Understanding Stars close to the Gap

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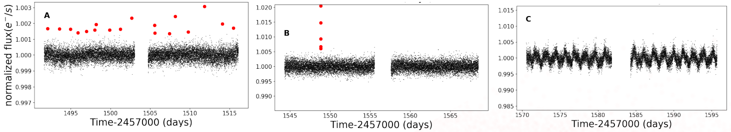
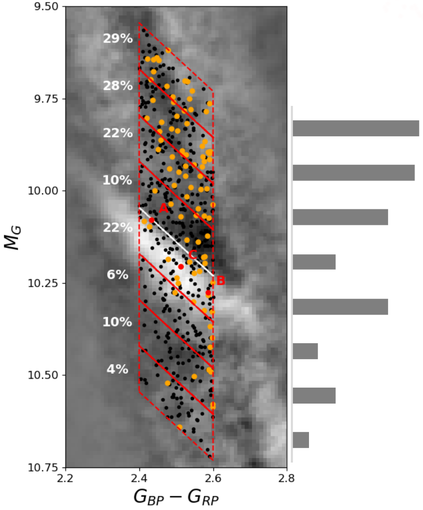
Abstract Theoretical models show the main sequence gap is a result of the mixing of ^{3}He during the merger of envelope and core convection zones. Unlike stars the either side of the gap, stars in a narrow mass range will go through instability phases, where their dynamos could switch between the $\alpha\Omega$ dynamo like the Sun and Ω^2 dynamo like late M dwarfs. At the same time, they show radial pulsation and their fluxes fluctuate, which resemble the pulsations observed in evolved stars like red giants and asymptotic giant branch stars. Consequently, they are a unique type of dwarf like no other on the main sequence. In this work, we would like to know 1) will the unstable interior structures result in observable characteristics such as flaring and spots, and 2) what is the mass range for these stars observationally? Here we present our preliminary results: 1) stars in the gap have higher percentage rate of activities than their adjacent regions, and 2) high resolution speckle results yield promising close binaries to yield dynamical masses in the future.

Flares and Spots Activities in *TESS*





We select 521 nearby stars within 40 pc from *Gaia*-DR2, and they are shown within the red parallelogram in the left figure. The gap is shown as the white stripe in this enhanced HRD (Jao and Feiden 2020), and a white line represents the edge of the gap. The red parallelogram is divided into eight sub-regions with an equal height 0.125 mag, which is the approximate height of the gap. All 521 targets (black and orange dots) have *TESS* 2-min cadence data. Our preliminary result shows 92 stars (orange dots) **have either flares or spot rotations**, which indicate stellar activities. The percentages of stars showing either activities in each sub-region are labelled in white font and in the form of a bar chart. Three example *TESS* light curves of stars in the gap are shown above. **Our preliminary result shows stars in this gap have higher percentage rate of activities than those stars in the regions directly above and below it.** It implies that the interior ^{3}He instability appears to affect their activities on the surface.

Our preliminary result is still yet to be further analyzed. The reasons are the following. 1) Although these 521 stars are 10 degrees above and below the galactic plane, we still expect unresolved close binaries or background stars could affect the light curves. Further contamination studies are necessary. 2) The short temporal coverages of 30 days from *TESS* could miss the sporadic flaring events or longer rotational periods. Independent spectroscopic studies of measuring H-alpha emissions and analyzing targets in multi-sectors in *TESS* could offer additional evidences to bolster this preliminary result.

Baraffe & Chabrier, 2018, A&A, 619, 177
Jao & Feiden, 2020, AJ, 160, 102
van Saders & Pinsonneault, 2012, 751, 98
MacDonald & Gizis, 2018, MNRAS, 480, 1711

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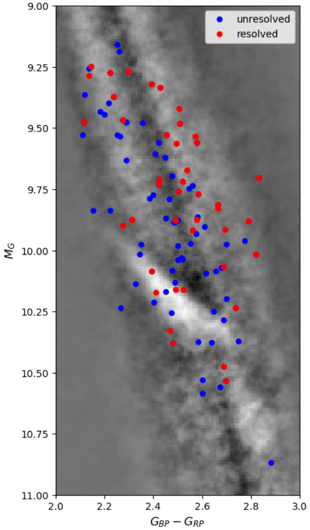

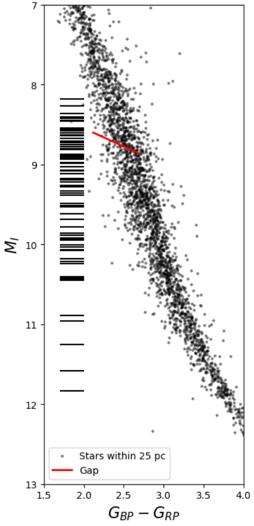

Speckle Results of Close Binaries

The instability region has different mass ranges according to various models (van Saders and Pinsonneault 2012, MacDonald and Gizis 2018 and Baraeffe and Chabrier 2018), and current empirical mass-luminosity relation is smooth and has no kink at this transition zone. To **understand the mass range close to the gap empirically**, we used the ‘Alopeke and Zorro speckle cameras to detect probable close binaries to measure their masses. A total of 102 stars were observed in 2020B. Targets are selected from *Gaia* DR2 with RUWE>1.4 to indicate higher probabilities to be unresolved binaries in DR2. **Initial results show 58 stars are unresolved (blue dots) and 44 stars are resolved (red dots).** Their distributions on the HRD are shown above.

By assuming the $\Delta m_{832nm}=\Delta I$ and using the magnitude conversion relation between G_{RP} and I (Jao et al 2018), we estimate the deconvolved individual I mags for all 44 systems and their results are shown in the upper right plot. The tick marks represent their estimated absolute I magnitudes on the HRD. The red line represent the edge of the gap and black dots represents stars within 25 pc. The components with absolute I magnitudes close to the gap ($\pm\Delta 1$ mag) would be the best targets to follow up. Furthermore, because the final *Gaia* data release will include astrometric perturbations for unresolved binaries, this work also provides crucial initial data of separations, position angles and magnitude differences to combine with astrometric data to determine their dynamical masses in the future.