

CAMK Annual Meeting

(Cepheid astrophysics)

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Warszawa, 23.01.2025



2024 summary publications

- **7 referred publications (+ 1 accepted, + 1 submitted)**

1) *Fundamentalization of Periods for First- and Second-overtone Classical Cepheids*
Pilecki, B., 2024, ApJL, 970, L14

2) *Cepheids with giant companions. II. Spectroscopic confirmation of nine new double-lined binary systems composed of two Cepheids*
Pilecki, B., Thompson, I. B.; Espinoza-Arancibia, F., et al., 2024, A&A, 686, 263

3) *Empirical instability strip for classical Cepheids: I. The LMC galaxy*
Espinoza-Arancibia, F.; **Pilecki B.**, et al., 2024, A&A, 682, 185

4) *Toward Early-type Eclipsing Binaries as Extragalactic Milestones. III. Physical Properties of the O-type Eclipsing Binary OGLE LMC-ECL-21568 in a Quadruple System*
Taormina, M.; Kudritzki, R.-P.; **Pilecki, B.**; Pietrzyński, G.; et al., 2024, ApJ, 967, 64

5) Nardetto, N.; et al., 2024, A&A., 684, L9

6) Wielgórski, P.; et al., 2024, A&A., 689, 241

7) Rojas García, G.; et al., 2024, A&A., 692, A110

- **3 conference contributions**

2024 summary

other activities

- **Talks (1 invited + 3 contributed + 1 seminar):**
 - Invited talk at the KOPAL 2024, Litomyśl, Czech Republic
 - Contributed talks at
 - EAS2024, Padova, Italy
 - Araucaria2024, Paris, France
 - RRLYR/CEP2024, Marrakesh, Marrocco
 - Seminar at CAMK Toruń
- **Observing time: 3 succesful proposals (9 nights + 23h) + collaboration:**
 - Spectroscopy: 5n @ MIKE/LCO
13h @ UVES/Paranal
4n @ HARPS/La Silla
 - Speckle: 10h @ ZORRO/Gemini South
- **Grants:**
 - SONATA BIS (ongoing) – “Understanding Cepheids: physical and empirical basis ...”
 - EU MSCA Staff Exchanges (01.01.2025 –) – “Overcoming Challenges in the Evolution and Nature of Massive Stars”

Fundamentalization of Cepheid periods

- **Fundamentalization** – finding a *corresponding* fundamental mode period for stars pulsating in higher-order modes
- **Why?**
 - To increase the sample size
 - To compare results for *F* and *HO*-mode Cepheids
 - To test pulsation hydrodynamical models
- **How?**
 - Study of 989 double-mode Cepheids
 - (different ways of fundamentalization possible)

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Fundamentalization of Periods for First- and Second-overtone Classical Cepheids

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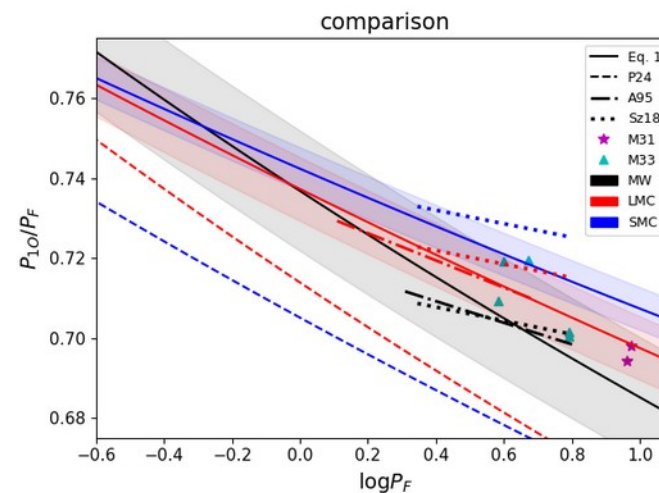
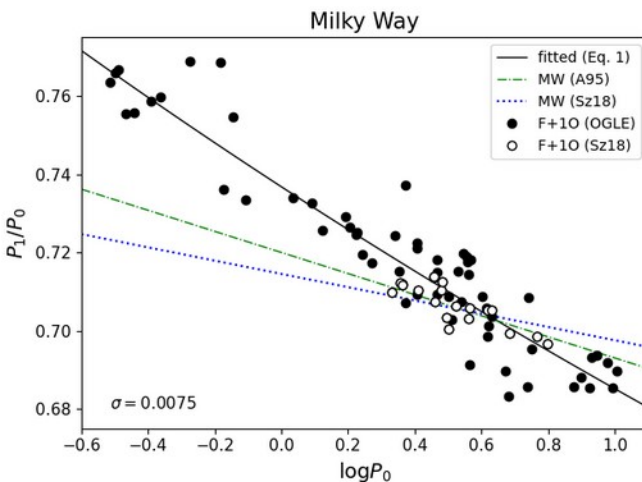
Abstract

Almost half of all classical Cepheids do not pulsate in fundamental mode, and nowadays, the fundamentalization of their higher-mode periods is frequently applied to increase the sample size in astrophysical investigations and allow for comparison with fundamentalized Cepheids. On the other hand, the relations used to obtain fundamentalized periods are either old or based on small samples that cover narrow period ranges. We used available data of 989 Cepheids pulsating in at least two modes to obtain modern, high-quality empirical fundamentalization relations applicable in a wide range of periods of first- and second-overtone Cepheids for metallicities typical for the Milky Way and Magellanic Clouds. A clear correlation between the features of these relations and metallicity is seen, and periods with lower sensitivity to metallicity are identified. We also compare our results with double-mode Cepheids from the M31 and M33 galaxies. For the first galaxy, this indicates Cepheids have metallicities from supersolar to typical for the LMC, while for the latter, from solar to typical for the SMC. A general discussion of the usage of different types of fundamentalization relations, depending on the scientific problem, is included.

Unified Astronomy Thesaurus concepts: Cepheid variable stars (218); Pulsating variable stars (1307); Double-mode Cepheid variable stars (402); Large Magellanic Cloud (903); Small Magellanic Cloud (1468); Milky Way Galaxy (1054); Andromeda Galaxy (39); Triangulum Galaxy (1712)

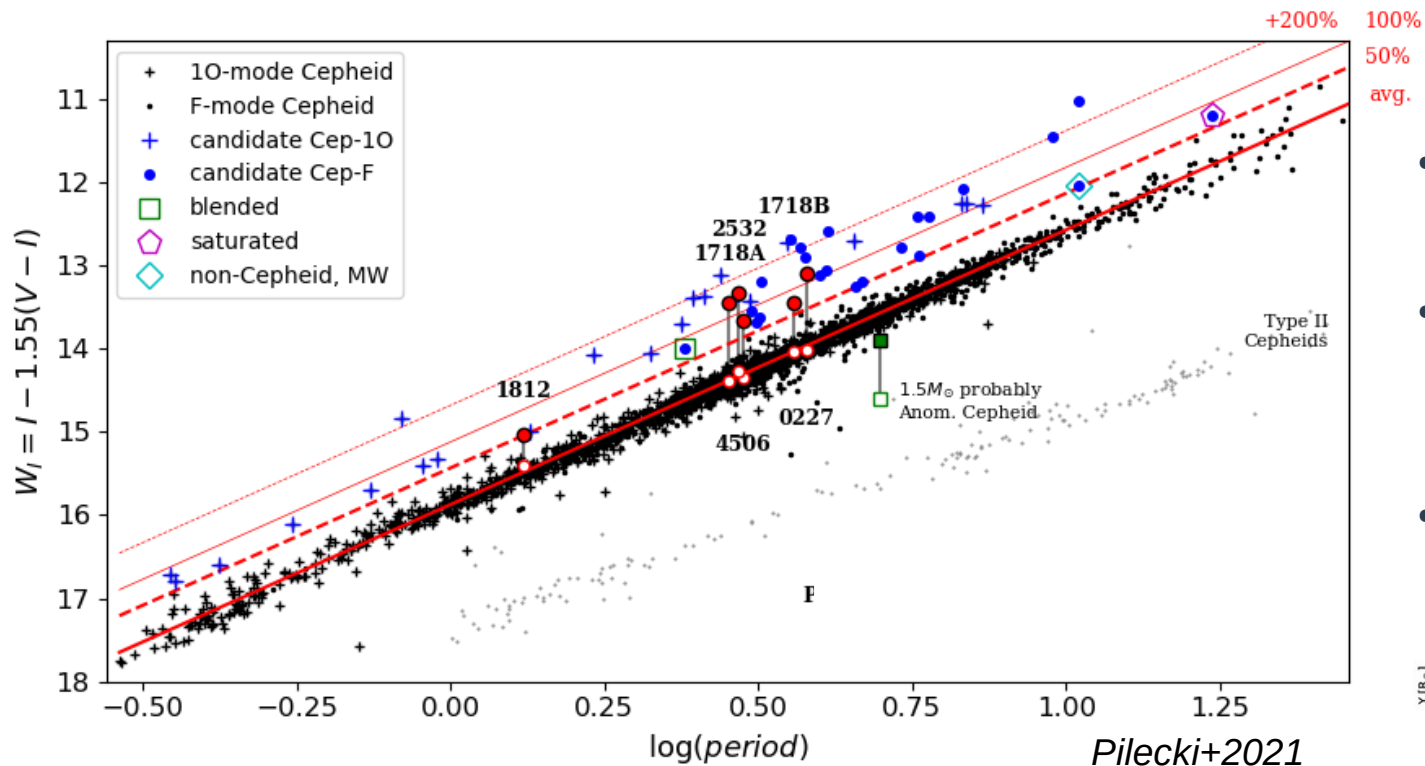
CONCLUSIONS:

- use correct fundamentalization!
- don't use old relations!
- dependence on *Z* non-linear
- metallicity:
M31 – supersolar to LMC
M33 – solar to SMC



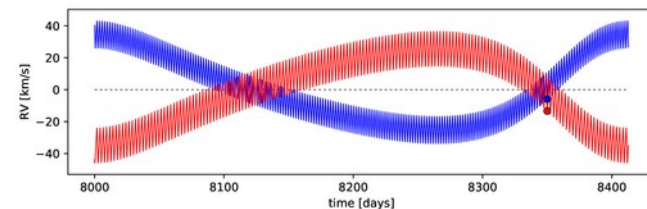
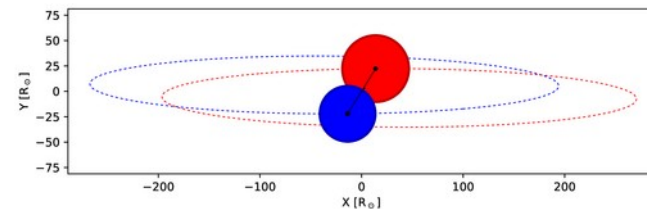
Cepheids with giant companions

new double-lined binary Cepheids



Motivation:

- ~15000 Cepheids known
- masses of only 9 measured (accurate, from SB2: 6)
- low # of SB2 Cepheids

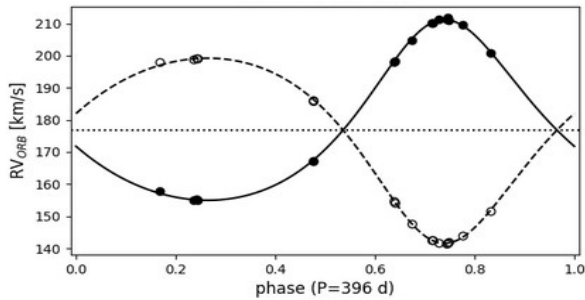


- Cepheids brighter at least 50% than typical – 100+ new binary candidates
- + 9 binary-candidate double Cepheids

Cepheids with giant companions

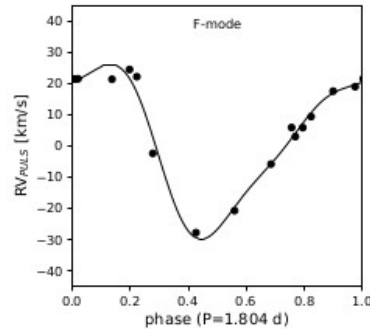
new double-lined binary Cepheids

orbital RVs



+

puls. RVs



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Astronomy
& Astrophysics

Cepheids with giant companions

II. Spectroscopic confirmation of nine new double-lined binary systems composed of two Cepheids***

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CONCLUSIONS:

- 9 new Cepheid+Cepheid binaries
- strong binary interactions ~15%
- ~10% Cepheids of merger origin
- Cepheids can be older than appear
- True Cepheid PLR fainter by:
 $\Delta W(I,V) = 0.024 \pm 0.010$ mag

Number of SB2 Cepheids **before** and **now**:

	LMC	SMC	MW	ALL
BEFORE	5	0	0	5
SB2	43	15	3	61
ORB	25	12	3	40