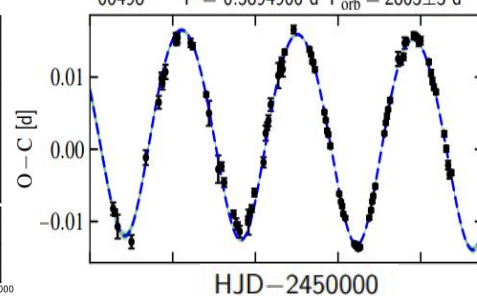
($\sim 10^3$ days)

Irregular



LTTE

06498 $P = 0.5894900$ d $P_{orb} = 2803 \pm 3$ d



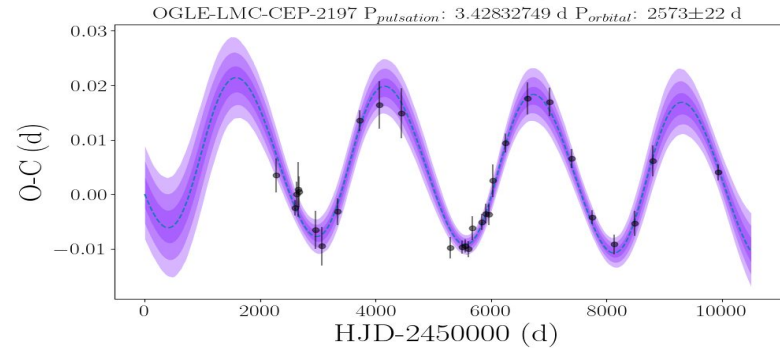
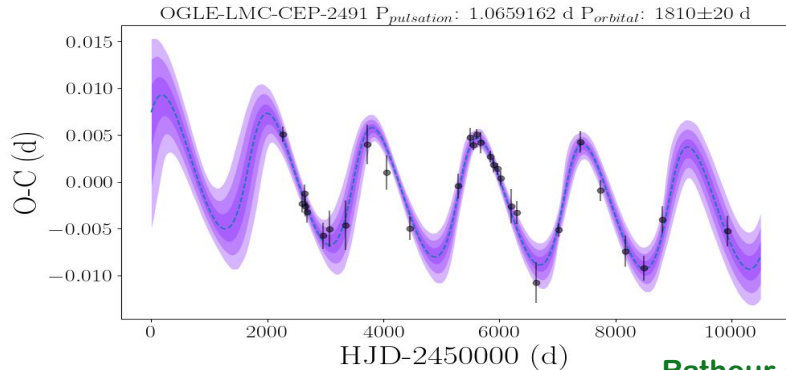
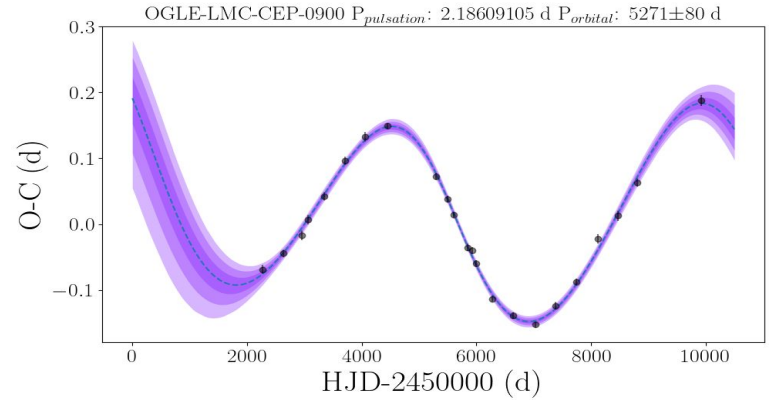
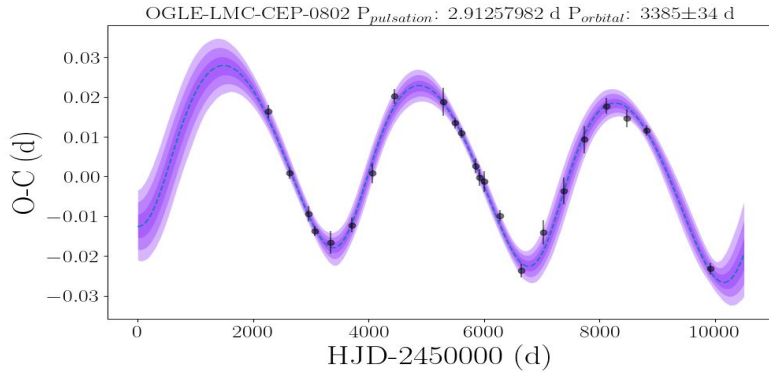
G. Hajdu et al. (2021)

Non-evolutionary effects I: Cepheids in Binary systems

LMC Binary candidates

Fundamental

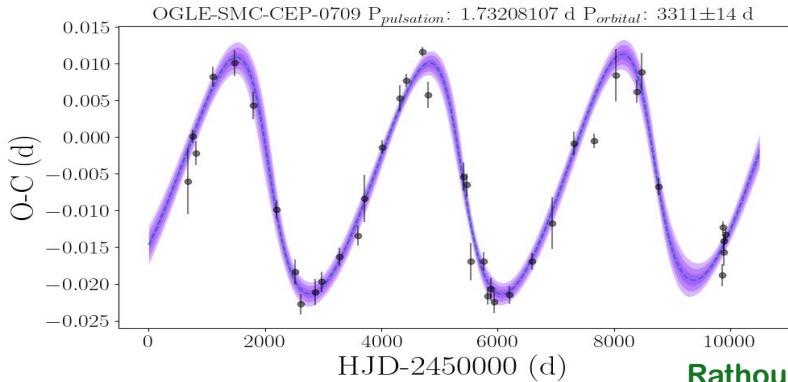
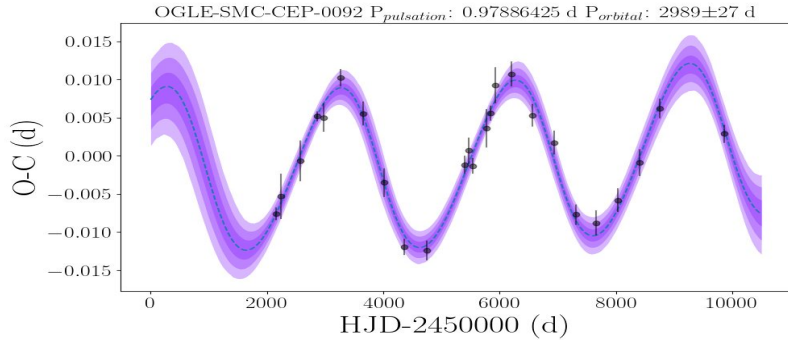
Overtone



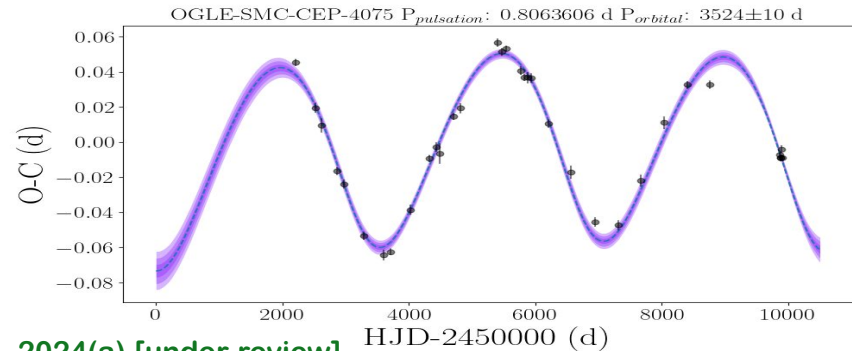
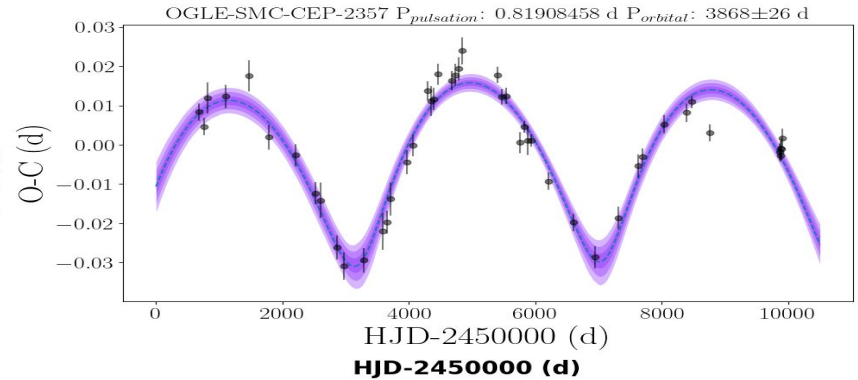
Rathour et al. 2024(a) [under review]

SMC Binary candidates

Fundamental



Overtone



Rathour et al. 2024(a) [under review]

Key Results

- **Final sample with binary parameters: 197 Cepheids**
LMC F: **30**; LMC 1O: **22**; SMC F: **85**; SMC 1O: **60**
Context: ~25 LMC (~5 EBs) (Pilecki et al. 2021; Szabados & Nehez 2012)
~ 9 SMC (~2 EBs) (Szabados & Nehez 2012)
- **Agreement between population synthesis predictions and observations on incidence rate ratio. [within limits of our detected binary sample]**
- **Overbright Cepheids detected in SMC (first time!) and LMC (already reported). Indication of giant-type companions.**
- **In 21 Cepheids, binary analysis pointing to very high mass companions! (Non-evolutionary PC? Triple systems? Black holes?)**

Key Results



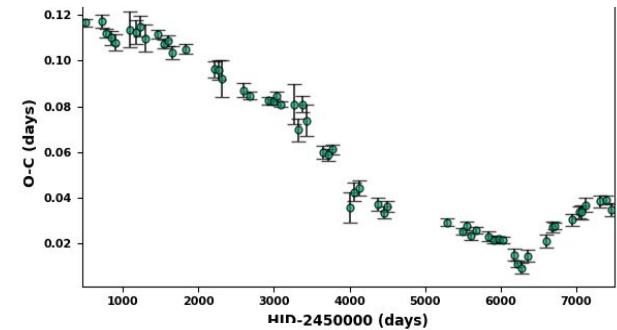
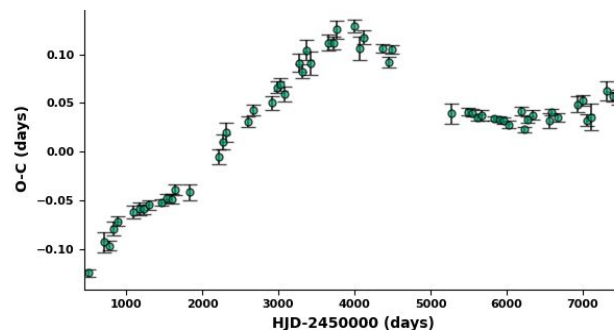
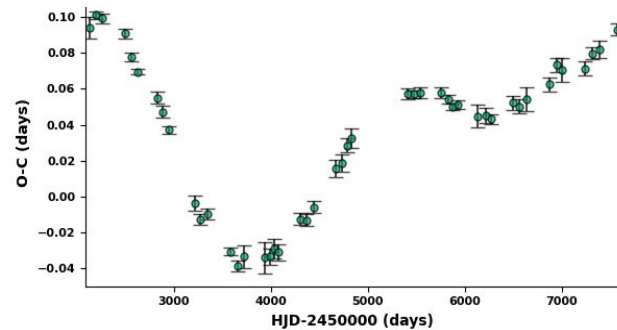
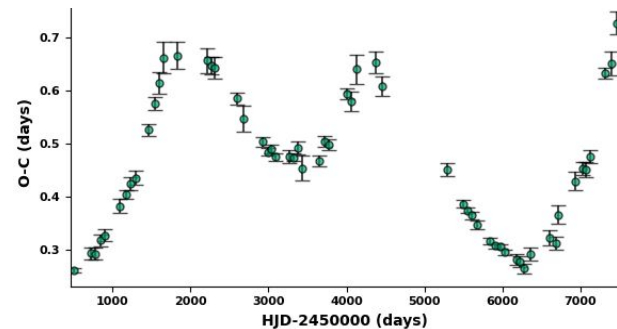
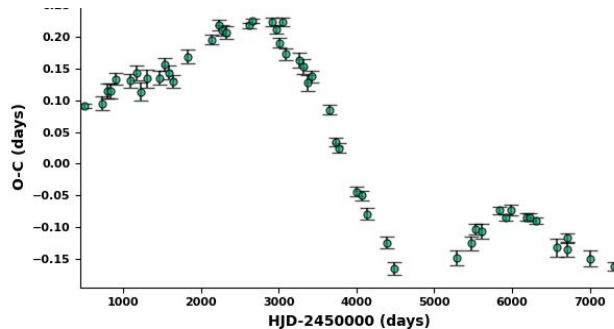
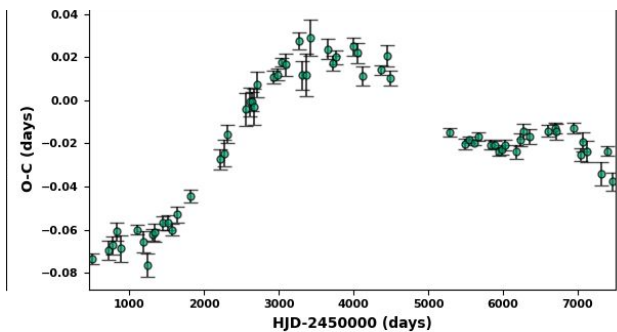
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- Agreement between population synthesis predictions and observations on incidence rate ratio. [within limits of our detected binary sample]
- Overbright Cepheids detected in SMC (first time!) and LMC (already reported). Indication of giant-type companions.
- In 21 Cepheids, binary analysis pointing to very high mass companions! (Non-evolutionary PC? Triple systems? Black holes?)

“Do not be afraid to claim bold ideas. What's the worse? You could be wrong. Best case you will be first to claim it!”

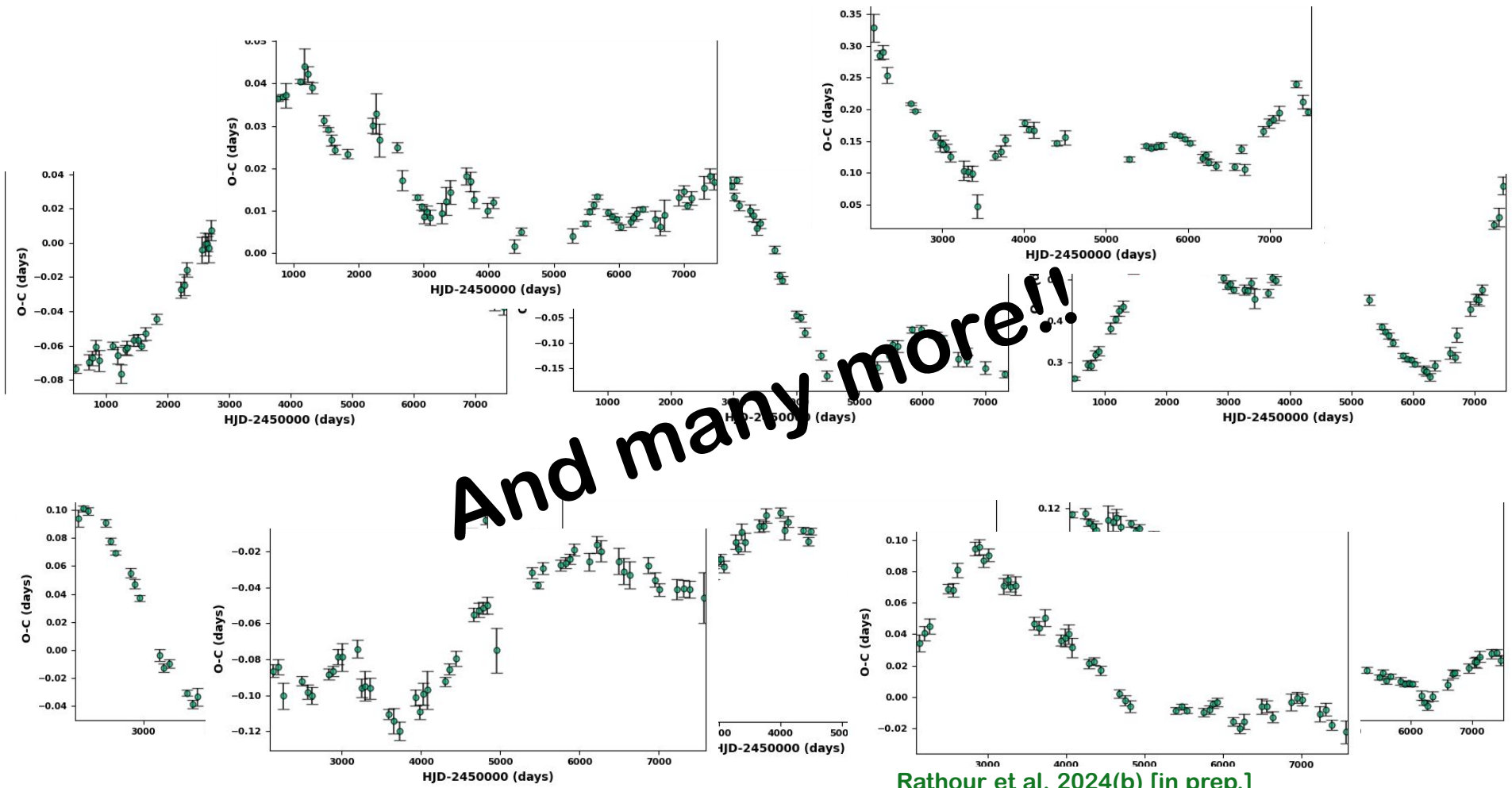
-Prof. Krzysztof Belczyński

Non-evolutionary effects II: Cepheids with Irregular PC

Irregular Period Change Examples



Rathour et al. 2024(b) [in prep.]



Rathour et al. 2024(b) [in prep.]

Initial Key Results

- **Final sample: ~3000 Cepheids; LMC F: 1303; SMC: 1925**
Context: Total sample ~1260 OGLE LMC Cepheids (Poleski 2008)
- **Irregular PC candidates are more in overtone Cepheids (Poleski 2008)**
[F mode pulsation periods more stable!]
- **Low metallicity field (SMC) seems to favour irregular PC (Deasy 1985)**
- **Fluctuations in O-C diagram increase with pulsation period (Csörnyei et al. 2021)**

Scientific Activities

Publications

- **Non-evolutionary effects on Period change in Magellanic Cepheids I: New binary systems revealed from Light Travel Time Effect [A&A, In review]**
[R. S. Rathour](#), G. Hajdu, R. Smolec, P. Karczmarek, V. Hocdé, O. Ziółkowska, I. Soszyński, A. Udalski
- **Non-evolutionary effects on Period change in Magellanic Cepheids II: Quantifying irregular period changes [In prep.]**
[R. S. Rathour](#), G. Hajdu, R. Smolec, O. Ziółkowska, V. Hocdé, I. Soszyński, A. Udalski
- **Pulsation modelling of the Cepheid Y Ophiuchi with RSP/MESA [A&A, Published]**
V. Hocdé, R. Smolec, P. Moskalik, [R. S. Rathour](#), O. Ziółkowska
- **Precise Fourier parameters of Cepheid Radial Velocity Curves [A&A, In review]**
V. Hocdé, P. Moskalik, R. Smolec, N. A. Gorynya, [R. S. Rathour](#), O. Ziółkowska

Proceedings

- Insights from O-C study of 7000+ Magellanic Cepheids from OGLE survey: Census of irregular period changes and binary Cepheids candidates, *Proceedings of Polish Astronomical Society from Annual PAS meeting in Torun (2023)* [**Submitted**]
R. S. Rathour, G. Hajdu, R. Smolec, P. Karczmarek, V. Hócdé, O. Ziółkowska, I. Soszyński, A. Udalski

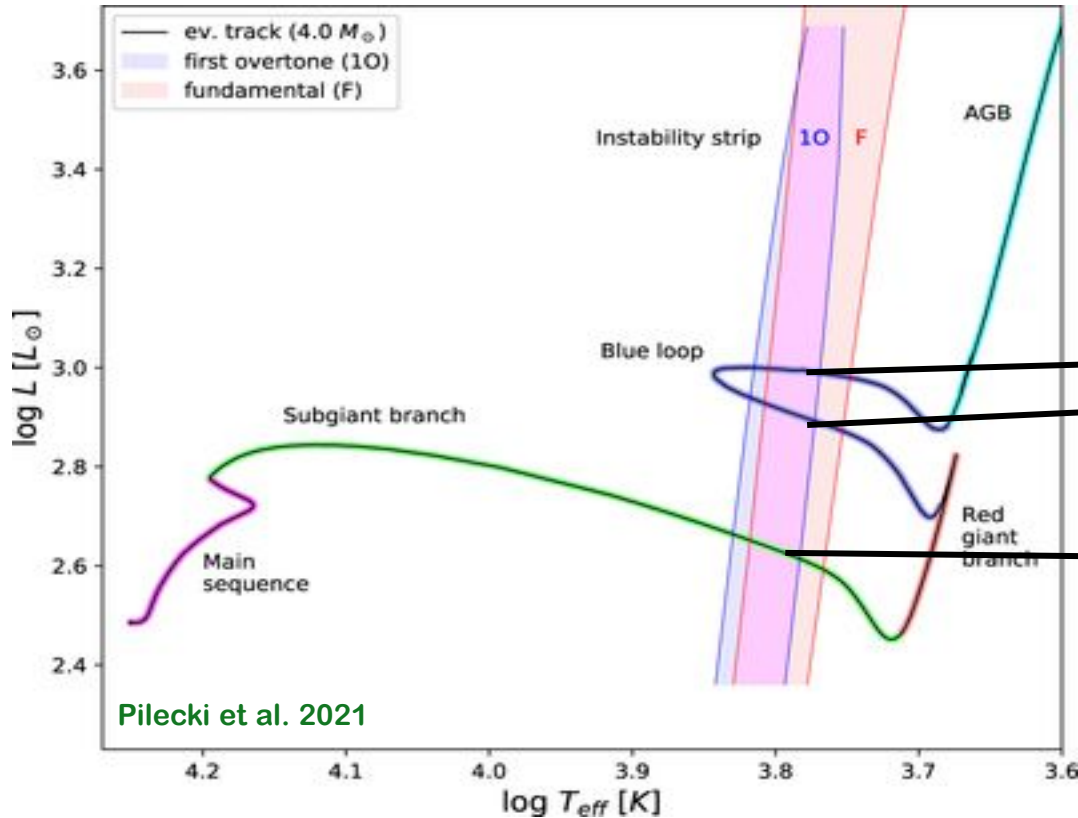
Other Activities

- Contributed Talk: **41st Congress of the Polish Astronomical Society, Toruń**
- Contributed Talk: **5th European Astronomical Society meeting, Kraków**
- Poster: **5th European Astronomical Society meeting, Kraków**
- Supervising summer internship student: **Ms. Zofia Piszczek (University of Warsaw)**

Thank you for your attention!

Dziękuję za uwagę!

Period change (PC) and Crossing Number



$$\text{Period - Mean Density Relation: } \Pi \sim \sqrt{1/\bar{\rho}} \sim R^{3/2} M^{-1/2}$$

Core Helium burning

Hydrogen exhaustion at the core
Shell hydrogen burning