TARGETING STARS IN THE MASSIVE YOUNG OPEN CLUSTER M35

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When its characteristics are enumerated, the open star cluster M35 presents a compelling target for in-depth study in the proposed K2 Field 0. M35 is a very rich (~2400 $M_\odot$; Leonard & Merritt 1989) but nearby (~900 pc; Kalirai et al. 2003) open cluster covering a sky area similar to the full Moon, thereby providing the opportunity to study a uniform population of stars that is uniquely matched to the capabilities of Kepler. The youth (~150 Myr) and low metal content ([Fe/H]≈-0.2; Barrado y Navascues et al. 2001) of the stars also enable important stellar and planetary investigations in new regimes.

1. Planets. M35 can be used to study planet formation in a higher-stellar-mass regime and among a large sample of young stars. Recent discoveries by Kepler of two planets in NGC 6811 (Meibom et al. 2013) underlined the possibility of finding planets in the dynamical environment of clusters. By virtue mainly of its larger mass, M35 contains at least 3 times more member stars than NGC 6811 that can be studied by Kepler. Transit detections of planet candidates around intermediate-mass stars (M>1.5-2 $M_\odot$) will be possible, although characterization of those candidates will be difficult due to rapid stellar rotation and smaller ensembles of absorption lines for radial velocity measurement.

2. Asteroseismology. A major astrophysics outcome from Kepler has been the asteroseismic characterization of ~1 $M_\odot$ cluster giants. M35 will probably be the youngest cluster having giant stars observed by Kepler, thus providing a unique window on the interior structure of intermediate (~5 $M_\odot$) mass stars. Three rather bright (7.4<V<8.5) giant stars (see the diagram below) are known members of the cluster. Although M35 would be observed for a shorter duration than for the main mission, the much greater flux from the stars will nonetheless enable asteroseismic analyses of these stars.

3. Binary Stars. Eclipsing binaries have been identified from the ground well down the M35 main sequence (V > 14; × in the diagram below), but the brightest cluster stars ($V_{turnoff}$ ≈ 9.5) have been neglected in previous variability studies. Discovery and characterization of eclipsing binaries at all brightness levels would produce basic astrophysical data for intermediate-mass stars (up to 5 $M_\odot$). Eclipsing systems at the bright end in particular would very tightly constrain the cluster age (e.g. Sandquist et al. 2013). Thanks to its richness, M35 is a key cluster for calibrating age determination methods like gyrochronology. In addition, M35 and the Pleiades are the most important contributors to the determination of the lower mass limit for the transition between stars producing white dwarfs and those producing neutron stars/supernovae (e.g. Williams, Bolte, & Koester 2009). If the age of this cluster can be more precisely determined, it will drastically reduce uncertainties in the progenitor star masses and greatly improve the precision of the high-mass end of the initial-final mass relation for white dwarfs.

For targets, we propose observations of essentially all of the known or likely cluster members, selected using proper motions (McNamara & Sekiguchi 1986 and Dias et al. 2001 for V<15) and radial velocities (Geller et al. 2010 and an unpublished continuation for 13<V<16.5) for most stars, but using color-magnitude diagram position for the faintest portion (V<18) of the sample. We understand that the observation of this list would lock up a substantial fraction of the target slots available, and we have sorted the targets by magnitude to facilitate trimming if necessary. However, while the asteroseismic and age science goals are best met through the study of the brighter stars, a planet search (and also study of the binary stars in this uniform population) benefits from study of the largest possible star sample.