Classical and Type II Cepheids in the Galactic Bulge

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Scientific justification

Cepheid stars are crucial objects for a variety of topics that range from stellar pulsation and the evolution of giant stars to the understanding the structure of the Galaxy and the Universe through the distance measurements they provide. Only a handful of them have been observed by photometric missions so far, but they already revealed new insights. Kepler showed that classical Cepheids may exhibit both period jitter and low-amplitude modulation (Derekas et al. 2012, Kanev et al. 2015). Early data from the K2 mission suggests that cycle-to-cycle variations and/or additional modes are also present in Type II Cepheids (Plachy et al., in prep.).

We expect that the exquisite K2 light curves are going to shed light on several important questions about the various Cepheid subtypes. These include:

- Low-amplitude additional modes. The discovery of additional modes in RR Lyrae stars have stirred up the field of stellar pulsations: with the K2 data we expect the same for Cepheids.

- Mode interaction, period doubling, modulation and beat pulsation. The OGLE survey revealed that period doubling can occur in the BL Her subtype, but hydrodynamic models suggest that temporal variations and modulation can also occur in them (Smolec & Moskalik 2012, Smolec 2015). K2 observations may open up the possibility to non-linear asteroseismic studies of Type II Cepheids through the direct comparison of models and observations.

- The properties of period jitter, its dependence on pulsation modes and/or periods. The jitter is possibly connected to convective motions that are related to the physical characteristics of the star.

- Study long-period variables, W Vir and RV Tau stars. Various irregularities and even low-dimensional chaos can be expected in their light curves.

- Detailed properties of the stars on the other side of the Milky Way, in the flared outer disk (Feast et al. 2014).
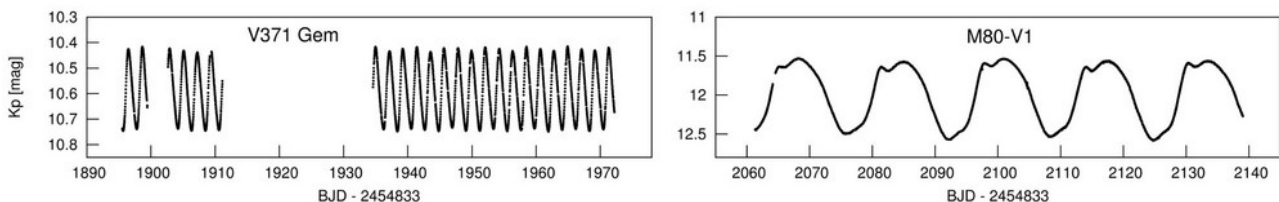
K2 light curves of a classical Cepheid and a W Vir (Type II Cep) star.

Targets and technical feasibility

Targets were selected based on their ASAS and OGLE light curves, including the most recent, unpublished OGLE-IV data. We selected 35 high-priority targets

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that are critical for the success of this study. These are the brightest stars and/or stars with the highest expected scientific return. We also listed an additional 149 stars in the proposal whose observations are needed for a thorough analysis and to fully meet all goals we set out.

The proposal includes a number of relatively faint targets whose photometry will undoubtedly be a challenge. Nevertheless, we expect that with proper methods, such as differential image photometry, we will be able to extract useful data for these large-amplitude pulsators. A successful application of that method was presented by Molnár et al. (2015) for very faint, blended RR Lyrae stars within the galaxy Leo IV.

We note that the two brightest Cepheids that fall on silicon, Y Sgr and 12 Sgr (Kp=5.60 and 6.96 mag) are omitted from this proposal. Instead of investing a large number of pixels, we plan to extract smear photometry for them (Pope et al. 2015).

Relevance and legacy

Most Cepheids reside within the disk and bulge of the Milky Way, therefore Campaign 9 is the best opportunity the mission can offer for us to observe these stars. The bulge population may provide the bulk of the K2 Cepheid light curves, and can greatly increase the science potential of our regular GO proposals. One proposal, in particular, focuses on the Cepheids in the dwarf galaxy IC1613. With a larger sample size, the planned comparison between the populations of the Milky Way and IC1613 will also be much more robust.

We envisage a lasting legacy, as well as strong synergies with other projects. The Gaia mission will provide accurate distances and in some cases, radial velocities for these stars. Together with the exceptional K2 light curves, both evolutionary and pulsation models can be more precisely constrained. These developments then can lead to a refinement of the period-luminosity relation as well.

The bulge has been extensively studied by the ASAS and OGLE surveys, extending the 3-month K2 light curves with multi-year photometric observations. Conversely, the K2 observations provide high-precision snapshots for the ground-based surveys. These measurement may represent the most extensive data sets we have from Galactic Cepheid stars so far. The processed light curves will be released to the public, to serve as benchmarks for stellar pulsation models as well as textbook examples for Cepheid variability.

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