Annual Progress Report for award number 80NSSC24K0491

Dates covered by this report: 02/01/2024 - 01/01/2025

Proposal Title: Orbital Periods And Flare Rates Of White Dwarf - Main Sequence Star Binaries With TESS
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I) Summary of research originally proposed.

Binaries consisting of a white dwarf and a main sequence star are common throughout the galaxy, and provide insight into a range of astrophysical questions such as the activity of M dwarfs and the origins of Type-1A supernovae. Over 3000 have been identified via spectroscopy, but the orbital periods for the majority of those systems are unknown. TESS photometry is the ideal tool to detect the percent-level optical variations induced by reflection, ellipsoidal modulation and starspots that reveal the orbital period. We will survey over 500 systems, expecting to detect at least 100 new orbital periods. We will also calculate flare frequency distributions for the main-sequence stars, comparing them as a function of rotation period with single stars.

II) Summary of accomplishments made during this period.

We have made considerable progress with the first stage of the project, identifying new periods for known binaires. Much of this work has been carried out by an undergraduate researcher (not funded by this project), with the PI acting as advisor. We have developed the algorithms to retrieve light curves, identify periodic variation and identify the origin of that variation, following the process outlined in the proposal. Specifically, TESS light curves for each target are retrieved, normalized and abutted, and a lomb-scargle periodogram generated for each target. Significant periods are then identified (defined as peaks in the periodogram > 5 sigma above the median). If a signal is detected, the light curve is then folded onto the strongest signal as well as multiples of the period and a diagnosis plot produced. These are then visually inspected (a practical method for our several hundred targets) and a best-guess made for the origin of the variation. The dominant modes are either irradiation of the near side of the main-sequence companion (one peak per orbit) or ellipsoidal variation (two peaks per orbit). If the correct variation mode can be identified, the period is recorded, if not a note made that there may be a factor 2 error (considerably better than the state of the art of no period known!).

We have run the routine on all targets with known periods from radial velocities. We found a good match between the known RV periods and the periods identified from TESS photometry, confirming that our techniques can be confidently used to search for periods at stars without existing measurements.

III) Summary of risks or obstacles, plus mitigation strategies.

Identification of flares for the second part of the project has been harder, with routines such as stella less able to identify flares than we hoped. This is likely due to the stars being fainter on average than stella's training set. We will attempt to mitigate this by using a tighter magnitude cut for the flare search, cutting our sample size down to those stars where we can be confident of detecting a statistically valid sample of flares.

IV) Summary of plans for the coming year.

With the period identification routines written and tested, we are ready to ingest the whole sample and start working through them. A first pass identified 278 significant periods out of 1048 input targets. We will identify and catalog periods for all stars where we can, aiming to provide a catalog of > 100 periods and sub-percent limits on optical variation at the remaining stars. We will also conduct a survey of flares in our sample, combining our magnitude cut as described above with improved flare detection algorithms to produce flare frequency distributions for our sample and compare them with single stars. We will publish the period catalog and, if successful, the flare analysis.

V) Publications and data products released during the past year.

i) Peer-reviewed articles

None

ii) Abstracts and extended abstracts

None (plans to attend the TESS science conference were changed due to schedule conflicts and illness.)

iii) Other Publications

None

iv) Published or archived data sets

None

VI) Publications and data products released in previous years of this award.

n/a