HUN-REN
Magyar Kutatási Hálózat

PHOTOCENTER SHIFTS CAUSED BY MAGNETIC ACTIVITY

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HUN-REN CSFK Konkoly Observatory

KONKOLY

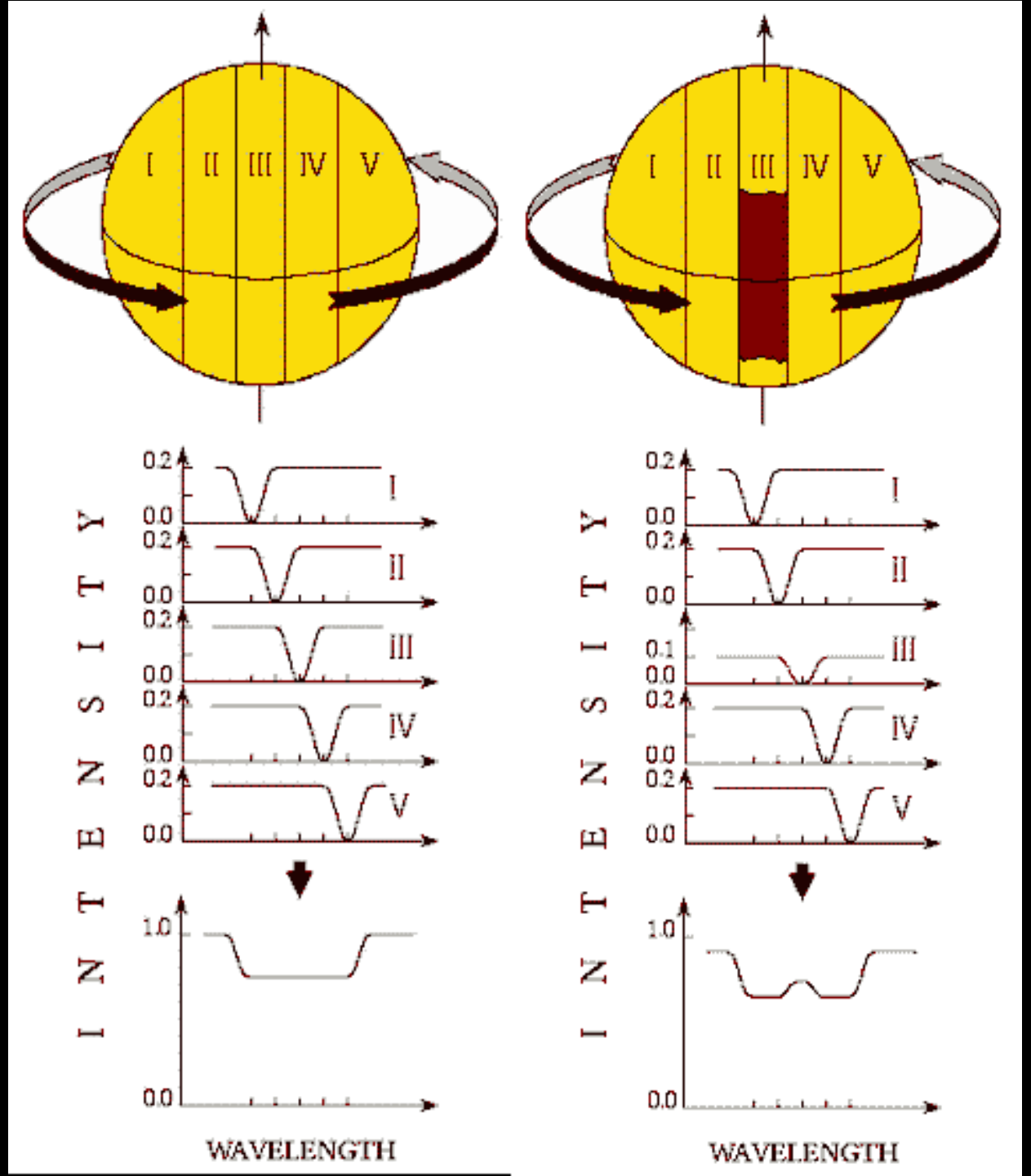
INTRODUCTION

STELLAR ACTIVITY

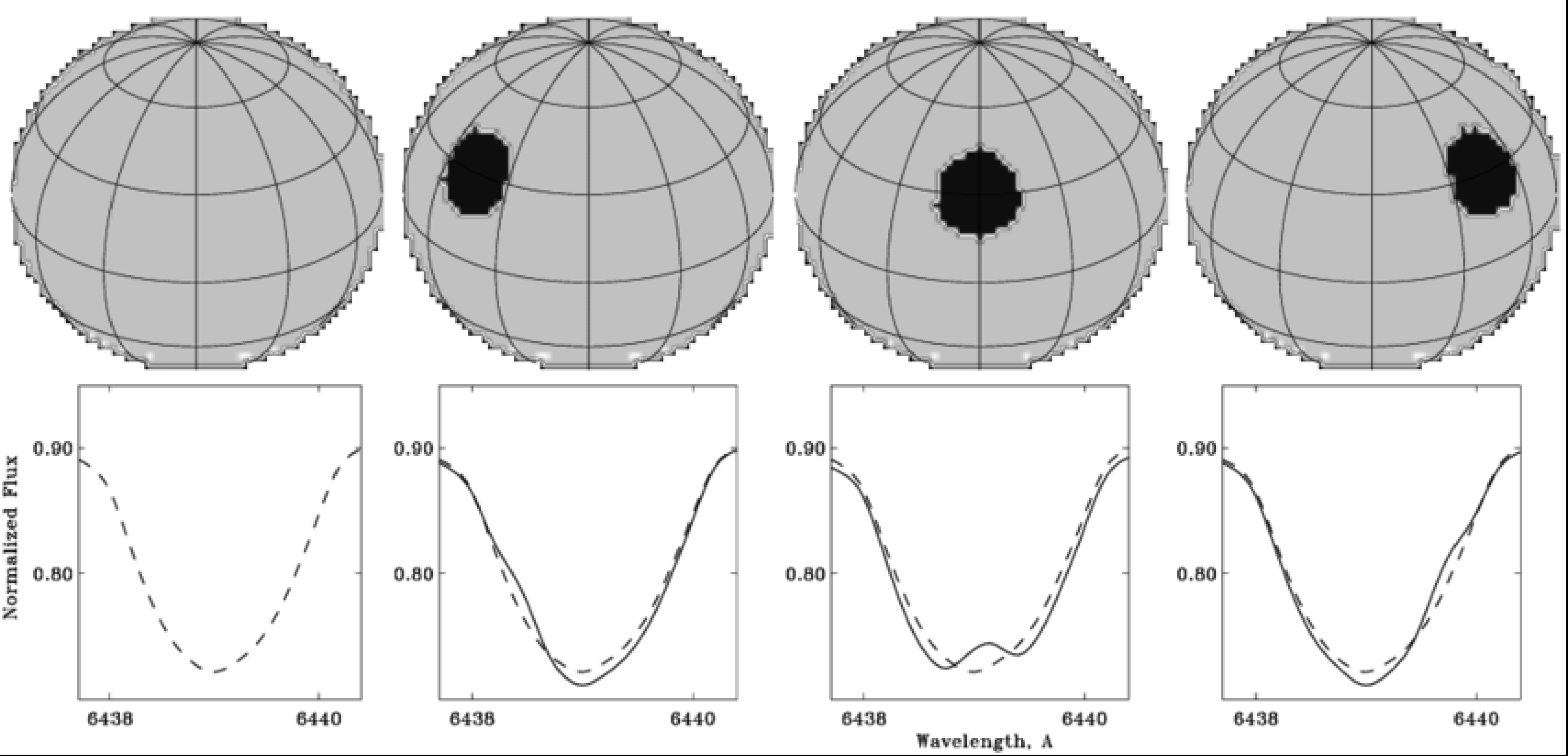
- Sunspot study since the ancient times, first observation with telescope: Galilei
- α-Ω dinamo ⇨ magnetic field in the Sun
- Flux tubes break trough the surface ⇨ sunspots
- The ratio of convection decreases due to the magnetic freezing, that's why they are darker
- The spots cause decreament in the flux
- Not only on the Sun, on other variable stars as well: BY Draconis, FK Comae, RS CVn, W UMa

DOPPLER IMAGING

- With our current technology we cannot really observe starspots dricetly
- Indirect spectroscopic method: Doppler imaging
- Gives back the spot's location and width from their „wandering trough the phases"
- Gives back surface temperature distribution more precisely
- Cutting up the disk of the target into equal parallel bands
- The doppler-shift is different in each band's line-profile ⇨ the superposition gives back the rotationally broadened line
- The spot causes flux decreament in the continuum ⇨ a bump „moves during rotation" on the line-profile



Source: Rice, 1996

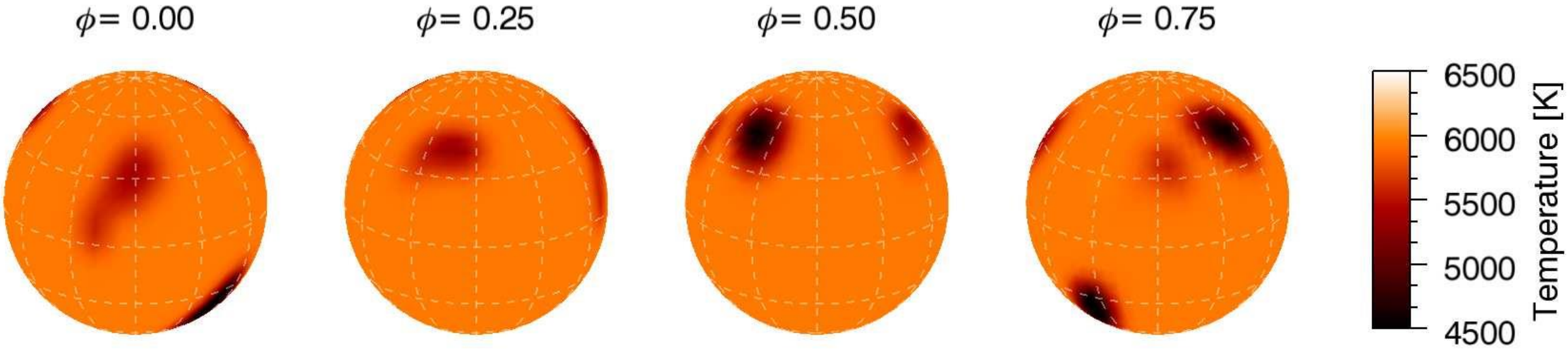


Source: Svetlana V. Berdyugina, 2005

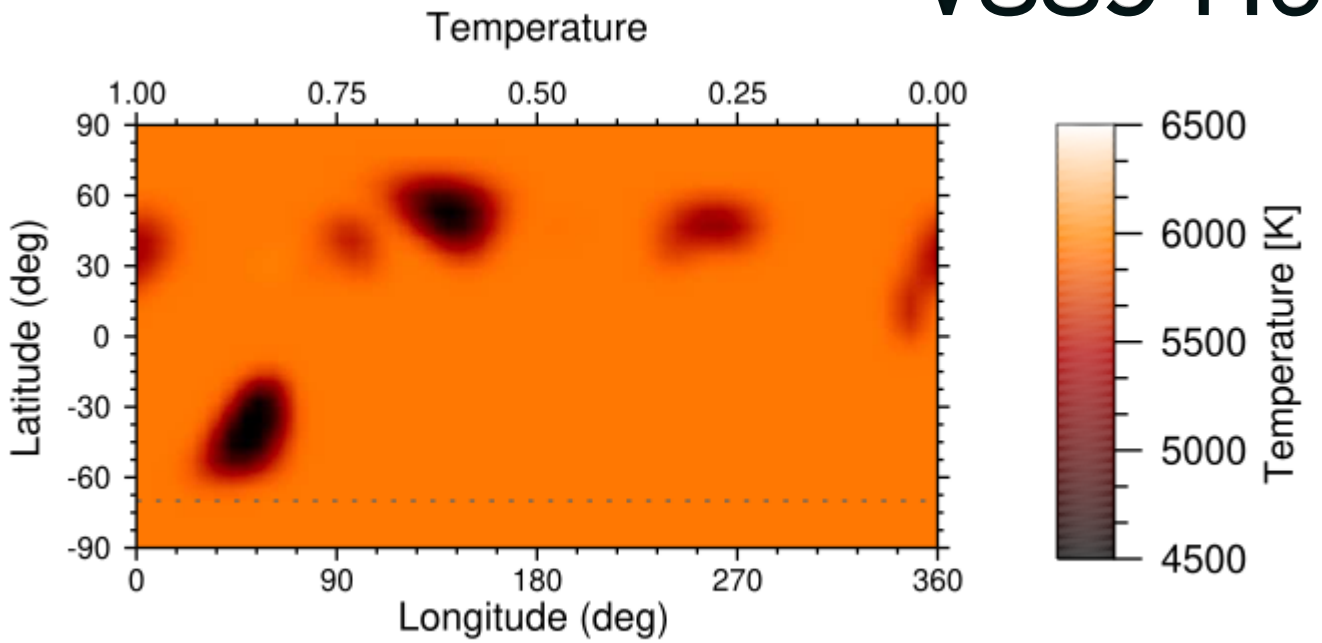
DATA PROCESSING AND TEMPERATURE MAPS

DATA AND ANALYSIS

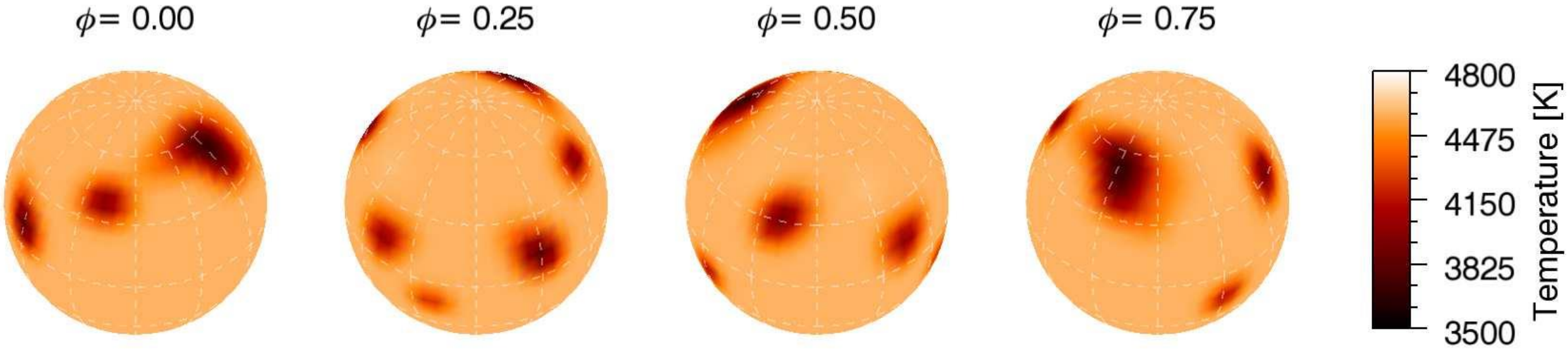
- Utilization of previous data from the spectrograph of Piszkéstető Observatory's 102 cm RCC telescope
- Reduction: according to CCD reduction
- Spectral sythesis with *Spectroscopy Made Easy (SME)* software
- Creation of surface temperature maps with *iMap* Doppler Imaging program



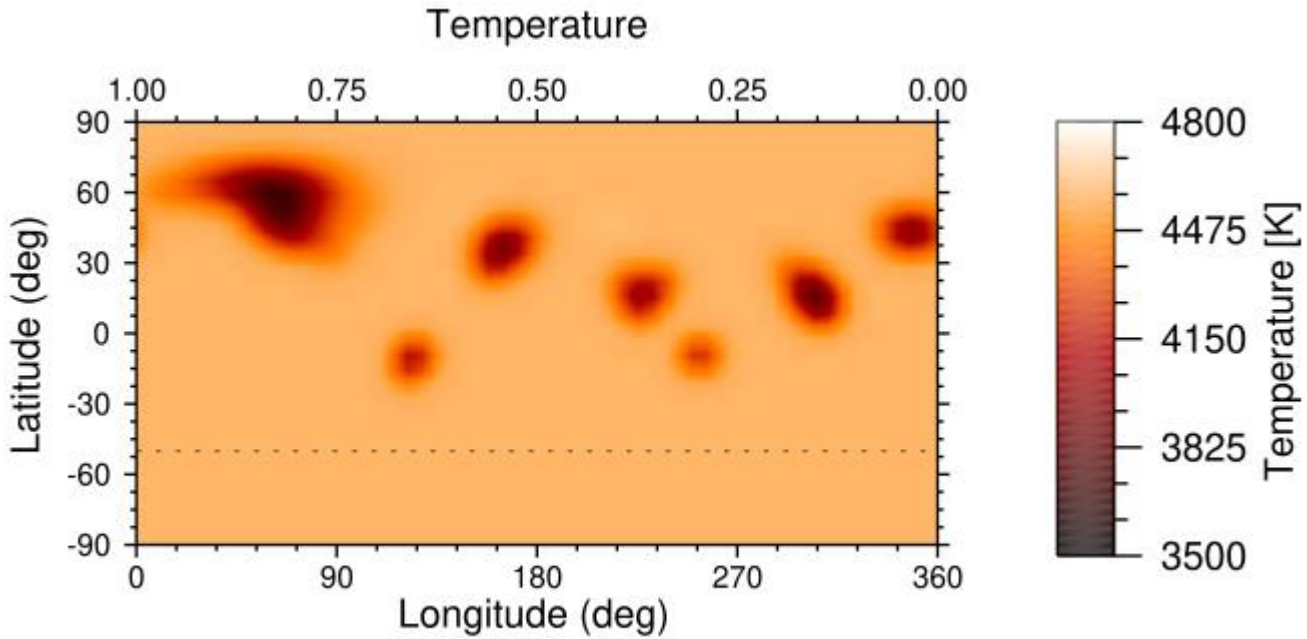
V889 Her



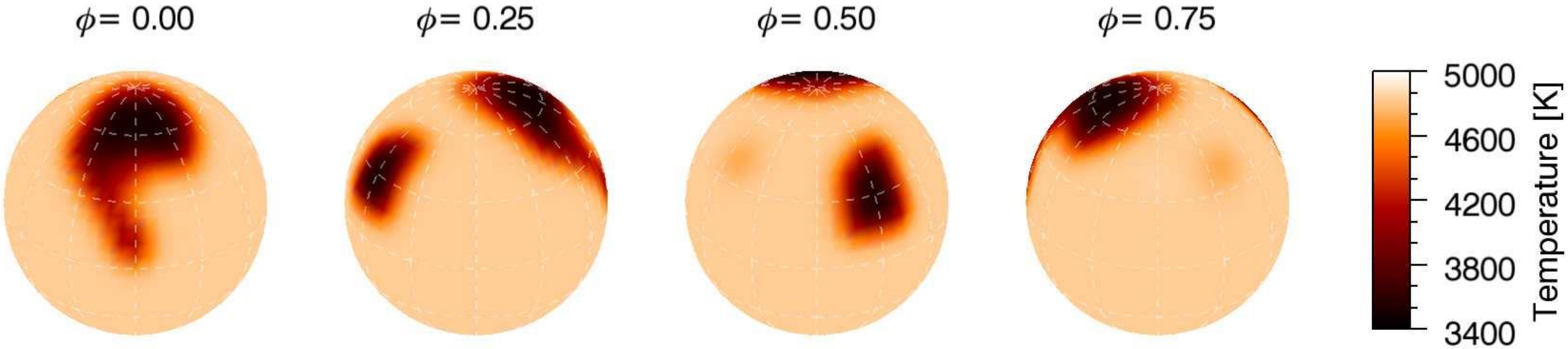
T_{eff} [K]	5940
$\log g$	4.35
[Me/H]	0.12
v_{mic} [km/s]	1.9
v_{mac} [km/s]	3.9
$v \sin i$ [km/s]	43.7



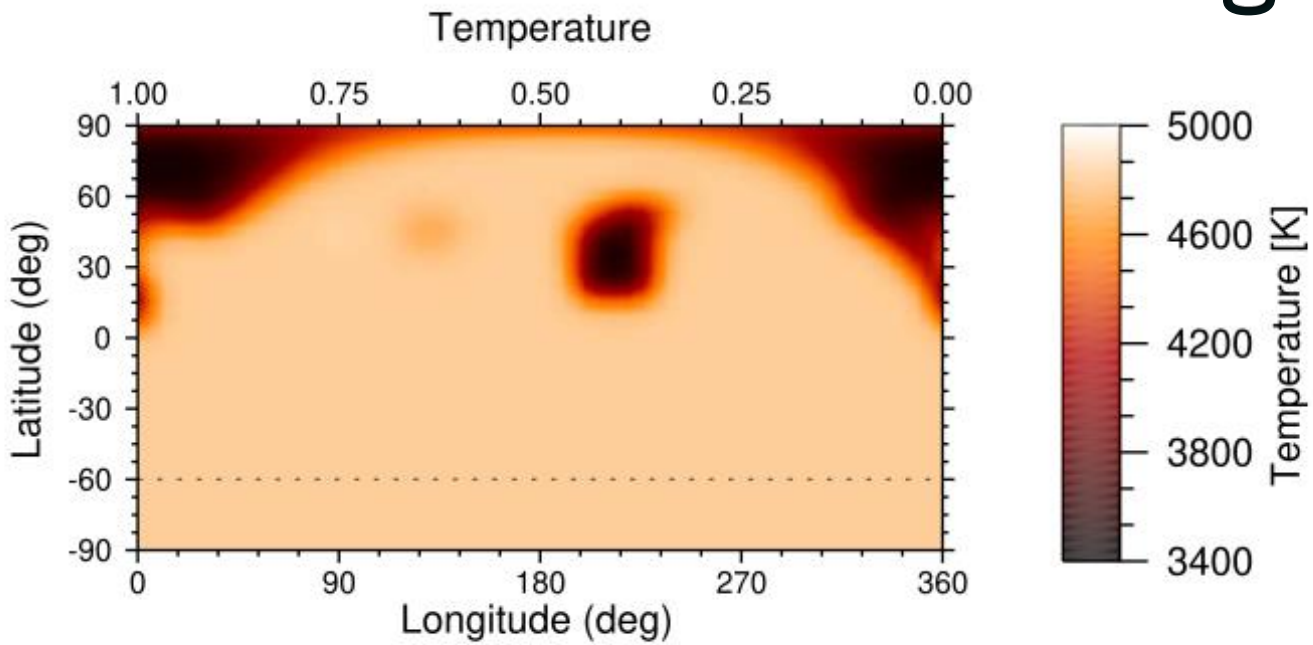
DI Psc



T_{eff} [K]	4600.74
$\log g$	2.28
[Me/H]	0.04
v_{mic} [km/s]	1.62
v_{mac} [km/s]	5.78
$v \sin i$ [km/s]	44.65



II Peg

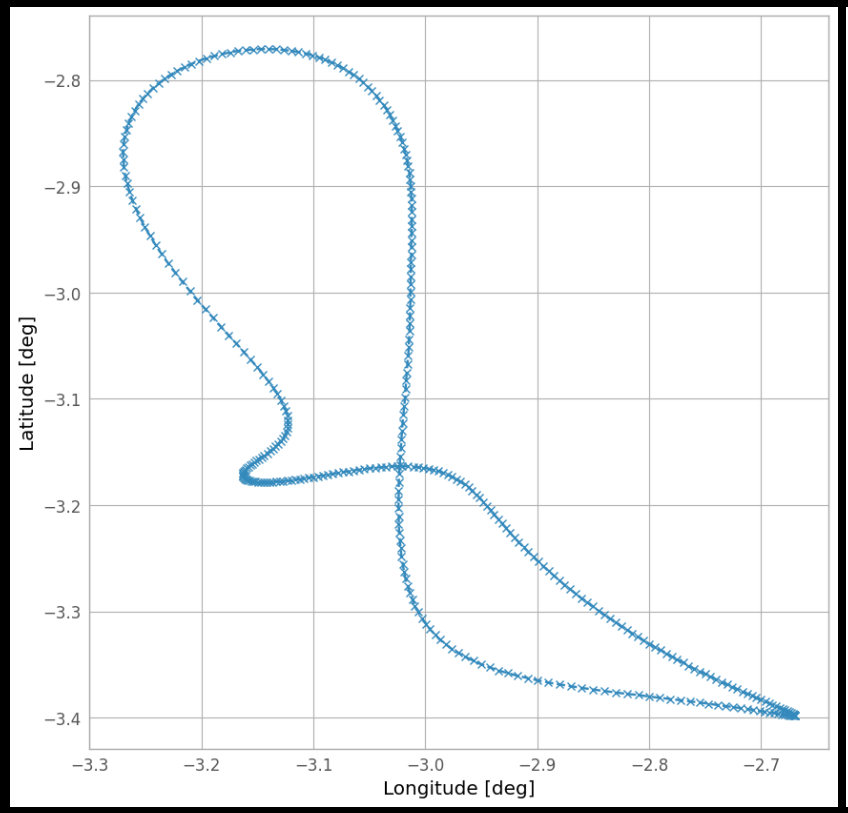


T_{eff} [K]	4832.86
$\log g$	3.8
[Me/H]	-0.11
v_{mic} [km/s]	1.31
v_{mac} [km/s]	5.63
$v \sin i$ [km/s]	28.67

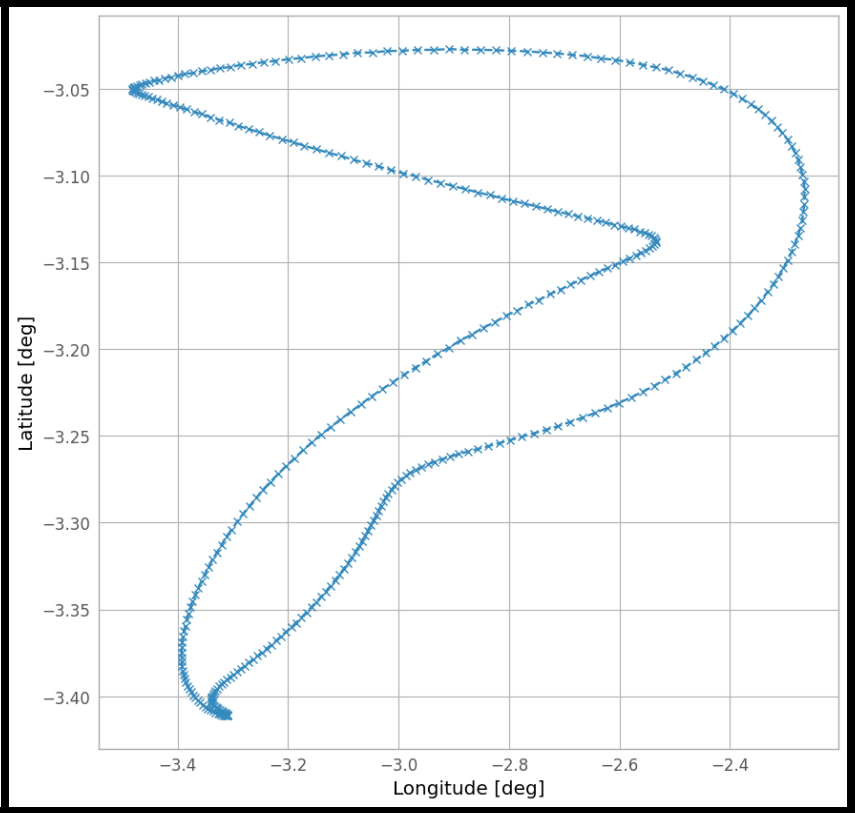
PHOTOCENTER

CALCULATING THE SHIFTS

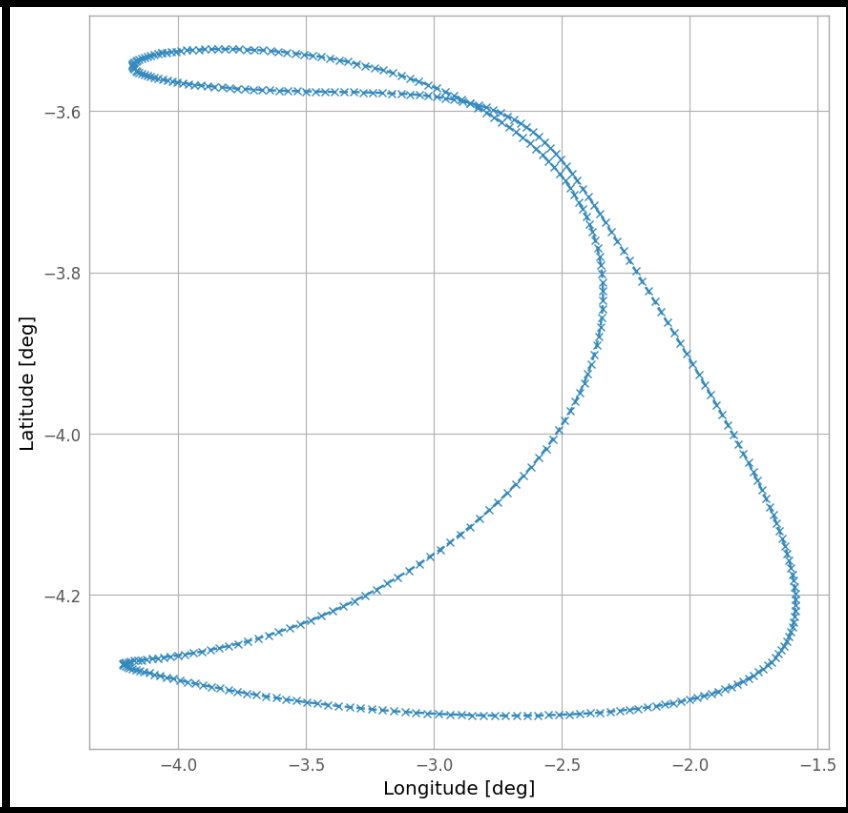
- Python code to calculate the coordinates of the photocenter for each star in at least 180 different rotational phases
- Calculates the angular diameter of the distance between the two farthest point of the curve
- With this the maximum angular variation of the photocenter can be determined



V889 Herculis



DI Piscium



II Pegasi

RESULTS

Star	Gaia DR3 error [mas]	Angular size of the shift [mas]
V889 Herculis	0.0188	0.0012
DI Piscium	0.0261	0.0065
II Pegasi	0.0504	0.0118

A factor of 4 and 2-2.5 difference!

CONCLUSION

- Photocenter shifts caused by starspots and stellar rotation can theoretically affect the precision of parallax measurements
- We showed that this indeed can be the case with certain spot configurations
- We conclude that certain asymmetrical spot configurations which not uncommon could be in the order of the Gaia parallax measurement errors
- In the case of the expected higher precision of DR4 in the future the shifts might exceed the errors

eas 2024 Padova

Photocenter shifts caused by magnetic activity

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HUN-REN Hungarian Research Network

KONKOLY

Method

Observational data

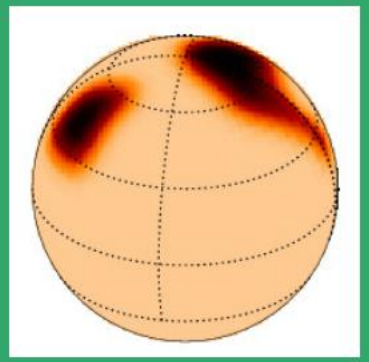
Our spectra were taken with the R=21000 resolution echelle spectrograph mounted on the 102 cm Ritchey–Chrétien–Coudé telescope at Piszkéstető Observatory, Hungary. Most of the data were gathered in 2021. We reduced the spectra with standard reduction steps. Wavelength calibration was done with respect to a ThAr lamp.

Picture 1: The 1 meter teselcope dome at Piszkés Observatory

Spectral Synthesis

II Peg

Animation

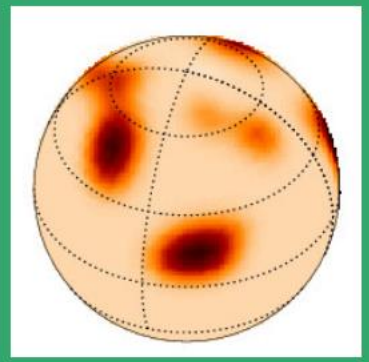


About the star

II Pegasi is an RS CVn type variable sub-giant of a spectral type of K2IV. It has a period of P=6.72 days and a radius of 3.4 R the primary

DI Psc

Animation

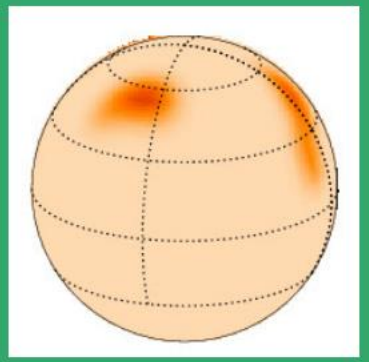


About the star

DI Piscium is a FK Com-like giant with the spectral type of K1III. It has a period of P=18.02 days and a radius of 19.6 R e star has high

V889 Her

Animation



About the star

The V889 Herculis (HD 171488, HIP 91043) is a BY Dra type, young (30-50 million years old) Sun analogue variable star of ectral class of

Contact

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References

1.) Jeff A. Valenti and Debra A. Fischer 2005 ApJS 159 141

2.) Kriskovics, L. et al., A&A 627, A52 (2019)

Conclusion

Photocenter shifts caused by starspots and stellar rotation can theoretically affect the precision of parallax measurements. We showed that this indeed can be the case with certain spot configurations.

- **V889 Herculis:** In this case the photocenter shift was an order of magnitude lower than the measurement errors of the parallax in Gaia DR3. It is not unexpected that this effect is not prominent in case of dwarfs.

TAKE HOME MESSAGE

- With Doppler Imaging we can recreate the surface of distant stars
- We can „see” the spots which is cool!
- Maybe they are causing error in parallax data ⇨ we will find out!