Short cadence RR Lyrae targets - K2/C0 proposal

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Introduction. RR Lyrae stars are horizontal branch, large-amplitude pulsators that are used as cosmic distance indicators and tracers of galactic history and dynamics. Ultra-precise, continuous photometric observations with *Kepler*, both in long (30-min) and in short (1-min) cadence, have revolutionized our understanding of these objects. New dynamical phenomena, like period doubling [10] and chaos [8], and new pulsational modes and behaviors [4,5,6,7,9] have been discovered, while we got a fairly complete and new picture on the mysterious light curve modulation, the *Blazhko effect* [1,2,3]. With this proposal we capitalize on *Kepler*'s findings and plan to extend our investigations by looking at a few selected RR Lyrae stars in 1-minute cadence.

During the nominal *Kepler* mission, the KASC RR Lyrae working group made sure to obtain at least one quarter (3 months) of short-cadence data for each known RR Lyrae star in the *Kepler* field, i.e., for more than 40 stars by the end of the *Kepler* mission. In addition, RR Lyr, the prototype of the class, was observed in 1-minute cadence from Q5 onwards. Several discoveries were based on the latter data set, including the presence of the first overtone radial mode in RR Lyr [4], as well as the variations of the pulsation and modulation period in the star [9] and more complex behavior than period doubling [4].

Aims. The advantages of short-cadence observations over long cadence lie primarily in the fact that 1-min cadence samples the light variation over the pulsation cycle of typically 8-14 hours in much more detail (0.1-0.2% time resolution). This time resolution is essential to study specific phases in the pulsation cycle, such as the rising branch of the light curve, during which an RRab star increases in brightness by often more than a magnitude in V over a time span of less than two hours, and the phases associated with shock waves in the star. From our previous findings based on *Kepler* data we could conclude that these phases can vary significantly from cycle to cycle for stars that show period doubling (which we assume to be a symptom of the Blazhko effect). In addition, period doubling, manifesting in alternatingly higher and lower maxima, can sometimes be missed with long-cadence observations. Detailed time-resolved studies of the light variations of an RR Lyrae star will allow us to: **(a)** provide new insights into the intricate dynamics of these pulsators thanks to the high time resolution in the phases where the light intensity rapidly changes, which include the shock phases and period doubling; **(b)** get a detailed picture of additional frequencies, e.g., those with 0.60-0.64 period ratio in RRc stars [5,6] and the supposedly higher-overtones and/or nonradial modes; **(c)** unveil transient events in modulated and non-modulated stars that would be missed by long-cadence observations.
Follow-up observations are planned after the C0 run with small and medium-sized telescopes to put the detected variations (period, Blazhko cycle, etc.) into context.

Targets. We propose 5-10 RR Lyrae targets for short-cadence observations. Our list is ordered by ranking (favorite stars higher up). They are a subset of the list proposed for long-cadence observations, containing stars within a 12 degree radius circle around the published C0 field center. The selected targets show a variety of pulsational properties: RRab–BL, RRc and stable RRab. We give priority to targets that can more easily be observed, for both photometric and spectroscopic follow-up, from the ground.

References

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