Asteroseismology of Red Horizontal Branch Variables in M4 - K2/C2 proposal

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Introduction Stars along the horizontal branch (HB) display a variety of pulsations. Solar-like oscillations are seen in red clump stars, located on the red end of the HB near the red giant branch (RGB). Where the HB crosses the instability strip, RR Lyrae stars display classical radial pulsations. On the blue end of the HB, subdwarf B stars can exhibit p and *g*-mode oscillations driven by an iron opacity bump. However, HB stars located between the instability strip and the red clump, which we will refer to as red horizontal branch (RHB) stars, are currently not known to oscillate.

RHB stars have a thick, convective envelope and thus it is likely that they will exhibit stochastically excited solar-like oscillations. While RR Lyrae variations are large enough to be easily detected from the ground, photometric variability of red clump stars was not detected until the launch of space missions, especially CoRoT and Kepler (de Ridder et al. 2009, Nature, 459, 398; Huber et al. 2010, ApJ, 723, 1607). It is possible that RHB stars, like red clump stars, vary with amplitudes too low to be detected by ground-based observations. RHB stars are difficult to find in field populations because it is difficult to separate them from main sequence stars of the same temperature due to the lack of distance information; the presence of globular clusters in the K2 field of view makes it much easier to find RHB stars than was the case in the original Kepler field.

There have been some detections of potential RHB variables in globular clusters (Yao 1987, ESO Messenger, 50, 33; Yao et al. 1993, Inf. Bull. Variable Stars, No. 3962), however, there is no record of any follow-up in the literature.

Aims The globular cluster M4 falls partially in the campaign 2 field of view and features a well-populated horizontal branch that stretches from the RGB across the instability strip and includes a number of RHB stars. M4 thus presents the perfect opportunity to observe RHB stars in order to determine whether they are actually oscillating and how their oscillations differ from what is seen in red clump stars. By also observing the RR Lyrae stars in M4, we hope to gain a better understanding of the transition between solar-type oscillations and classical radial pulsations that occurs at the red edge of the instability strip.

One of the major unanswered questions of stellar evolution is how much mass stars lose while on the red giant branch (RGB) and what is the resulting distribution of masses on the HB. If RHB stars are found to oscillate, we will be able to use asteroseismic methods that have been beautifully demonstrated on Kepler observations of other classes of stars to determine masses and radii of a class of low-metallicity stars for which this had not been previously possible. We will be able to compare these masses to those of other stars on the HB as well as to stars that are still on the RGB; we will collaborate with other groups who are proposing targets on the RGB and in the red clump.

Targets We propose 12 RHB and 16 RR Lyrae targets for observation; we also propose 4 stars that are located within the instability strip but which have not been previously classified as RR Lyrae stars. Our list is ranked, giving RHB stars highest priority. Using the established asteroseismic scaling relationships, we estimate that the RHB stars should oscillate with a frequency of maximum power of 50-80 microhertz meaning that long cadence observations will be sufficient. Kepler observations will be supplemented with ground-based spectroscopic observations of the RHB and RR Lyrae stars and BVI photometric observations of the RR Lyrae.

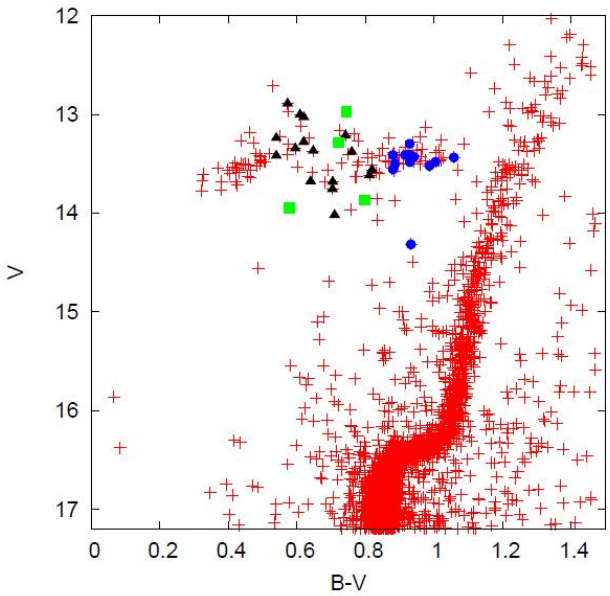

Figure 1. Color-magnitude diagram for the globular cluster M4. The well-populated HB is very apparent. Proposed RHB targets are indicated by blue circles and RR Lyrae targets are shown as black triangles. Green squares mark the target stars that are located in the instability strip but which are not known to pulsate. Photometry courtesy Javier Alonso-García (private communication).