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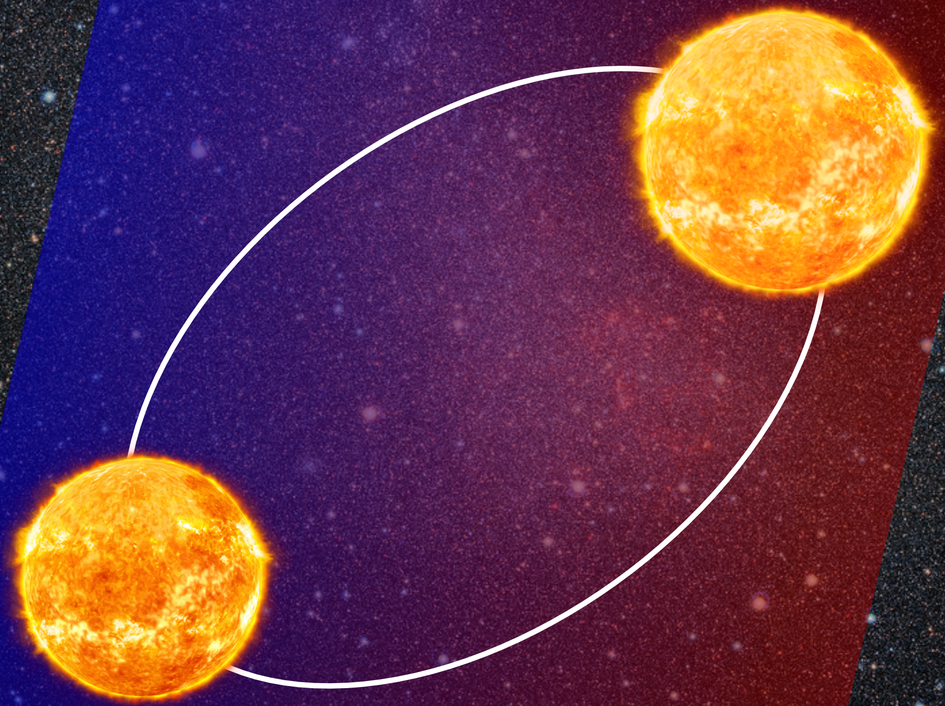
ANNUAL MEETING REPORT



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TWO PUBLICATIONS

A Novel q-PED Method: Precise Physical Properties of a Merger-origin Binary Cepheid OGLE-LMC-CEP-1347 (ApJL, 981, L35) - 4 Citations

Empirical instability strip for classical Cepheids II. The Small Magellanic Cloud galaxy (Accepted in A&A)

The Astrophysical Journal Letters, 981:L35 (6pp), 2025 March 10 https://doi.org/10.3847/2041-8213/adb96b

A Novel *q*-PED Method: Precise Physical Properties of a Merger-origin Binary Cepheid OGLE-LMC-CEP-1347

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Abstract

Recently, a double-lined binary classical Cepheid, OGLE-LMC-CEP-1347, was discovered with the orbital period ($P_{\rm orb} = 59$ days), 5 times shorter than that of any binary Cepheid known before. The expected mass of the Cepheid was below 3.5 $M_\odot$, which, if confirmed, would also probe uncharted territory. The system configuration also pointed to the Cepheid being a merger. We present a novel method for determining precise physical parameters of binary Cepheids using both theory and observations. This *q*-PED method combines the measured mass ratio (q), pulsation (P), and evolutionary (E) models and the known distance (D), supplemented with multiband photometry. Applying it, we determined the mass of the Cepheid to be $3.41 \pm 0.08\,M_\odot$ and its radius to be $13.65 \pm 0.27\,R_\odot$, and the companion's mass to be $1.89 \pm 0.04\,M_\odot$ and radius to be $12.51 \pm 0.62\,R_\odot$. With the current configuration, the apparent evolutionary age difference of almost 1 Gyr between the components strongly favors the Cepheid merger origin scenario. If so, the actual age of the Cepheid would be 1.09 Gyr, on the edge of Population II stars, indicating that a significant fraction of Cepheids may be much older than typically assumed. We also applied our method to an eclipsing binary Cepheid OGLE-LMC-CEP-1812 with accurately determined physical parameters, obtaining a close agreement, which confirmed our method's reliability.

Unified Astronomy Thesaurus concepts: Cepheid variable stars (218); Double-mode Cepheid variable stars (402); Spectroscopic binary stars (1557)

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Empirical instability strip for classical Cepheids II. The Small Magellanic Cloud galaxy

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ABSTRACT

Aims. This study aims to determine empirical intrinsic edges of the classical Cepheids instability strip (IS) in the Small Magellanic Cloud (SMC) galaxy, considering various effects that alter its shape, and compare them with theoretical models and other galaxies.
Methods. We used the data of classical fundamental-mode (F) and first-overtone mode (1O) SMC Cepheids from the OGLE-IV variable star catalog, with the final cleaned sample including 2388 F and 1560 1O Cepheids. The IS borders are determined by tracing the edges of the color distribution along the strip. Based on that, and using evolutionary tracks, the IS crossing times are then calculated.
Results. We obtained the blue and red edges of the IS in V- and I-photometric bands and in the HR diagram, and detected breaks at periods between 1.4 and 3 days. Interestingly, the central SMC Cepheids are redder than those located farther away. A comparison with existing theoretical models showed good agreement for the blue edge and significant differences for the red edge. We also found that the IS of the SMC is wider than that of the Large Magellanic Cloud (LMC), with its red edge being redder despite its lower metallicity. The analysis of crossing times showed that the expected number of Cepheids as a function of period agrees with the observed distribution for $P > 1$ days but differs for $P < 1$ days.
Conclusions. Slope changes along the SMC IS borders are most likely explained by the distribution of metallicity. The behavior of the blue loops at the SMC metallicity is not consistent with observations, and at the LMC metallicity, the blue loops are too short for lower-mass stars. A comparison of theoretical edges with our empirical ISs imposes constraints on the models and enables the identification of valid ones. Based on the positions of the breaks, our study also suggests that fundamental-mode Cepheids with periods longer than 3 days should be used for distance determination.

Key words. Stars: variables: Cepheids – Stars: oscillations – Stars: evolution – Stars: abundances – Magellanic Clouds

A NOVEL Q-PED METHOD

(ApJL, 981, L35)

- OGLE-LMC-CEP-1347: Double-lined binary (SB2) system (Pilecki+2021). **The orbital period (59 d) is the shortest known to date for a binary Cepheid.**
- We determined precise parameters for both components using a modeling method that uses the mass ratio (q), pulsation + evolutionary models, and the distance to the object (q-PED method).
- Our results agreed with a merger-origin scenario for the Cepheid.

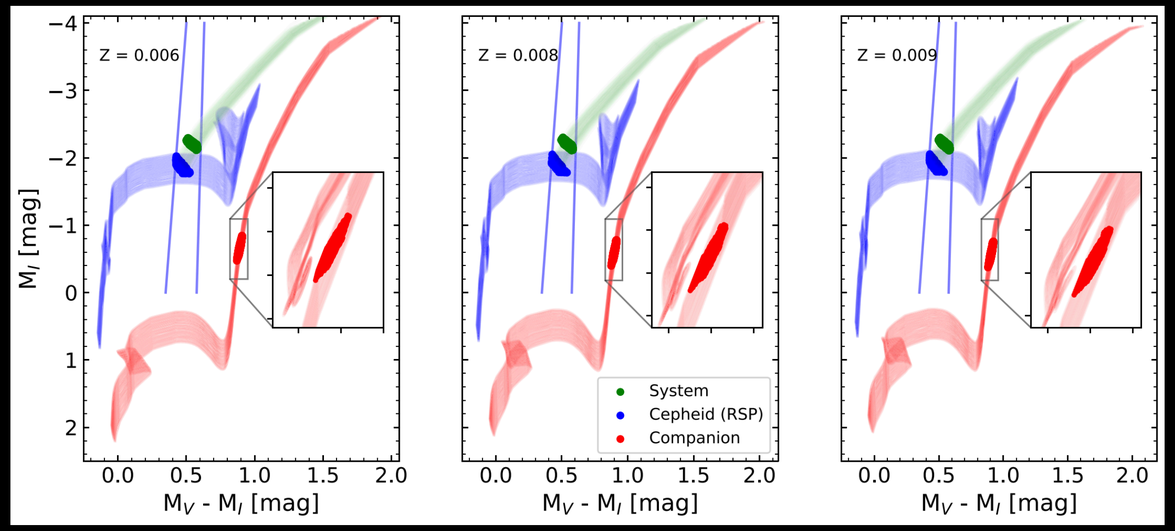
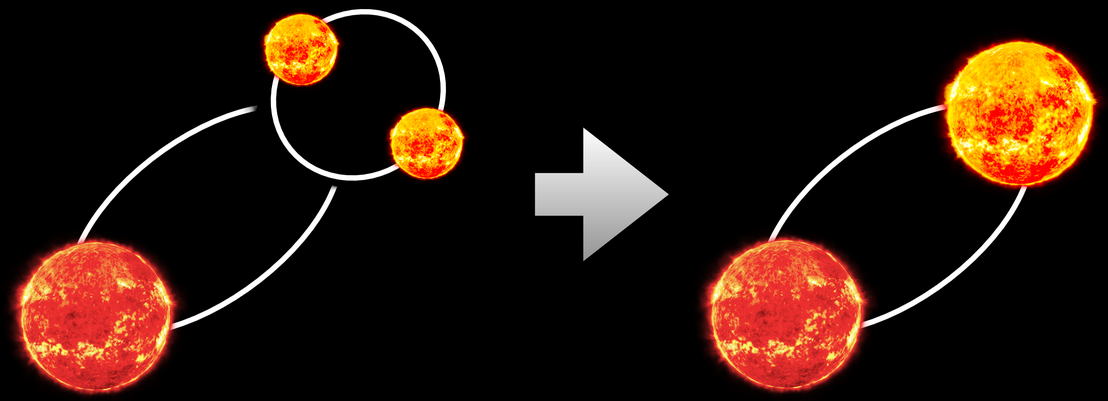


Table 1
Physical Parameters of CEP-1347

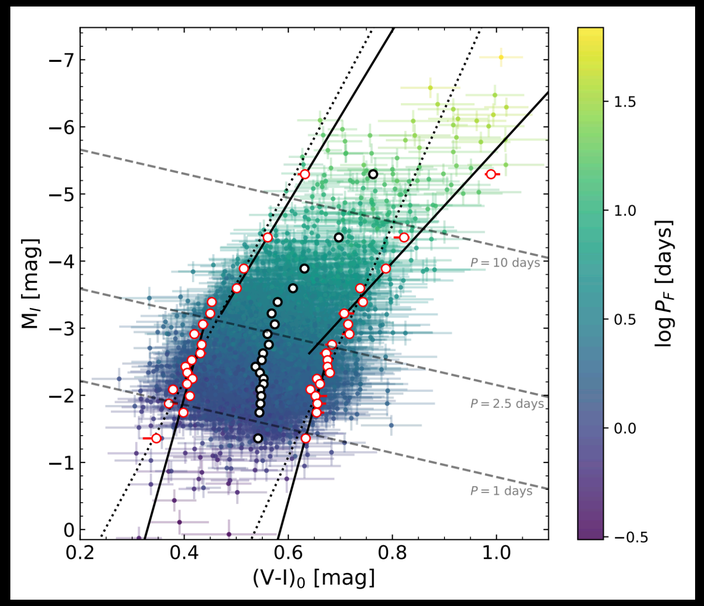
Parameter	Cepheid (5%)	Cepheid (20%)	Companion (5%)	Companion (20%)	Unit
Mass	3.41 ± 0.08	3.43 ± 0.13	1.89 ± 0.04	1.92 ± 0.07	$M_\odot$
Radius	13.65 ± 0.27	13.97 ± 0.89	12.51 ± 0.62	11.68 ± 1.67	$R_\odot$
log g	2.705 ± 0.013	2.689 ± 0.044	2.520 ± 0.047	2.594 ± 0.138	cgs
Temperature	6490 ± 96	6452 ± 122	4910 ± 63	4967 ± 120	K
log L	2.47 ± 0.03	2.48 ± 0.05	1.91 ± 0.03	1.86 ± 0.09	$L_\odot$
Age	0.23 ± 0.01	0.23 ± 0.02	1.09 ± 0.07	1.07 ± 0.1	Gyr
E_{B-V}	0.08 ± 0.02				mag
Distance[a]	49.8 ± 0.5				kpc

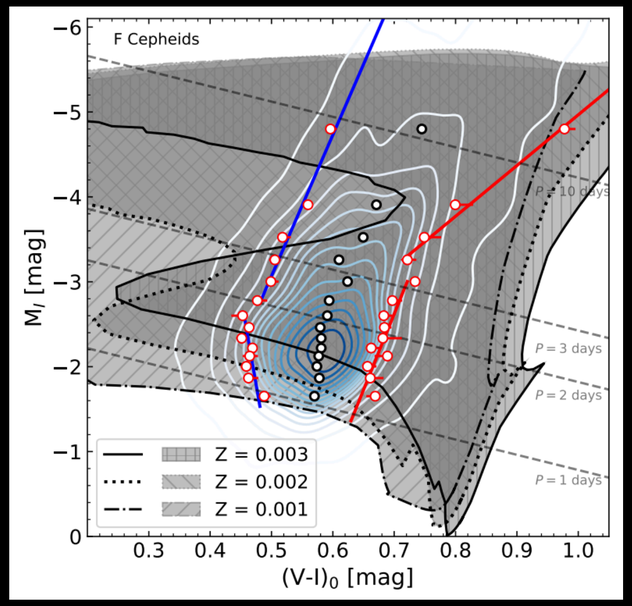


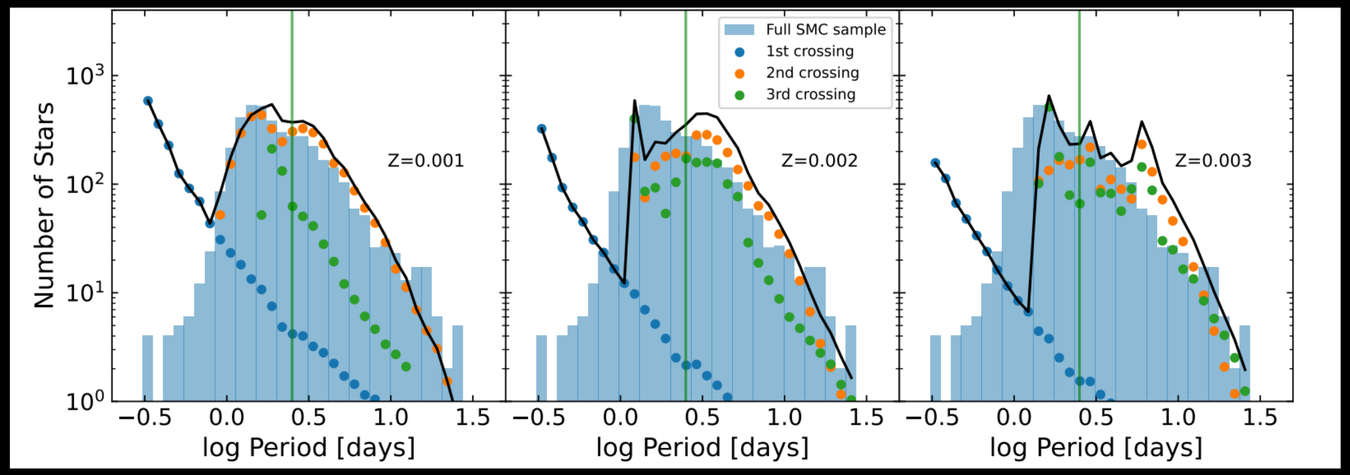
EMPIRICAL INSTABILITY STRIP IN THE SMC

(arXiv:2512.16997)

- We determined empirical edges for the classical instability strip. We noted significant slope changes in the red edge.
- We compared them with theoretical models, noting significant differences for some metallicities.
- Our results imposes constraints on the models and enable the identification of valid ones.

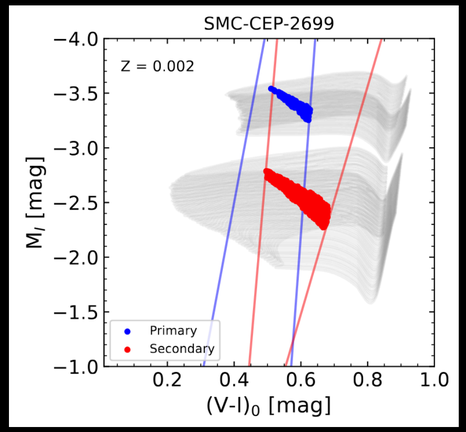


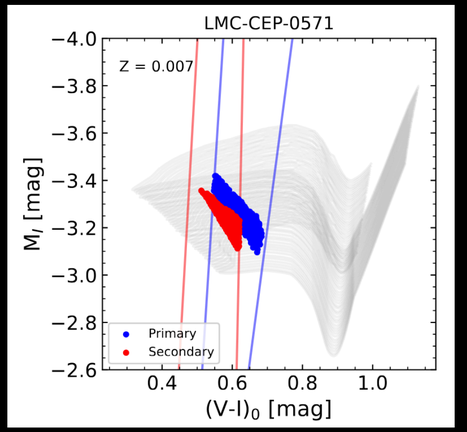


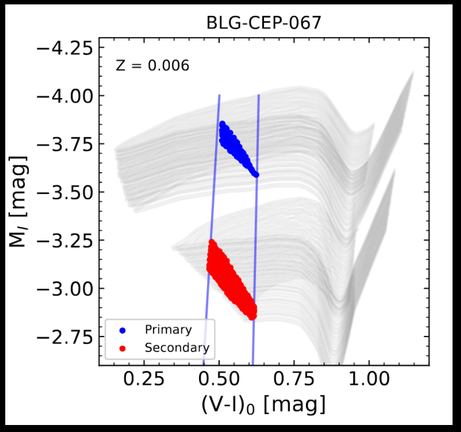


Q-PED ON DOUBLE BINARY CEPHEIDS

In progress

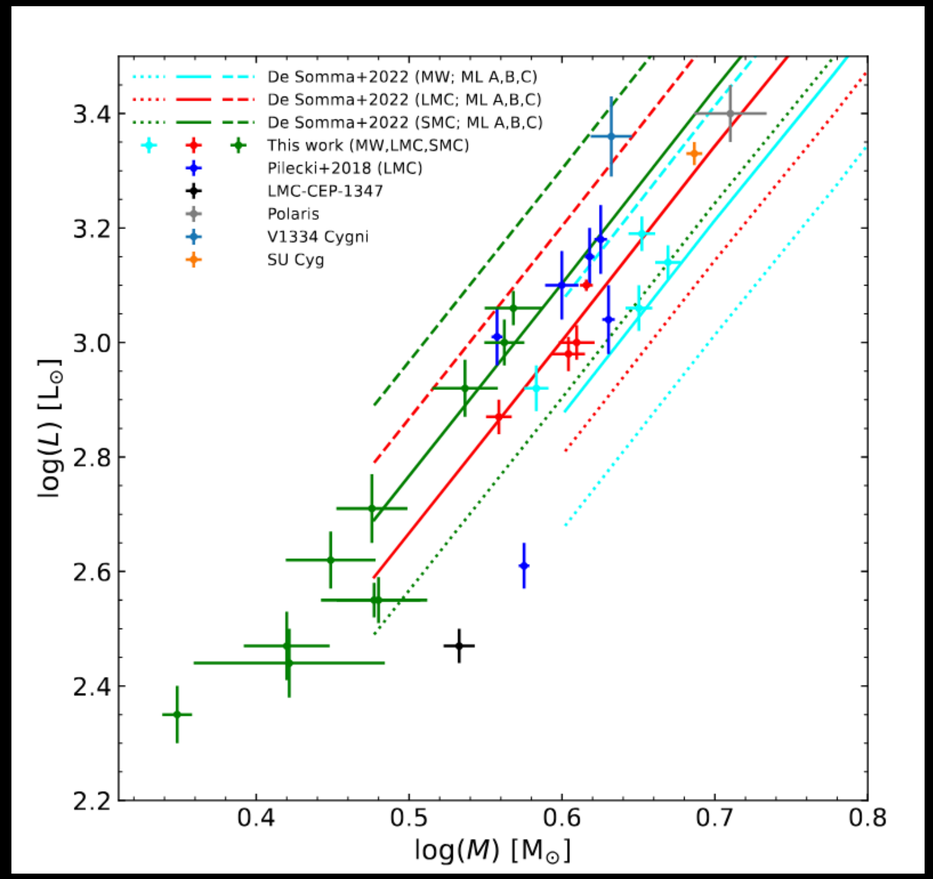






- We applied the q-PED method to 9 newly identified double binary Cepheids

- The 18 new Cepheid masses will greatly improve our understanding of the mass-luminosity relation.




Thanks!