

## Paulina Karczmarek



### Title

The impact of classical Cepheids' companions on the extragalactic distance scale

### Abstract

Majority of classical Cepheids are binary stars, yet the contribution of companions' light to the total brightness of the system has been assumed negligible and lacked thorough, quantitative evaluation. I present an extensive study of synthetic populations of binary Cepheids, that aims to characterize Cepheids' companions (e.g. masses, evolutionary and spectral types), quantify their contribution to the brightness and color of Cepheid binaries, and assess the relevance of input parameters on the results. Synthetic populations are free from the selection and completeness biases, while the percentage of Cepheid binaries is controlled by the binarity parameter. With this tool I successfully reproduce recent theoretical and empirical results: the percentage of binary Cepheids with main sequence (MS) companions, the contrast-mass ratio relation for binary Cepheids with MS companions, the manifestation of binary Cepheids with evolved, giant companions as outlier data points above the period-luminosity relation. Next, I use the synthetic populations to estimate, for the first time, the percentage of binary Cepheids in the Large Magellanic Cloud, and quantify the effect of binarity on the slope and zero point of multiband period-luminosity relations. Finally, I present a promising method of detecting binary Cepheids on color-color diagrams, provided multi-epoch, high quality, multi-band data. Large volumes of such data are anticipated from Vera C. Rubin Observatory, presenting an exciting opportunity for discovery of binary Cepheids on a large-scale.

# Paulina Karczmarek

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My main scientific interests are pulsating stars in binary systems. In particular, I explore how binarity among standard candles, like Cepheids and RR Lyrae stars, affects distance determinations based on period-luminosity relations. My research is a part of the Araucaria Project, whose main goal is to refine the extragalactic distance scale.

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## Work

2019-present Postdoctoral researcher in Universidad de Concepción, Chile  
The contract within the **European Research Council Synergy Grant** for the project *A sub-percent calibration of the extragalactic distance scale in the era of big surveys (UniverScale)* and the **European Research Council Advanced Grant** for the project *A sub-percent distance scale from binaries and Cepheids*

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## Research & Collaboration

2018-present Study of synthetic populations of binary Cepheids; investigation of the impact of Cepheids' companions on multiband period-luminosity relations

2012-present A member of the **Araucaria Project**, an international project devoted to precise and accurate calibration of the cosmic distance scale based on distance measurements to various galaxies in the Local Group.

Main tasks:

- project coordination: distance determinations to nearby galaxies from the near-infrared photometry of RR Lyrae stars with the precision at level of 5%
- management of near-infrared data

2013-2017 **Principal Investigator of the project *Observations, characteristics and simulations using evolutionary codes of a new class of pulsating stars in binary systems***, funded by the Polish National Science Centre under the grant **PRELUDIUM 4**.

I used the population synthesis method to investigate a new class of binary systems with RR Lyr-like pulsating components.

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## Observational experience (total of ~100 observing nights)

- conducting spectroscopic observations with MIKE/Clay (Las Campanas, Chile), CORALIE/Euler, HARPS/3.6-m (La Silla, Chile)
- conducting photometric observations in the near-infrared domain with FourStar/Baade (Las Campanas, Chile), SOFI/NTT (La Silla, Chile), IRSF Telescope (SAAO, RSA)
- conducting photometric observations in visual domain with SMARTS 0.9-m Telescope and SARA 0.6-m Telescope (Cerro Tololo Observatory, Chile)
- operating 4 telescopes (visual and near-infrared) at Cerro Armazones Observatory, Chile

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## Observing time awarded

- 2020-2021 PI of CNTAC programme 2020A, 2020B, and 2021A, titled *Classical Cepheids in the SDSS photometric system*, time awarded: 13 nights on SMARTS 0.9m, 26 nights on SARA, 140 hours on LCOGT 0.4m
- 2020 PI of ESO programme 106.21H2, titled *Revealing the true nature of an LMC eclipsing binary with a mysterious pulsating star classified as an RR Lyrae variable*, 10h awarded at UVES/VLT (Paranal, Chile)

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## Education

- 2021-present Postgraduate course *Nonviolent communication according to Marshall Rosenberg*, Collegium Civitas, Warsaw, Poland
- 2012-2019 PhD in Astronomy in Astronomical Observatory, University of Warsaw, Poland  
Thesis topic: *The impact of binary evolution on the properties of pulsating stars, on an example of Cepheid and RR Lyrae variables*
- 2010-2012 Master of Science in Astronomy at Nicolaus Copernicus University, Toruń, Poland
- 2006-2010 Bachelor of Science in Astronomy at Nicolaus Copernicus University, Toruń, Poland

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## First author publications (last 5 years)

- Karczmarek et al. 2021, *The Araucaria Project: Deep Near-infrared Photometric Maps of Local and Sculptor Group Galaxies. I. Carina, Fornax, and Sculptor*, 2021, ApJS, 253, 42
- Karczmarek et al. 2020, *The impact of binary Cepheids on the distance determinations*, Proceedings of the Polish Astronomical Society, 10, 40
- Karczmarek et al. 2017, *The occurrence of Binary Evolution Pulsators in the classical instability strip of RR Lyrae and Cepheid variables*, MNRAS, 466, 2842

In total 50 publications (40 refereed), 11 publications as a first author (7 refereed).

For all publications [click here](#)

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## Conferences & workshops attended (last 5 years)

- Sep 13-17, 2021 Biennial Araucaria Conference, Sopot, Poland (invited talk)
- Nov, 11-22, 2019 VIII La Plata International School: Pulsations Along Stellar Evolution, La Plata, Argentina
- Sep, 9-12, 2019 39th Polish Astronomical Society Assembly, Olsztyn, Poland (contributed talk)
- Aug 12-16, 2019 MESA Summer School, UC Santa Barbara, USA
- Mar 6-8, 2019 Biennial Araucaria Conference, Concepción, Chile (invited talk)
- Sep 21-23, 2017 Biennial Araucaria Conference, Kraków, Poland
- Sep 17-21, 2017 The RR Lyrae 2017 Conference. Revival of the Classical Pulsators: From Galactic Structure to Stellar Interior Diagnostics, Niepołomice, Poland (contributed poster)

- Jul 10-13, 2017      Conference of the physics of evolved stars II: the role of binarity, Nice, France (contributed talk)
- Jul 3-7, 2017        ESO Workshop: The IMPACT of BINARIES on STELLAR EVOLUTION, Garching, Germany (contributed talk)
- Nov 28-Dec 2, 2016      22nd Los Alamos Stellar Pulsation Conference Series Meeting: wide-field variability surveys: a 21st-century perspective, San Pedro de Atacama, Chile (contributed poster)

## Teaching, Outreach, Academic & Public Engagement

- chairing Astronomical Seminars at the University of Concepción (*Astro-UdeC Seminars*, 2021)
- writing popular science articles to a Polish astronomical journal *Urania*
- invited popular science talk about cosmic distance measurements (Wszechnica Naukowo-Kulturalna PAU, Gliwice, Poland, 2018)
- webmaster of [araucaria.camk.edu.pl](http://araucaria.camk.edu.pl)
- review for *Research in Astronomy and Astrophysics*
- co-organization of the Biennial Araucaria Workshop, Sopot, Poland, Poland (2021)
- co-organization of the ESO Workshop: A Revolution in Stellar Physics with Gaia and Large Surveys, Warsaw, Poland (2018)
- teaching *Statistics for Astronomers* for 3rd year students at Warsaw University, 45h/yr, (2013-2016)

## Skills

- programming: Python (advanced), C (beginner), Fortran (beginner)
- statistical data analysis and visualization: Python (pandas, numpy, scipy, matplotlib, astropy), Jupyter, TopCat, Aladin
- scientific writing with LaTeX & Overleaf, Google documents, Open Office, presenting with Beamer
- operating systems: MacOS, Linux, Windows
- WordPress

## Languages

- Polish (native)
- English (advanced)
- Spanish (beginner)
- Russian (beginner)

## Interests

- outreach & teaching
- jigsaw puzzles & board games
- bachata dance
- traveling & cultural immersion
- my Suzuki GZ150