Exploiting the globular cluster M4 with K2

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Star clusters have long been used to obtain insights into stellar evolution as well as properties of the clusters themselves, including their ages. The unprecedented precision and time coverage of the *Kepler* mission made it possible for the first time to combine constraints from colour-magnitude diagrams, detached eclipsing binaries (Sandquist et al. 2013, Brogaard et al. 2014 in press) and asteroseismology of single giant stars in open clusters (Stello et al. 2011, Corsaro et al. 2012). Such synergies enhance the amount of knowledge that can be extracted from the observations (Brogaard et al. 2012, Miglio et al. 2012, Sandquist et al. 2013, Brogaard et al. 2014 in press).

The older globular clusters are also still the subject of many investigations, both because of their importance in relation to the build-up of the Galaxy, and because of the multiple populations phenomena, the 2. parameter problem and related issues, such a mass loss of stars on the red giant branch (RGB), which are still far from understood. In that respect, the relatively nearby globular cluster M4 holds great potential for improved knowledge through a *HST* large program that some of us are involved in (Bedin et al. 2013) and which has allowed us to identify a number of suitable eclipsing and other variable stars (Nascimbeni et al. 2014, arxiv:1405.1626). Time-series photometry from K2 will however very significantly boost the possibilities of these detailed studies by allowing also asteroseismology of giant stars and by providing full phase coverage and period determination for known eclipsing binaries while discovering longer period systems that would likely never be found from the ground. It is likely that several decades will pass before *any* other instrument will be able to achieve such observations in a globular cluster and therefore this is a truly unique possibility.

Among the important results already obtained from the open clusters in the *Kepler* field are tests of the asteroseismic scaling relations for mass and radius (Sandquist et al. 2013, Brogaard et al. 2014 in press) and the estimate of mass loss on the RGB in the old metal-rich open cluster NGC6791 (Miglio et al. 2012) which turned out to be smaller than expected. However, both these results can be put on a much firmer footing by observing stars in M4 with K2. That way, we will be able to estimate the size of the RGB mass-loss directly in a globular cluster and learn how the mass-loss changes as function of age and metallicity by comparing to the results in NGC6791. We will also be able to investigate the masses of AGB stars, and potential mass differences between different populations of stars, as given by their chemistry. A significant fraction of our targets already have spectroscopic abundances measured. In relation to tests of the asteroseismic scaling relations, the metal-poor giants in M4 will allow us to test whether there is significant metallicity dependence in the asteroseismic scaling relations.

The detached eclipsing binary members of M4 will aid significantly in constraining the parameters of the cluster once their masses and radii have been measured, including the age and mass of the RGB stars. They will also allow measurements of not only the mean helium abundance of the cluster (as in Brogaard et al. 2012), but also star-to-star variations through differences (or lack thereof) in the mass-radius relation between the systems.

As the helium burning stars in M4 are of lower mass and metallicity than those in the open clusters they occupy the red horizontal branch (RHB) and not a red clump and are thus hotter than any helium burning star for which solar-like oscillations have so far been observed. We wish to observe stars along the horizontal branch (HB) from the coolest RHB stars and all the way through the RR Lyrae instability strip to the blue horizontal branch in order to investigate what happens at the transition between these two variability types.

Variability of blue straggler stars (BSS) in M4 at the precise level of K2 will provide improved insights into, as well as the multiplicity of, these special objects.

To achieve these goals we propose to observe a total of 823 targets in long cadence from our *HST* program and related investigations : 12 known eclipsing binary systems, 104 HB stars of which several are RR Lyrae, 362 RGB stars and AGB stars, 44 BSS, and 64 spectroscopic binary members plus 240 stars near the photometric binary main sequence in the search for more long period eclipsing systems to be exploited for mass and radius measurements. Since K2 is the only mission within a foreseeable future that will allow very detailed studies of variable stars in a globular cluster, we expect that there will be additional proposals asking for targets in M4. Therefore, we wish to suggest the possibility of maybe observing 'superstamps' in the region of M4 as it was done for the old open clusters in the *Kepler* mission.