

Characterizing delta Scuti and gamma Doradus Variable Stars in the *Kepler* ‘Superstamp’ Field of Open Cluster NGC 6819

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NGC 6819 is an open star cluster in the constellation Cygnus (Fig. 1) discovered by Caroline Herschel in 1784. NGC 6819 is about 2.4 billion years old (half the age of the Sun) and is about 8000 light years away [1, 2, 3, 4]. This cluster was in the NASA *Kepler* spacecraft continuous field-of-view from 2009-2013. The central part of the cluster (Fig. 2) was observed during these four years in 30-minute cadence photometry, providing a unique long time-series high precision data set for asteroseismology [5]. Studying clusters is advantageous for asteroseismology, because the cluster members presumably formed together and have a common age and element abundances, providing additional modeling constraints.

Since the cluster is younger than the Sun, the stars at the cluster main-sequence turnoff are somewhat more massive than the Sun, near the expected mass range for gamma Doradus-type pulsating variables, which pulsate with gravity mode periods of about 1 day. This cluster also contains “blue straggler” stars, i.e., stars on the main sequence above the cluster turnoff that should have already left the main sequence to become red giants. Blue stragglers are believed to have formed either via stellar mergers or mass transfer from a companion sometime in the star’s past [6]. The NGC 6819 blue stragglers have the right temperatures to show delta Scuti-type pulsations, i.e., acoustic-mode pulsations with periods of around 2 hours. If pulsations are found, stellar modeling and asteroseismic analysis may help to better understand the origins of these blue stragglers.

We present light curves and pulsation frequency analyses for delta Scuti and gamma Doradus star candidates for five confirmed cluster members. Four of these stars are blue stragglers and one is near the cluster turnoff. We searched for variations in each superstamp pixel and designed custom masks for each target. We used simple aperture photometry (SAP) for the light curves, and prepared final light curves using our custom scripts and PyKE software [7]. The membership

probabilities were derived using astrometry data from Gaia Early Data Release 3 [8]. Two of these five stars show a rich spectrum of delta Scuti pulsation modes, with 236 and 84 significant frequencies identified, respectively, while two stars show mainly low-frequency modes characteristic of either gamma Doradus pulsations or global Rossby modes. The fifth star has an unusual spectrum including several harmonics of two main frequencies, which may be best explained by either a four-star system with two eclipsing binaries, or an eclipsing binary with light contamination from an unidentified binary in the field. We also briefly summarize pulsation properties for seven additional stars in the superstamp field that are non-members.



Figure 1. NGC 6819 image from Wikipedia (source Stellarium, photo credit Roberto Mura) [4]. The image is approximately 42 x 32 arc minutes. The north celestial pole is toward the top, and increasing right ascension (east) is to the left.

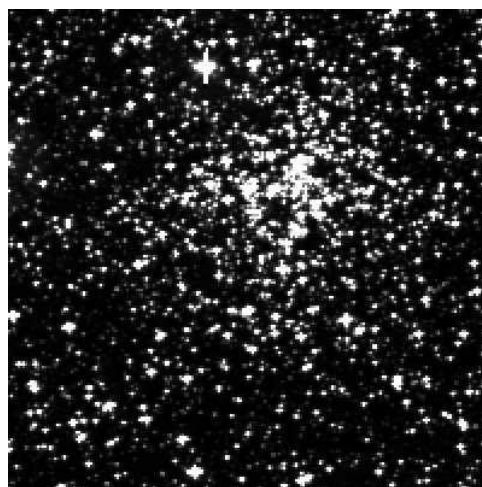


Figure 2. 200 x 200 pixel *Kepler* superstamp image of the center of NGC 6819 [5]. *Kepler* pixel sizes are 3.98 arsec/pixel.

References

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