THE PROTOTYPE STAR γ DORADUS OBSERVED BY *TESS*

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Abstract. γ Doradus is the prototype star for the eponymous class of pulsating stars that consists of late A to early F main-sequence stars oscillating in low-frequency gravito-inertial modes. Being among the brightest stars of its kind ($V = 4.2$ mag), γ Dor benefits from a large set of observational data that has recently been completed by high-quality space photometry from the *TESS* mission. With these new data, we propose to study γ Dor as an example of possibilities offered by synergies between multi-technical ground and space-based observations. We present here the preliminary results of our investigations.

Keywords: Asteroseismology, stars: oscillations, rotation, individual: gamma Doradus

1 *TESS* photometry

TESS observed γ Dor during Sectors 3, 4, and 5, representing 80 days of nearly uninterrupted data. Being bright, the star saturated the CCDs and left bleeding trails along CCD columns. That is shown on the Full Frame Image (FFI) cutout on the left panel of Fig. 1. The light-curve was extracted by performing simple aperture photometry on FFI cutouts with a custom mask chosen to include most of the target flux. Data downlink or scattered light from the Earth or the Moon are responsible for gaps in the data, but overall a duty cycle of 87% was achevied.

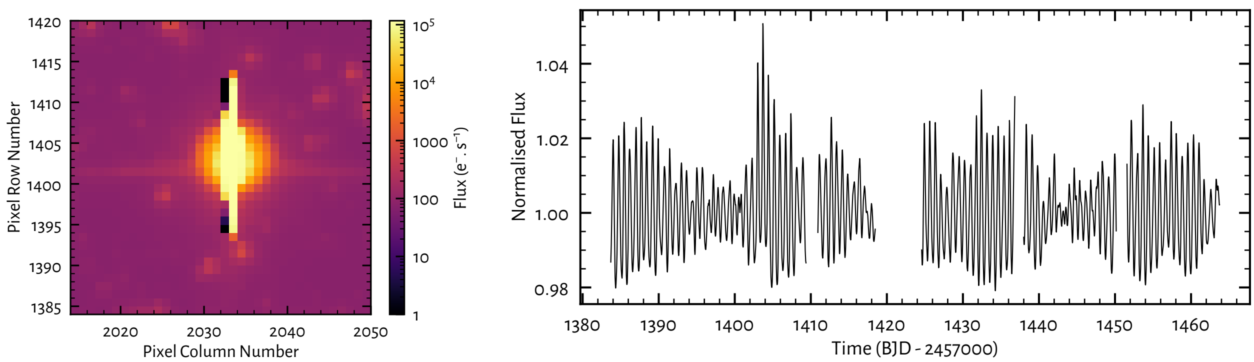

Fig. 1. Left: Example of *TESS* Full Frame Image (FFI) cutout for γ Dor. **Right:** Light-curve of γ Dor extracted from *TESS* FFI cutouts.

2 Asteroseismology from ground and space

We carried out the frequency analysis of the *TESS* light-curve by iterative prewhitening. We found 21 frequencies with S/N > 4 (see Fig. 2). The 6 previously known frequencies from ground-based observations (Brunsden et al. 2018) are all confirmed in the *TESS* data. Based on line profile variations, Brunsden et al. (2018) identified the

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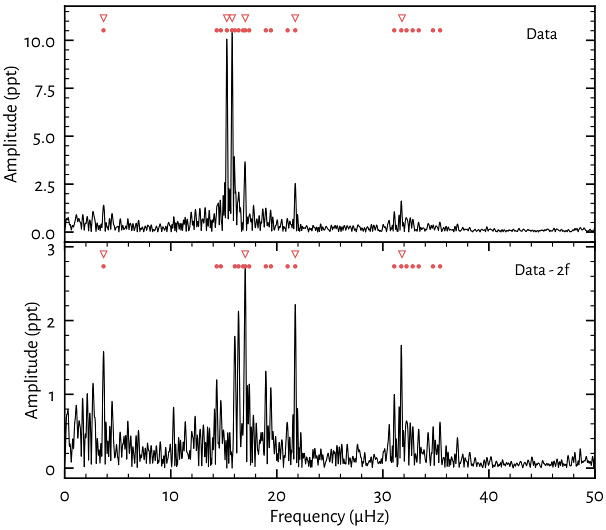

Fig. 2. Amplitude periodograms before (top) and after pre-whitening (bottom) of the first two frequencies of high amplitude. Red circles represent frequencies extracted from the *TESS* light-curve. Upside down triangles indicate frequencies found by Brunsden et al. (2018) from ground-based photometry and spectroscopy.

three frequencies at 15.3, 15.8 and 21.7 μHz to be prograde gravity modes of $(\ell, m) = (1, -1)$. Assuming the frequency group at $\sim$16 μHz is mostly consisting of $(1, -1)$ modes, we applied the method of Christophe et al. (2018) to estimate the near-core rotation rate of γ Dor. The mode frequencies are compatible with rotation rates in the 9–12 μHz range, but the limited resolution of the periodogram prevented us from obtaining a more precise value. The second frequency group around $\sim$32 μHz can be interpreted as either combination frequencies or $(\ell, m) = (2, -2)$ modes.

3 Surface rotation

In order to determine the surface rotation rate, we need the luminosity L, the effective temperature $T_{\rm eff}$, the projected surface velocity $v \sin i$, and the inclination angle i. The luminosity is taken from Gaia DR2 ($L = 6.99 \pm 0.06\ L_\odot$, Gaia Collaboration et al. 2018). We derived $T_{\rm eff} \approx 7145 \pm 150$ K by averaging the photometric and spectroscopic estimates available in the literature. The projected velocity, $v \sin i = 59.5 \pm 3$ km s^{-1} was taken from Ammler-von Eiff & Reiners (2012). γ Dor hosts a debris disk that has been observed with *Herschel* and modelled by Broekhoven-Fiene et al. (2013), who found $i \approx 70°$. Assuming the rotation axis of γ'Dor is aligned with its disk axis, we estimated the surface rotation rate to be 8.4 ± 0.8 μHz. That is close to the range of near-core rotation rates estimated from seismology, and suggesting a nearly uniform rotation profile.

This research made use of Lightkurve, a Python package for *Kepler* and *TESS* data analysis (Lightkurve Collaboration et al. 2018); Period04 (Lenz & Breger 2005) and Astroquery (Ginsburg et al. 2019). S.C. acknowledges support from the Programme National de Physique Stellaire (PNPS) of the CNRS/INSU co-funded by CEA and CNES.

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