Detection of photometric variability in the very low-mass binary VHS J1256-1257AB using TESS and Spitzer

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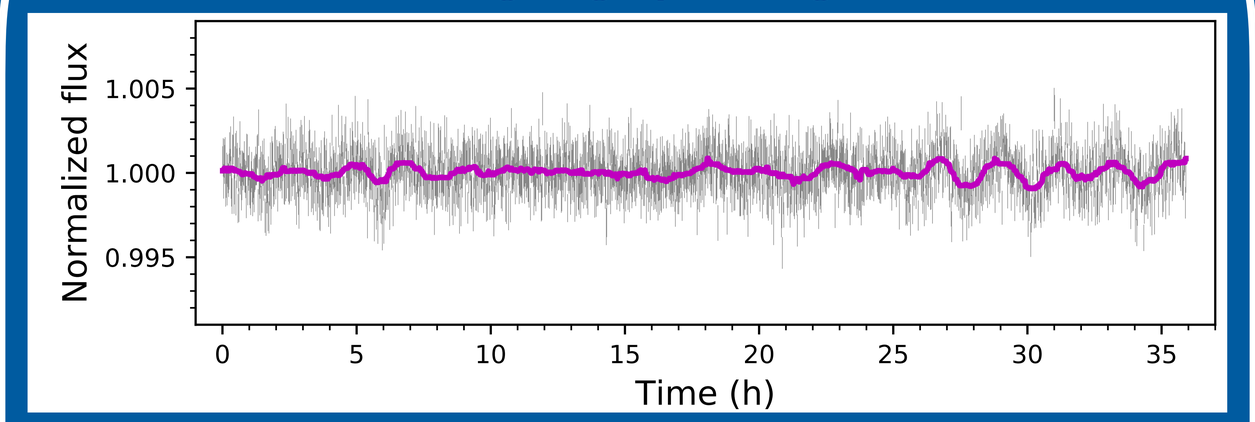
Overview

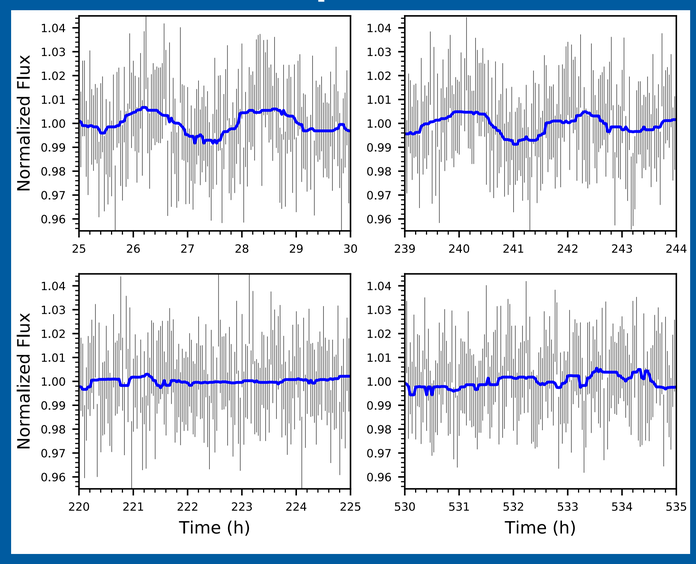
We report the detection of photometric variability in the M7.5 binary star VHS J1256-1257AB using archival data from TESS and Spitzer. The optical and infrared light curves periodically exhibit epochs of quasi-sinusoidal modulation followed by others of stochastic variability, which resembles the beat pattern created by two waves of similar frequencies that interfere with each other. Our two-waves model shows that the components of VHS J1256-1257AB rotate with periods of 2.0782 ± 0.0004 h and 2.1342 ± 0.0003 h. As a result the fluxes of the equal-brightness VHS J1256-1257A and B alternate states of phase and anti-phase, explaining the observed photometric variability in their combined light. This is only the first example of several beat-patterns revealed by TESS in different binaries (**Miles-Páez, 2021, A&A, 651, 7**).

VHS J1256-1257AB: a 0.1” equal-mass binary with an intriguing Spitzer light curve



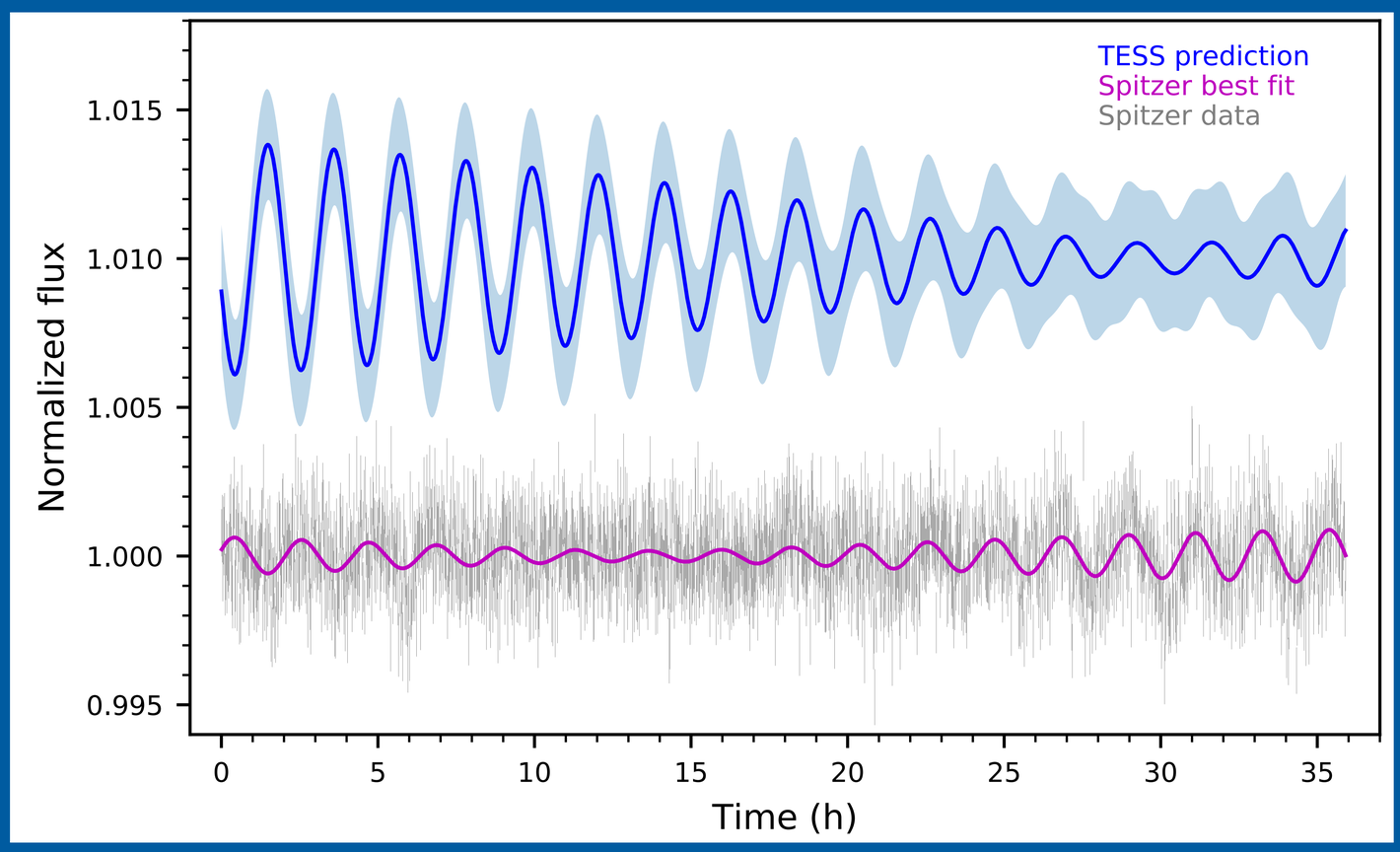
VHS J1256-1257AB and its companion VHS J1256-1257 b were monitored with the Spitzer Space Telescope using Channel 2 (4.5 μm). Data were collected every 2 seconds over three consecutive 12-hour astronomical observation requests (AORs) and are presented in Zhou et al. (2020, AJ, 60, 77). They reported a relatively flat light curve for the combined fluxes of VHS J1256-1257AB during the first ~24 hours of monitoring and some two-hour periodic variability with amplitudes <0.1 % in the last ~12 hours of the data set. The likely spurious or astrophysical origin of the periodicity is unclear. We reanalyzed this data set and show the light curve in the figure above. Data were averaged every 1-min, vertical bars show the standard deviation of data in each bin. The magenta line is a 51-point median filter. We confirm the findings from Zhou et al. (2020).

TESS confirms the photometric variability



VHS J1256-1257AB was observed with a cadence of 2 minutes by TESS in Sector 10. The light curve of the unresolved binary consists of 15,743 two-minute exposures, with a median uncertainty of 1.5 %, spanning 24.77 days. A Lomb-Scargle periodogram for the full data set shows two significant peaks at ~2.08 h and ~2.13 h. Interestingly, the TESS light curve exhibits some epochs of quasi-sinusoidal modulation (top panels), followed by epochs of stochastic variability (bottom panels), which resembles the behaviour of the Spitzer data. A 31-point median filter is shown in blue.

The combined light curve of VHS J1256-1257AB resembles the beat pattern of two waves that interfere with each other



We used Gaussian processes (GPs) to compare different models that can explain photometric modulation as either red noise (due to instrumental systematics and/or weather) or as a periodic feature of the star, as done in Littlefair et al. (2017, MNRAS, 466, 4250). The best model assumes that the observed signal is the combination of the light of two periodic sources with rotation periods of 2.0782 ± 0.0004 h and 2.1342 ± 0.0003 h. The figure above shows the Spitzer light curve for the combined light of VHS J1256-1257AB (gray symbols) and the best fit for the two-waves model (magenta). A projection of the TESS variability at the moment of the Spitzer observations (7.7 months later than the beginning of TESS sector 10) is shown in blue. This model nicely shows how the light of both components of the binary is in phase in some epochs, leading to the quasi-periodic variability seen, and out of phase in other epochs, resulting in stochastic variability.

Conclusions

- The components of VHS J1256-1257AB have the same age and mass, so they should equally imprint their signal in the combined flux measured by TESS and Spitzer
- We measure rotation periods of 2.0782 ± 0.0004 h and 2.1342 ± 0.0003 h for the components of VHS J1256-1257AB and variability amplitudes of 0.21 ± 0.02 % and 0.05 ± 0.01 % for TESS and Spitzer data, respectively.
- The light curves of each component seem stable over the full duration of the TESS sector, covering ~283 consecutive rotation cycles
- We conclude that the *v*sin*i* of both components should be similar to the observed value of the combined light.
- The spin axes of VHS J1256-1257A and VHS J1256-1257B are likely inclined at ~90 deg as already reported for their very low-mass companion VHS J1256-1257 b.

Check the paper!

Miles-Páez, 2021, A&A, 651, 7