K2 Proposal on behalf of KASC WG3

Asteroseismology of Beta Cephei stars

Prepared by Luis Balona, Gerald Handler and Peter De Cat

Even nowadays, the interior structure of main sequence stars and their temporal evolution is still not satisfactorily understood. With respect to massive stars (hereinafter defined as a star massive enough to undergo core collapse: $M \gtrsim 9\,\mathrm{M}_\odot$), essential uncertainties comprise:

- Rotation and angular momentum evolution. Rotation is believed to influence the evolution of massive stars as strongly as mass and metallicity (e.g., see Maeder 2009). Rotation leads to a reduction of the stellar luminosity and to an increase of its central density and a reduced central temperature, i.e. they have a reduced effective mass. Angular momentum transport from the core to the envelope in massive stars is needed to avoid that their iron cores in later evolutionary stages reach critical rotation.

- Internal mixing and main sequence lifetime. Rotation also induces internal mixing which causes surface abundance changes during stellar evolution (e.g., Maeder 1987). Mixing of material into the hydrogen-burning stellar core (”convective overshooting”) considerably affects the main sequence lifetimes of massive stars (e.g., Mowlavi & Forestini 1994). Different methods to determine the amount of convective core overshooting are still rather inaccurate and results contradictory (e.g., Briquet et al. 2012).

- Opacities. With the ”new” solar abundances (Asplund et al. 2004) an increase in the heavy-element opacities in the Sun is required (e.g., Villante 2011) to match helioseismic data. The same conclusion holds for pulsational mode excitation in massive stars (e.g., Lenz 2012). Using the new method of ”complex asteroseismology”, Walczak & Daszyńska-Daszkiewicz (2010) showed that it is even not clear which of the presently available opacity tables are preferable.

These essential questions can be addressed, and likely solved, using asteroseismology. The prerequisite for such studies are suitable observations of the pulsations must be obtained. These must be precise, and have a sufficient time span (at least one stellar rotation period) to assure the detection of a suitable number of pulsation modes.

For massive pulsating stars, such as the β Cephei stars (variability periods between $2-7$ hr, masses between $9-17$ $\mathrm{M}_\odot$, Stankov & Handler 2005), this strategy has been demonstrably applicable. For example, using photometric and spectroscopic results, Pamyatnykh, Handler & Dziembowski (2004) constrained the convective core size (=overshooting) and heavy element abundance of the star ν Eri, and found an increase of the rotation rate towards the core. However, to arrive at a consistent picture for all massive stars, more objects, over a large range of parameter space, must be seismically sounded.

In the nominal Kepler mission, the β Cep stars were poorly represented because of the rather high Galactic latitude of the observed field. As a result, none these stars could be seismically studied. Field 0 has better prospects because it is closer to the Galactic plane. We can identify 5 candidate β Cep stars within a 12^o radius of the centre of the field. These are listed in Table 1 (file wg3_bcep_f00_t1.coomag) and are our highest priority.

It is very likely that many undiscovered β Cep and SPB stars are present in Field 0, so in Table 2 (file wg3_bcep_f00_t2.coomag) we give a selection of B stars which likely lie in the β Cep instability strip. All these stars can be observed in long-cadence mode, albeit it would be useful to have short-cadence data for some of the targets in Table 1.