Rotational periods and planetary angular momenta of CARMENES GTO stars with TESS data

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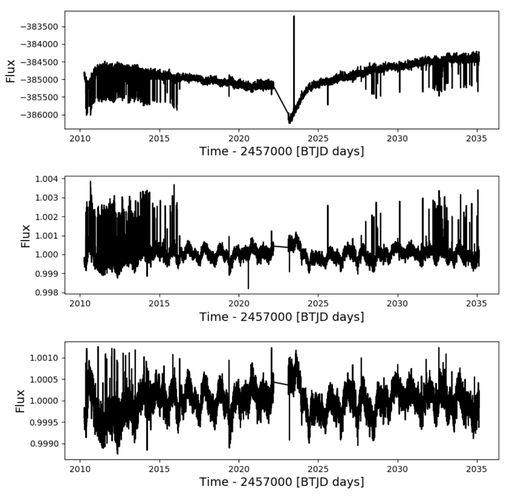
Abstract: We go on paving the way for the study of Earth-like exoplanets around M-type dwarfs stars by measuring the rotation periods of stars observed by the CARMENES survey using *TESS* data. This study will help to distinguish exoplanet radial-velocity signals from the ones produced by features on the rotating features in the stellar atmosphere. We looked for signals in the photometric time series of 352 CARMENES M dwarfs of the guaranteed time observations GTO sample covered by the first 26 *TESS* sectors. We collected either SAP (Simple Aperture Photometry) or PDCSAP (Pre-search Data Conditioning SAP) time series for 210 stars, and custom extracted the light curves for a further 32 stars from the FFI (Full Frame Images). We measured 69 rotational periods between 0.12 d and 13.20 d of which 23 are new. With those periods in hand, we studied the distribution of angular momenta of stellar systems with and without planets.

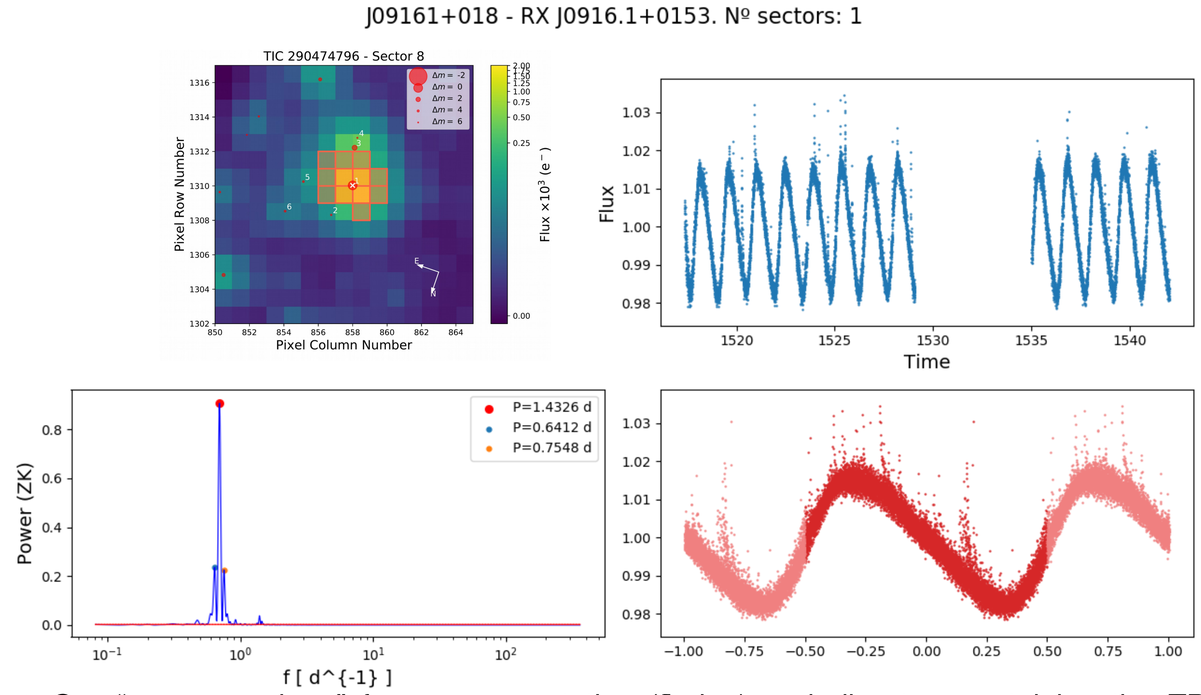
Method.

- We focused on the 352 M and 3 K dwarfs observed under CARMENES GTO [1].
- We mainly made use of the PDCSAP light curves that *TESS* automatically produces while for some stars, that did not have PDCSAP or SAP, we recovered their light curves from the FFI's.
- After removing flares [2], sigma clipping, detrending and stitching observations in different sectors, GLS (Generalised Lomb-Scargle) algorythm [3] was performed to find significant periods.
- The ACF (Auto Correlation Function) method was also implemented, which improved the accuracy for the periods near ~10 d and supported the ones obtained with the GLS.
- A comparison with the rotation velocity of the star *vsini* was helpful to exclude periods which are apparently good, but are not consistent with those derived from vsini.
- The stellar and planetary angular momentum (J_{sys}) was calculated for the stars compiled by Sabotta et al. [4] by adding the stellar and the planetary angular momenta obtained from the orbital parameters for each of the known (multi-)planetary systems.

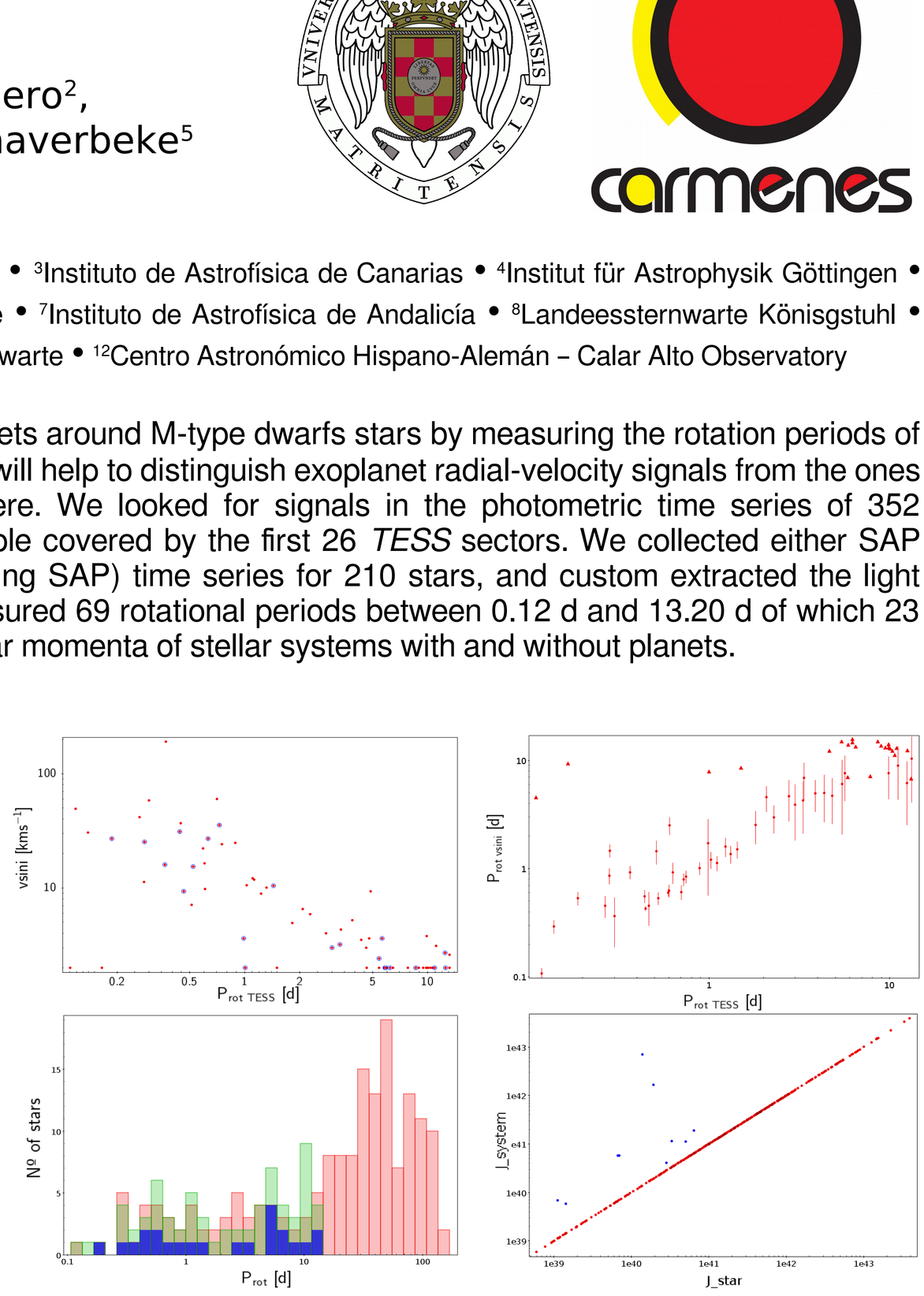


Nº of observations	Nº of studied stars	Nº of GTO stars
1	48	176
2	8	24
3	9	22
4	-	5
5	1	3
6	-	-
7	1	1
8	-	-
9	1	1
10	1	1
11	2	3
12	-	2
13	-	2

▲ *TESS data proccesing stages. Left panels, from top to bottom: SAP (raw), PDCSAP (detrended and normalized) and final (flare and long-term corrected) light curve. Right table: number of stars with observations in different sectors (right).*



▲ *Our "summary sheet" for a representative (flaring) periodic star, containing the TPF (Target Pixel File) and aperture mask made with TPFplotter [5] (top left), PDCSAP light curve (top right), GLS periodogram (bottom left) and phase-folded light curve with the main GLS period.*



▲ *Rotation periods and angular momenta. Our vsini vs. TESS Prot (top left; blue: new periods). Prot from R⋆ and vsini vs. TESS Prot (top right). Prot distribution (bottom left; red: literature; green: confirmed by us; blue: new). And comparison of stellar (J_{star} from Prot) and system (blue: stellar plus planetary) angular momenta (bottom right).*

Results.

- We measured 71 rotation periods from *TESS* data, of which 23 are new.
- 175 (~ 50 %) stars of the GTO sample have known periods, while of the 252 studied stars in this work, 118 (~ 49 %) had previously tabulated periods. By presenting this news results we increment the percentage of known periods in the GTO sample to a 55.9 %.
- Most of the found periods are shorter than 10 d and contribute to populate that region of periods.
- In order to search for a possible relation or threshold between the star angular momentum and the possibily of hosting planets a larger database of planets around M dwarfs is needed.

References.

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