V1298 Tau SPOTS: MULTIBAND PHOTOMETRY

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Ariel-It Science (May 2022)





Young Stellar Objects (YSO)



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Difficult observations because of high stellar activity Only few young planetary systems known



CDOTC



STELLAR VARIABILITY

SOHO image (NASA) of a sunspost with respect to Earth dimensions

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- spectral lines distortion
- chromatic signals
- lightcurve alterations during transit observations
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V1298 TAU

This is a young star with the following properties (T. J. David, L. A. Hillenbrand et al., 2019) :

Mass (M_{\odot})	Radius (R_{\odot})	Age (Myr)	Rotational period (d)	Temperature (k)
1.101±0.005	1.34±0.06	23 ±4	2.87±0.02	4970±120

- 3 (b,c,d) confirmed transiting planets (KEPLER) and one to be confirmed (e)
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Possible clues about the Solar System formation

Gal-Hassin Observatory:

- Ritchey-Chretien
- Diameter: 40 cm
- f/3,8
- 83'x83'
- Sloan filters u', g', r', zs_2 and H alpha filter



Osservatorio Polifunzionale del Chianti (OPC):

- Ritchey-Chretien
- Diameter: 80 cm
- f/8
- 20'x20'
- Johnson filters U-B-V-R-I



REM Telescope (La Silla):

- Ritchey-Chretien
- Diameter: 60 cm
- f/8
- Ross2: g', r', i', z'
- REMIR: z', J, H, K



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BETTER SPOTS TEMPERATURE CONSTRAIN



V1298 TAU OBSERVATIONS

- February 2021:
 - Osservatorio Polifunzionale del Chianti (OPC) observed with B, V and R filters
 - Gal-Hassin using r' and H alpha filters.

High airmass and poor time coverage per night.

- December 2021:
 - OPC and REM observations
 - Gal Hassin observatory could not observe the star due to meteorological reasons

Low S/N ratio because of the Moon

- February-March 2022 (analysis ongoing):
 - Gal-Hassin observatory: r' and H alpha filters
 - OPC: B-V-R-I filters

DATA ANALYSIS

- **CALIBRATION:** dark frames, flatfield frames
- **DIFFERENTIAL PHOTOMETRY:** evaluation of the stellar flux with respect to STABLE check stars according to

$$F_{rel} = \frac{F_{star}}{\sum_i Fc_i}$$

• EVALUATION OF CHECK STARS, each with respect to the others

I used AstroImageJ (Karen A. Collins *et al* 2017) for the first steps of data reduction.

- TEMPORAL BINNING
- SELECTION ACCORDING TO AIRMASS



Balance between NUMBER, MAGNITUDE and STABILITY of CHECK STARS

RESULTS.1

OPC	ΔΒ ΔV		ΔR	
02/2021	0.0255±0.0017	0.020±0.002	0.017±0.002	
12/2021	/	0.028±0.002	0.0206±0.0018	

Gal-Hassin	Δr'	∆H alpha	
02/2021	0.015±0.009	0.033±0.015	

REM	Δg′	Δr'	Δi′	Δz′	ΔJ
12/2021-01-2022	0.042±0.009	0.040±0.008	0.033±0.006	0.017±0.006	0.021±0.006

Amplitude increases at shorter wavelengths (in B is 30% higher than in R band)



RESULTS.2



Data and fitted lightcurve of V1298 Tau observed in February 2021 by Gal-Hassin and OPC (left) and REM in December (2021). Lightcurves are shifted for clarity purpose.

RESULTS.3



Data and fitted lightcurve of V1298 Tau observed in February 2021 by OPC in both B and R band

SPOT_MODEL

Initial hyphotesis:

- Corotating spots
- Not evolving spots during an observational run (≈ 2 rotational periods of the star)

Lightcurve simulation:

- Estimation of visible stellar surface fraction occupied by spots at a given time
- Spots and surface emissions at different temperatures (estimated through Phoneix models)
- Rotation of the star

Fitting data:

- Fitting the data using the simulated lightcurves
- Search for intersection of results for all bands





GEOMETRY AND TEMPERATURE CONSTRAINS

MODEL PROCEDURE

- BIN of the data
- Data splitted in 3 sequence of 3 days each for each band observed.
- 1, 2, 3 and 4 spots model analysis through Multinest. Temperature range between 3000 K and 4970 K (star temperature)
- Comparison of the results of B-V-R bands for each period and BIC evaluation. 1 and 4 spots models discarded.
- Search for temperature intersection for all the days for 2 and 3 spots models
- New analysis of the data using 2 and 3 spots models with the new temperature constrain and BIC evaluation.

BIC SELECTION: 2 SPOTS MODEL prefered!!

PRELIMINARY SPOTS TEMPERATURE CONSTRAIN: 3400-3500 K





Filters (B-V-R)





17/20

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Better evaluation of the real temperature of the spots and the related uncertainties

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- Necessity of a **gaussian prior** for the common spots temperature
- Confirmation through IR data required



Better evaluation of the real temperature of the spots and the related uncertainties



REM DATA with STANDARD FIELD in AOT45

FUTURE PROJECTS

- COMPARISON with spots modeling results retrieved using TESS and HARPS-N data
- Analysis of the new observations of V1298 Tau
- Fit of IR data about V1298 Tau
- New refined model with spots evolution
- Observing proposal (already accepted) of 3 targets through REM:
 - V1298 Tau
 - DS Tuc A
 - TOI-179
- Monitoring of V1298 Tau with Gal-Hassin and OPC telescopes