PTFO 8-8695: Two Stars, Two Signals, No Planet

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Abstract

PTFO 8-8695 (CVSO 30) is a star in the 7-10 million year old Orion-OB1a cluster that shows brightness dips that resemble planetary transits. Although strong evidence against the planet hypothesis for this system has been presented, the possibility remains debated in the literature. To obtain further clues, we inspected data from the NASA TESS and the ESA Gaia missions. The Gaia data suggest that PTFO 8-8695 is a binary: the photometric data show it to be over-luminous with respect to members of its kinematic group, and the astrometric data are inconsistent with a single star. The TESS light curve shows two different photometric periods. The variability is dominated by a sinusoidal signal with a period of 11.98 hr, probably caused by stellar rotation. Also present is a 10.76 hr signal consisting of a not-quite sinusoid interrupted by hour-long dips, the type of signal previously interpreted as planetary transits. The phase of the dips is nearly 180° away from the phase of the originally reported dips. This makes the dips difficult to explain as planetary transits. Instead, we believe that PTFO 8-8695 is a pair of young and rapidly rotating M dwarfs, one of which shows the same "transient-dip" behavior that has been seen in at least 5 other cases. The origin of these transient dips is still unknown but likely involves circumstellar material. Combined with recent counter-arguments against the planetary nature of CI Tau b and V830 Tau b, the rejection of the planetary hypothesis for PTFO 8-8695b suggests that the number of known hot Jupiters younger than 100 Myr is approximately zero.

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PTFO 8-8695 (CVSO 30) is a star in the 7-10 million year old Orion-OB1a cluster that shows brightness dips that resemble planetary transits[1]. Although strong evidence against the planet hypothesis for this system has been presented[2,3], the possibility remains debated in the literature[4,5,6]. To obtain further clues, we inspected data from the NASA TESS and the ESA Gaia missions. The Gaia data suggest that PTFO 8-8695 is a binary: the photometric data show it to be over-luminous with respect to members of its kinematic group, and the astrometric data are inconsistent with a single star. The TESS light curve shows two different photometric periods. The variability is dominated by a sinusoidal signal with a period of 11.98 hr, probably caused by stellar rotation. Also present is a 10.76 hr signal consisting of a not-quite sinusoid interrupted by hour-long dips, the type of signal previously interpreted as planetary transits. The phase of the dips is nearly 180° away from the phase of the originally reported dips. This makes the dips difficult to explain as planetary transits. Instead, we believe that PTFO 8-8695 is a pair of young and rapidly rotating M dwarfs, one of which shows the same "transient-dip" behavior that has been seen in at least 5 other cases (Figure 1). The origin of these transient dips is still unknown but likely involves circumstellar material[7,8,9]. Combined with recent counter-arguments[10,11] against the planetary nature of CI Tau b and V830 Tau b, the rejection of the planetary hypothesis for PTFO 8-8695b suggests that the number of known hot Jupiters younger than 100 Myr is approximately[12] zero.

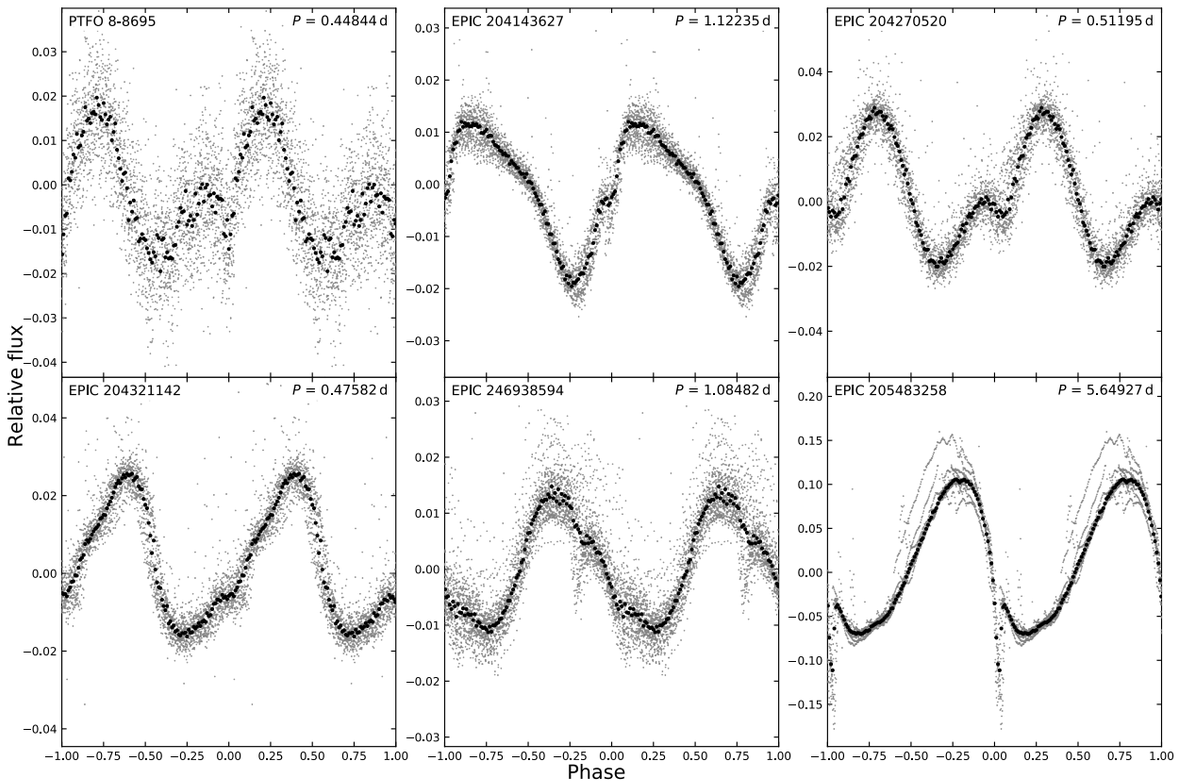

Figure 1. PTFO 8-8695 and its brethren. Top left is the TESS light curve of PTFO 8-8695 phase-folded at 10.76 hours, after subtracting the dominant 11.98 hour signal from the other star in the system. The other five panels show K2 light curves of 5-100 Myr old M dwarfs that show similar variability.

References & footnotes. [1]van Eyken+12. [2]Yu+15. [3]Onitsuka+17. [4]Ciardi+15. [5]Johns-Krull+16. [6]Tanimoto+20. [7]Stauffer+17. [8]Rebull+18. [9]Zhan+19. [10]Donati+20. [11]Damasso+20. [12]Rizzuto+20 recently found a 17 Myr old 0.9R_{Jup} planet with a 7 day orbital period; its mass will reveal whether it is the first clear counter-example.