Stars and their variability observed from space
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THE IMPOSTER Be STAR HD 19818: SUPERFLARES IN A COOL GIANT?

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Abstract. Classical Be stars are identified by certain observational features, most notably the presence of hydrogen emission. However, in samples of Be stars there is often contamination by other systems that mimic the observables that are generally attributed to Be stars. This paper discussed one such system, HD 19818, and argued that it is an imposter Be star that is actually a close binary comprised of a B9/A0V star and an unusually active cool-giant component that exhibits highly energetic superflares.

Keywords: Techniques: photometric, stars: emission-line, Be, flare, binaries: spectroscopic, individual: HD 19818

1 Introduction

Classical Be stars are near-main-sequence, very rapidly rotating, B-type stars with a circumstellar "decretion" disk that gives rise to emission lines in their spectra. One difficulty in studying Be stars as a population is that there are many types of astrophysical systems which seem to exhibit the features of classical Be stars (Rivinius et al. 2013) but which are actually quite different physical objects. This paper discussed one such object, HD 19818. It has been classified as a Be star, but a closer look at the data reveals it as more prbably a close binary comprised of a B9/A0V star plus a cooler giant that has dramatic flare events and a high degree of chromospheric activity which causes the Hα emission.

2 HD 19818: a binary with an active giant star masquerading as a Be star

Classical Be stars have many observational features which, taken together, can enable a reliable classification to be made (Rivinius et al. 2013). Common methods of discovering Be stars include analysis of hydrogen emission in spectra, narrow-band photometry (sampling Hα), SED analysis to measure the excess at long wavelengths caused by the disk, photometric variability studies to search for disk-building events, and polarimetric measurements to study the light scattered off the disk. However, most methods for discovering Be stars rely primarily on an incomplete set of these features, which can lead to mis-classification. Samples of Be stars often have some (unknown) degree of contamination from systems that, at first glance, mimic the characteristics of B stars with decretion disks.

HD 19818 is classified as a B9.5Vne star, and has so far been considered to be a classical Be star (Houk & Cowley 1975). It was observed by *TESS* in sectors 2 and 3 (2018 Aug 22–2018 Oct 18) in 2-minute cadence mode as part of a *TESS* GI proposal to study classical Be stars. The most remarkable features seen by *TESS* are two events that resemble flares, with durations of 5–10 hours and amplitudes of ∼1% and ∼6%, superimosed on a 3.34-d periodic signal. The *TESS* data for the two flares are plotted in Fig. 1. To the best of our knowledge, events like this are not seen in any of the other *TESS* Be stars, nor have they been observed in other space photometry of Be stars. That prompted us to obtain high-resolution spectroscopy as a first step towards classifying the system better.

Our first spectrum from the CHIRON spectrograph (on the SMARTS 1.5-m telescope at CTIO) revealed lines from two components (Fig. 2). One component is consistent with a main-sequence B9/A0 star, and the other with a cooler giant (which dominates the optical flux of the system). More recent spectra show clearly the relative motion of those lines, consistent with close binary motion. HD 19818 is also an X-ray source (with an unusually high ratio of X-ray to bolometric luminosity, and a low hardness ratio; Nazé & Motch 2018); the latter is generally inconsistent with later-type Be stars but is consistent with high levels of chromospheric activity in cooler stars. The morphology, amplitude, and time-scale of the two flares are consistent with the "superflares"

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in giant stars seen with *Kepler* (Van Doorsselaere et al. 2017; Balona 2015) and in the giant star HK Lac (Katsova et al. 2018). It is possible that tidal interactions have spun up the giant star in HD 19818, thereby enhancing the energy in its magnetic dynamo and driving its chromospheric activity. At $V \sim 9$, this system is bright enough for more detailed spectroscopic studies, and which are not feasible with the *Kepler* superflare giant stars. We are continuing to monitor HD 19818 in order to obtain an orbital solution, to characterize both stellar components, and study the (highly variable) Hα emission.

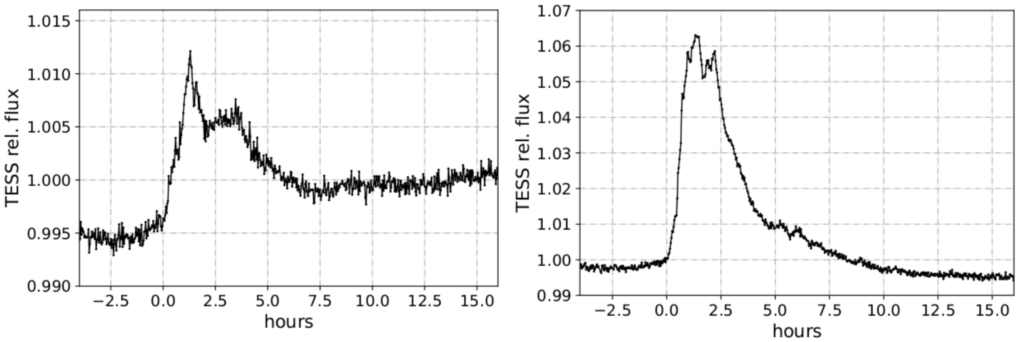

Fig. 1. Sections of the *TESS* 2-minute cadence light-curve for HD 19818, showing the two recorded flares.

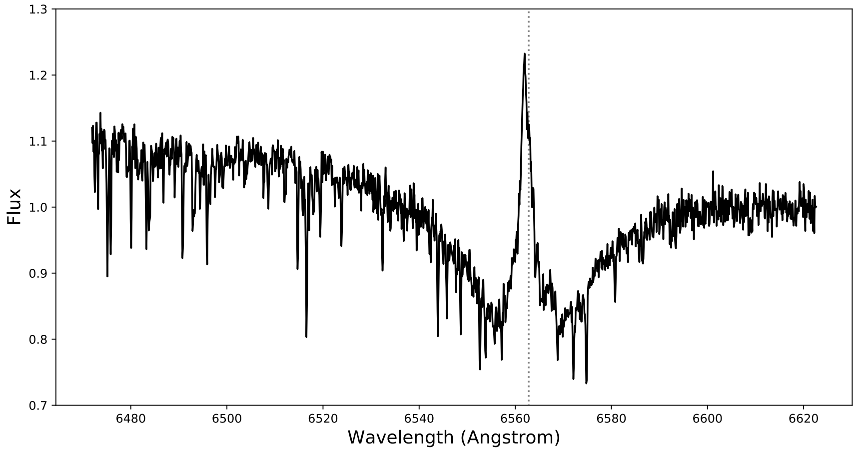

Fig. 2. CHIRON spectrum showing the region around Hα. We attribute the broad Hα absorption to the B9/A0V component. Most of the narrow lines are from the cooler giant, and the emission appears to be correlated with chromospheric activity in the giant star.

3 Conclusions

By studying new data from *TESS* and high-resolution spectroscopy, we could claim that HD 19818 is not a classical Be star but is instead more likely to be a close binary in which the broad hydrogen absorption lines are indeed from a B9/A0 main sequence star but the spectrum also includes lines from a cool giant. The Hα emission, flares seen in *TESS* data, and the observed X-ray flux, can be explained if the system contains a chromospherically-active cool giant that exhibits superflares.

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