Ankara University
Kreiken Observatory

Surface Inhomogeneities of the Eclipsing Binary System ER Vulpeculae

Observing Techniques, Instrumentation and Science
For Metre-Class Telescopes II

Tatranská Lomnica, Slovakia
September 24 - 28, 2018

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Telescope and Instruments

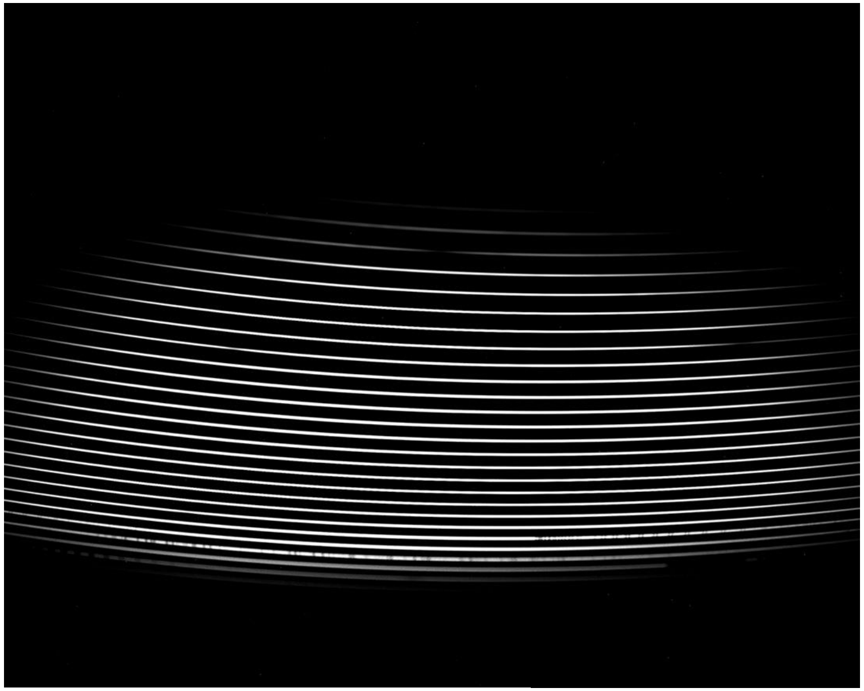
Kreiken Telescope (Meade LX200 16")

Technical Specifications

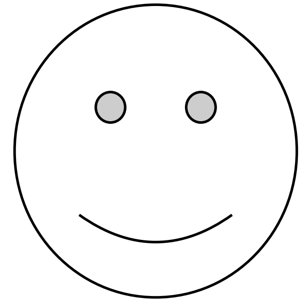
Diameter: 406 mm
Focal Ratio: f/10
Focal length: 4064 mm
Image scale: 51 arcsec/mm
Manufacturer: Meade Instruments Corp., California

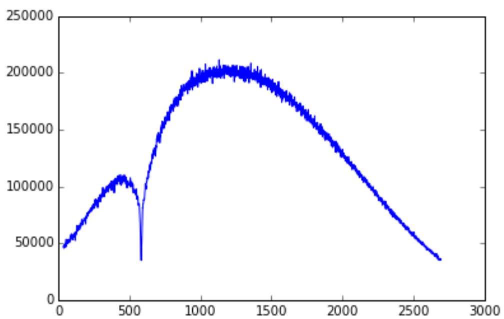
Focal Plane Instruments

- eShel Spectrograph (Shelyak Instruments), R~14000, Wavelength Range: 4340-7400 Å, Brightness Limit V < 8.0 mag
- Fiber Injection and Guiding Unit (f/6)
- Halogen, LED and Thorium-Argon lamp calibration unit
- QSI 660ws CCD camera
- 2758 x 2208 pixel 4.54 micron Sony ICX694 chip
- Autoguider system
- Various eye-pieces



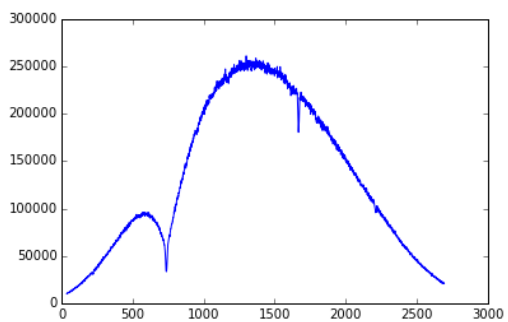
First Light β Leo m_v= 2.1 - 90 Sec (06.04.2016)





Vega - H_β

Vega - H_α

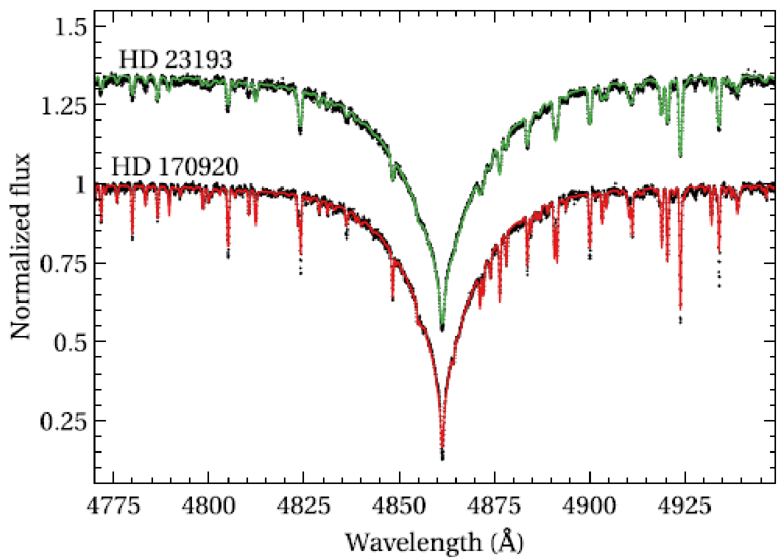


Some of Our Studies From This Setup

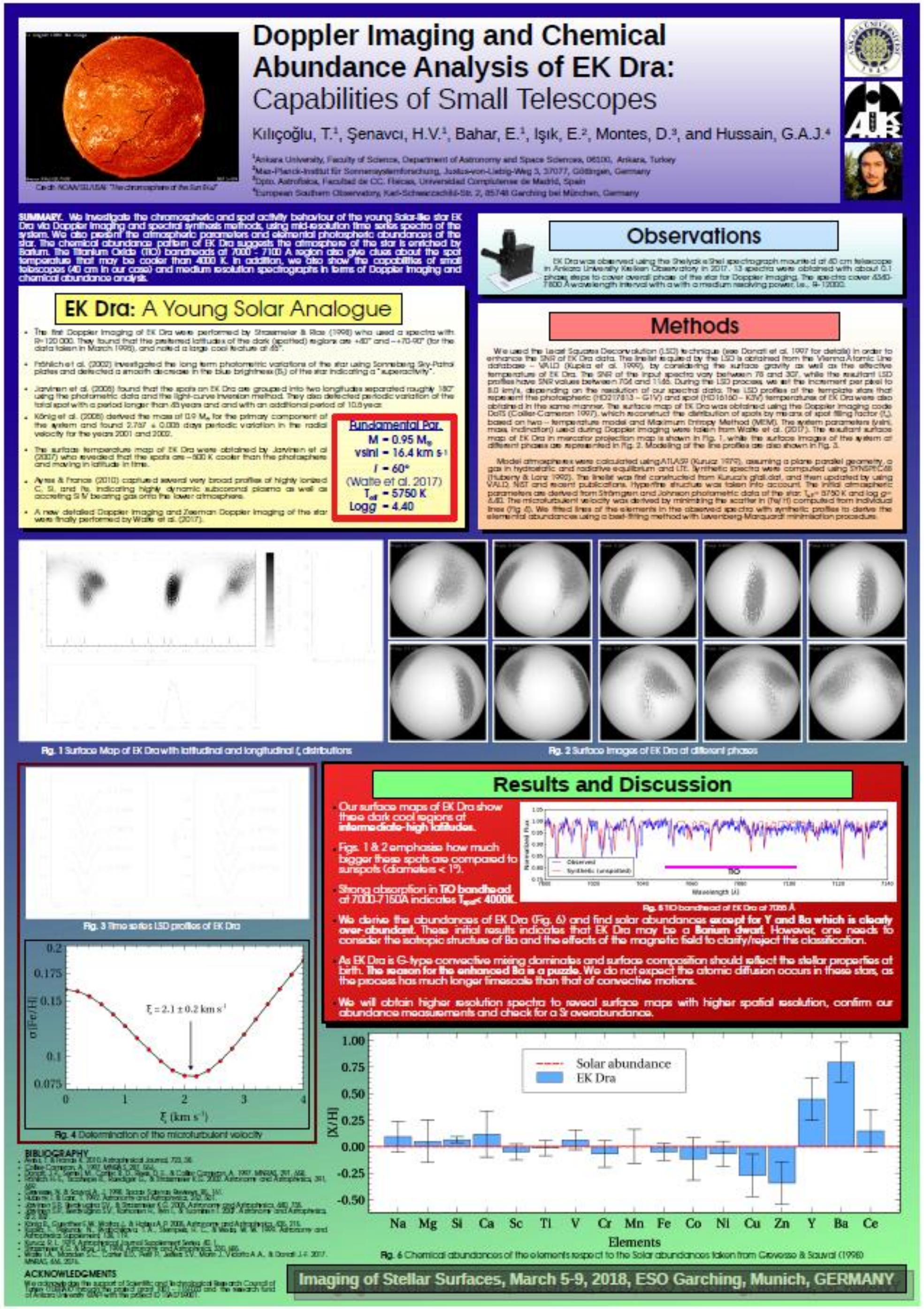
The Astrophysical Journal, 852:116 (5pp), 2018 January 10
https://doi.org/10.3847/1538-4357/aa9f14

Behavior of Abundances in Chemically Peculiar Dwarf and Subgiant A-Type Stars: HD 23193 and HD 170920*

Tolgahan Kılıçoğlu, Şeyma Çalışkan[1], and Kübraözge Ünal
Ankara University, Science Faculty, Department of Astronomy and Space Sciences, 06100, Ankara, Turkey; seyma.caliskan@science.ankara.edu.tr
Received 2017 October 9; revised 2017 November 30; accepted 2017 November 30; published 2018 January 12



HD 23193 and HD170920 H_{β} profiles and theoretical model



05 - 09 March 2018 ESO Garching Germany “Imaging of Stellar Surfaces” poster

(DOI: 10.5281/zenodo.1220763).

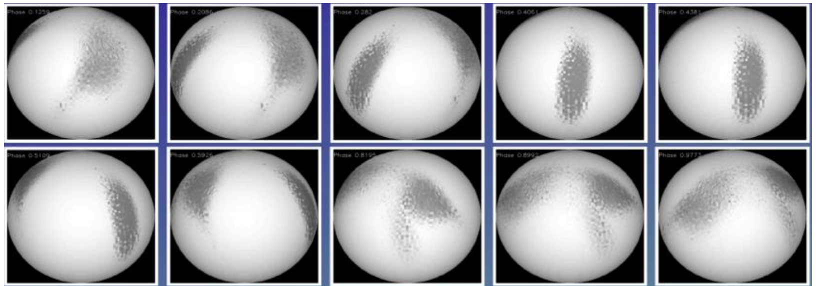


Fig. 2 Surface images of EK Dra at different phases

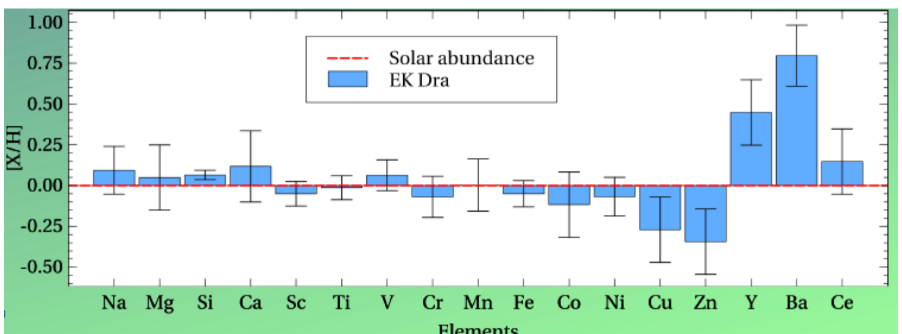


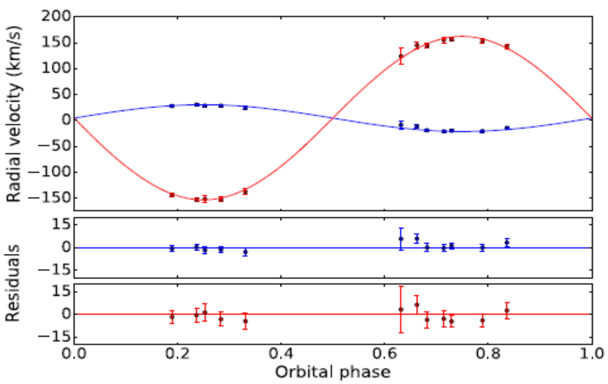
Fig. 6 Chemical abundances of the elements respect to the Solar abundances taken from Grevesse & Sauval (1998)

Astrophys Space Sci (2018) 363:34
https://doi.org/10.1007/s10509-018-3252-y

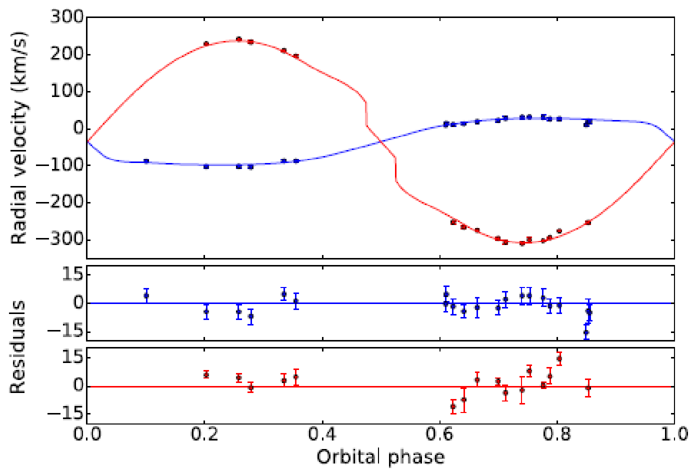
ORIGINAL ARTICLE

A simultaneous spectroscopic and photometric study of two eclipsing binaries: V566 Oph and V972 Her

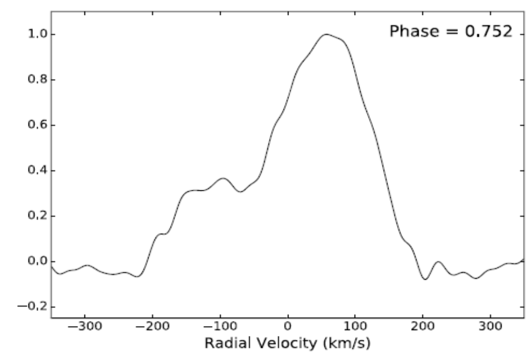
S.O. Selam[1,2] · E.M. Esmer[1,2] · H.V. Şenavcı[1,2] · E. Bahar[1,2] · O. Yörükoğlu[1,2] · M. Yılmaz[1,2] · Ö. Baştürk[1,2]



Radial velocity curve and theoretical model of V972 Her



Radial velocity curve and theoretical model of V566 Oph



V972 Her'in Broadening Function (phase= 0.752)

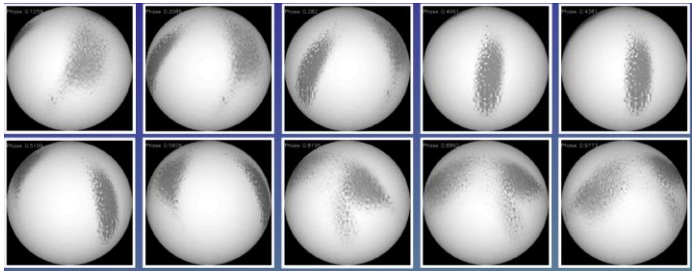
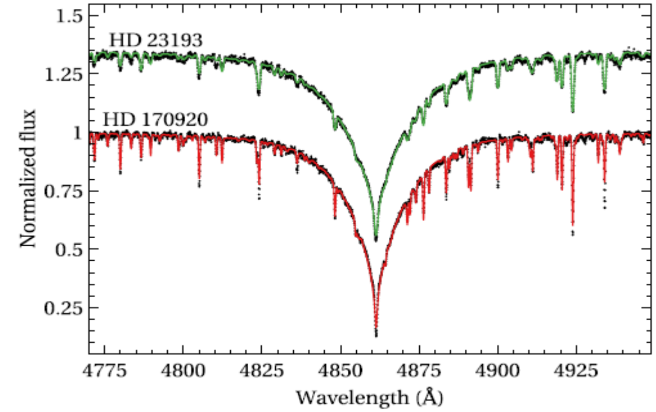
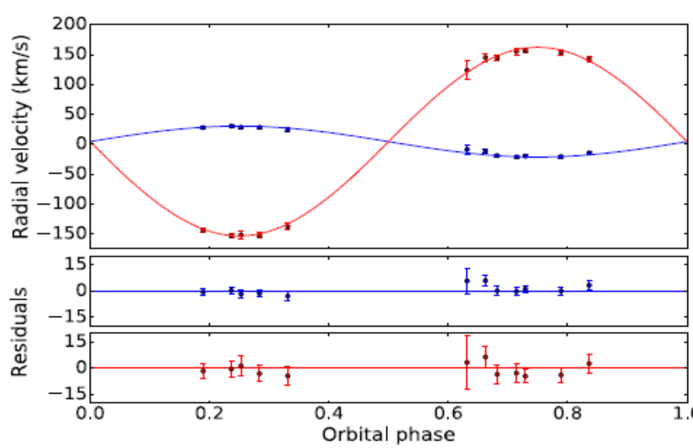
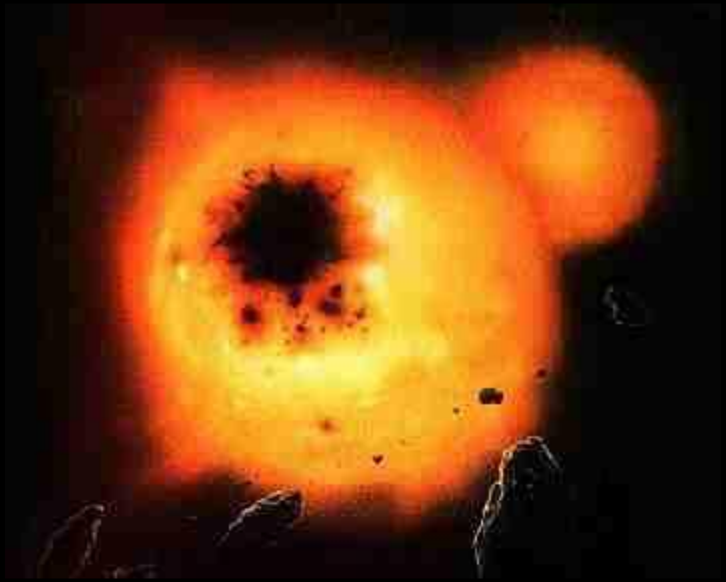


Fig. 2 Surface images of EK Dra at different phases





Why ER Vul ?

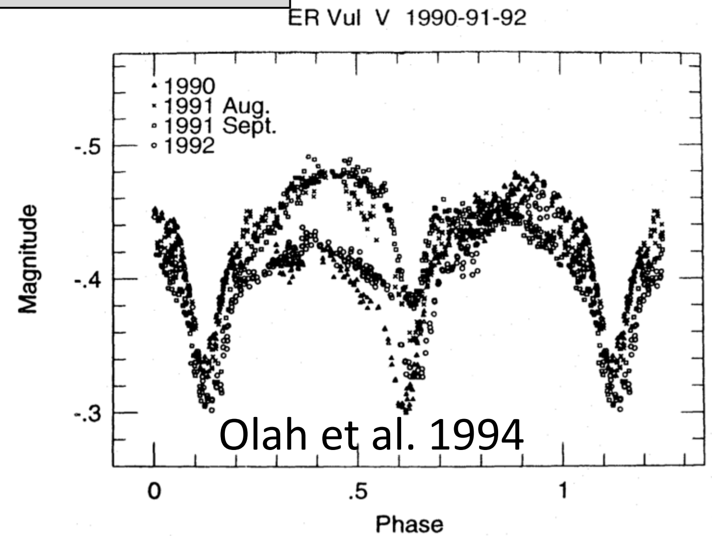


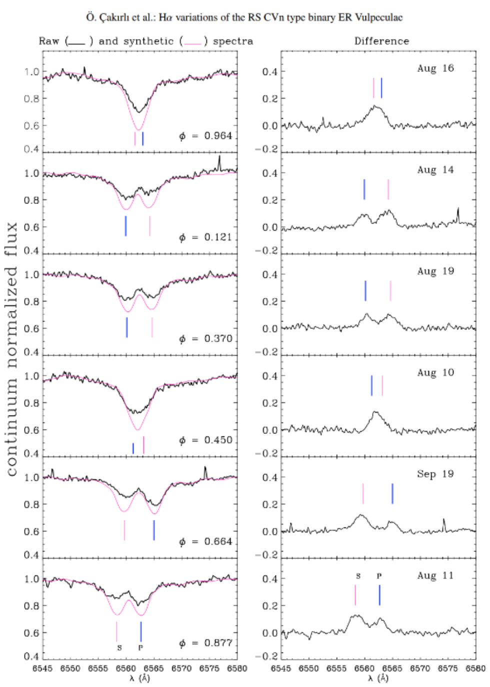
Credit: Martin Tsarev
(http://www.sv-cam.smolyan.info/rscvn.html)

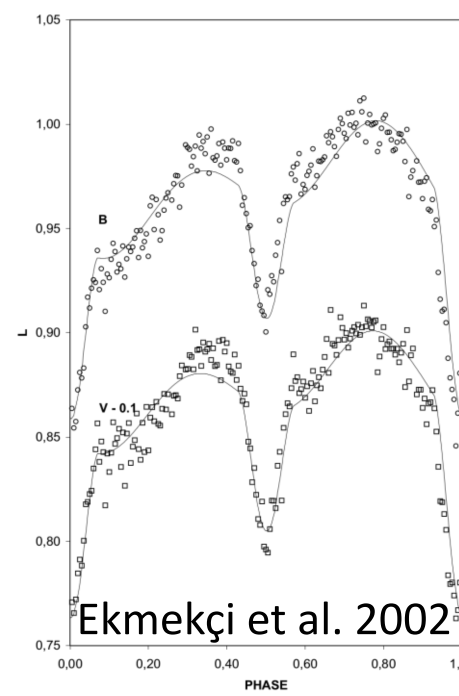
- Convenient for our setup (brightness) and is known to be magnetically active.
- Sun-like stars, G0V primary and G5V secondary
- Short-period (~0.7^d) RS CVn-type binary system.
- Primary star nearly fills its Roche lobe, but the binary system is still detached (Duemmler et al. 2003) .
- ER Vul is identified as a pre-contact binary system (Dryomova, Perevozkina & Svechnikov 2005)

Some Light Curves of ER Vul

- Hall (1976) → RS CVn type
- Olah et al. (1994), Ekmekçi,et al. (2002) and Wilson & Raichur (2011) → Light curve
- Çakırlı et al. (2003)→ the secondary star is more active than the primary one.

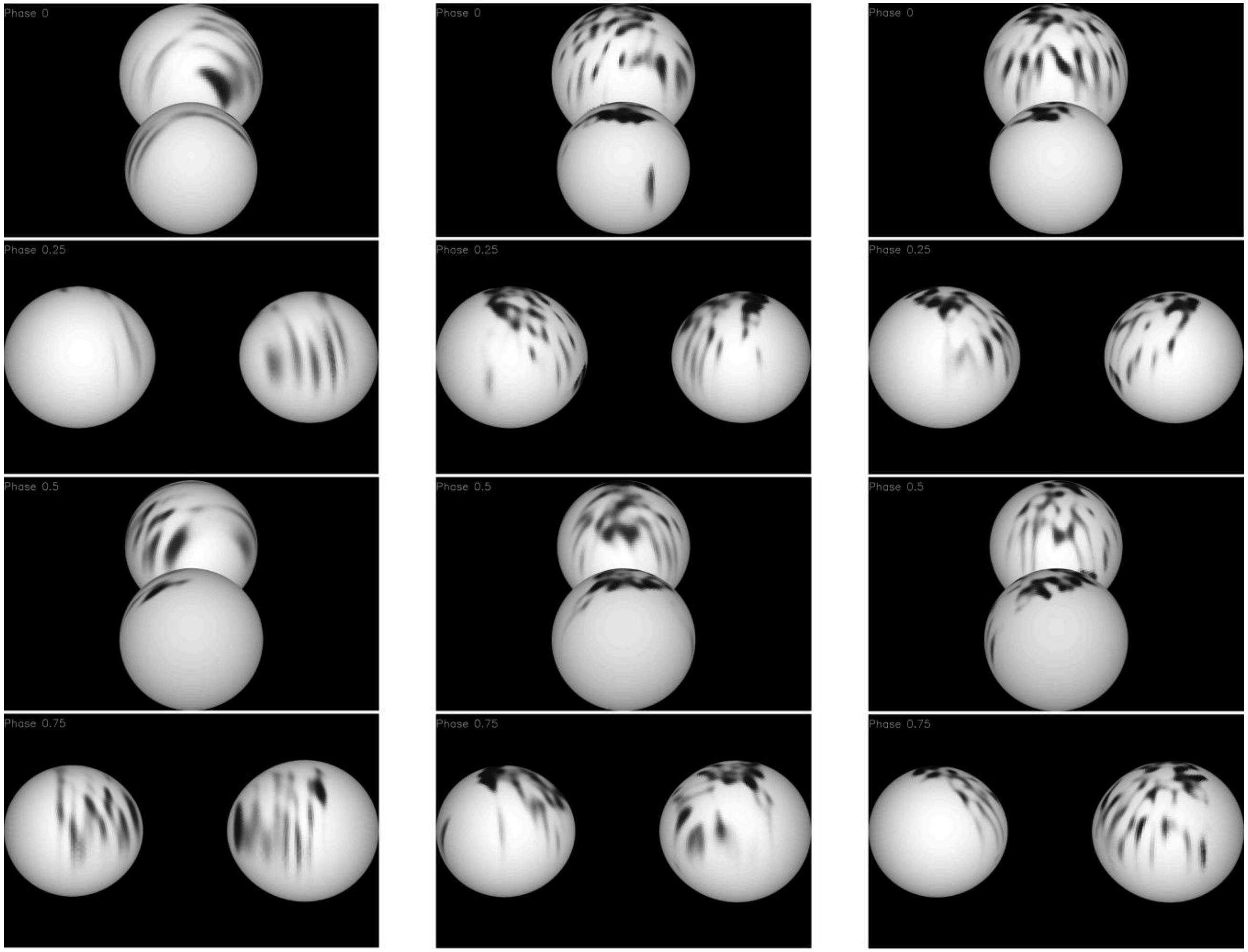






Piskunov → 1996, 2001 and 2008 and performed Doppler imaging

Xiang 2015 → the most recent Doppler imaging



(a) (b) (c)

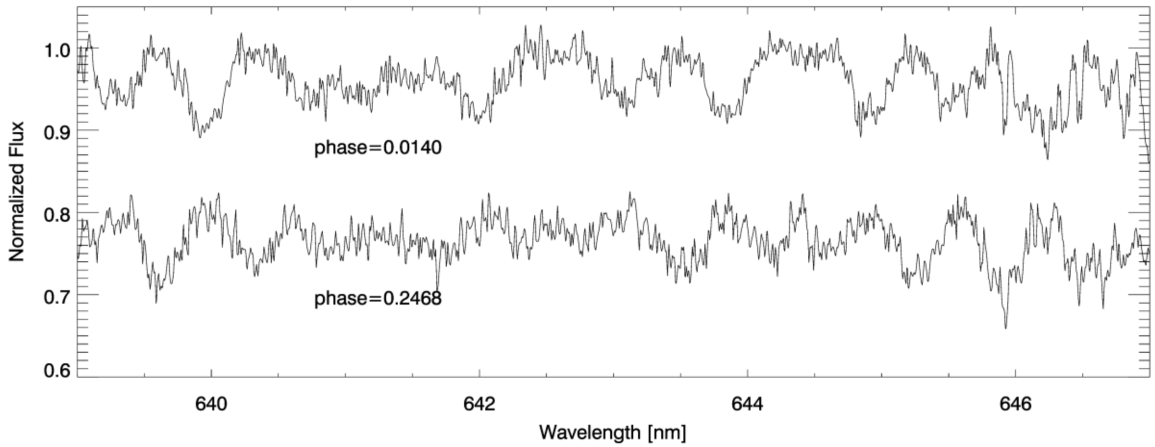
Observations

Table 1. Log of spectroscopic observations.

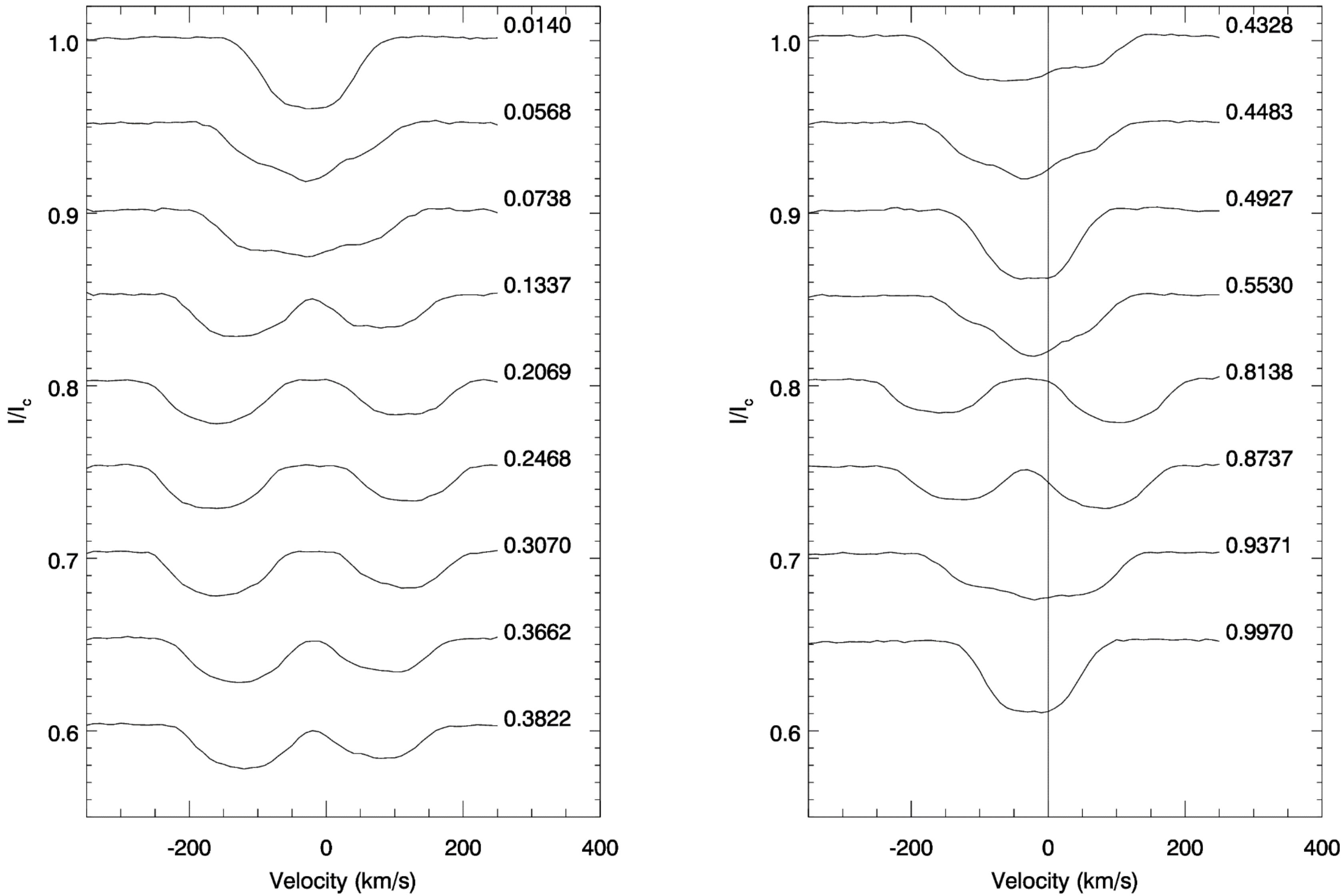
Date	HJD-2400000 Mid Time	Phase	SNR Input	SNR LSD
01/07/18	58301.3235	0.0140	77.78	1588
01/07/18	58301.3653	0.0738	71.22	1641
01/07/18	58301.4071	0.1337	58.76	1532
01/07/18	58301.4582	0.2069	94.86	1922
04/07/18	58304.3618	0.3662	84.55	1857
04/07/18	58304.4083	0.4328	80.16	1766
04/07/18	58304.4501	0.4927	75.07	1603
04/07/18	58304.4922	0.5530	67.67	1610
06/07/18	58306.3727	0.2468	77.72	1756
06/07/18	58306.4147	0.3070	99.14	1781
06/07/18	58306.4672	0.3822	77.06	1806
06/07/18	58306.5134	0.4483	62.39	1686
17/07/18	58317.3260	0.9371	85.31	1732
17/07/18	58317.3678	0.9970	65.51	1549
17/07/18	58317.4096	0.0568	58.35	1508
19/07/18	58319.3342	0.8138	86.46	1834
19/07/18	58319.3760	0.8737	81.13	1771

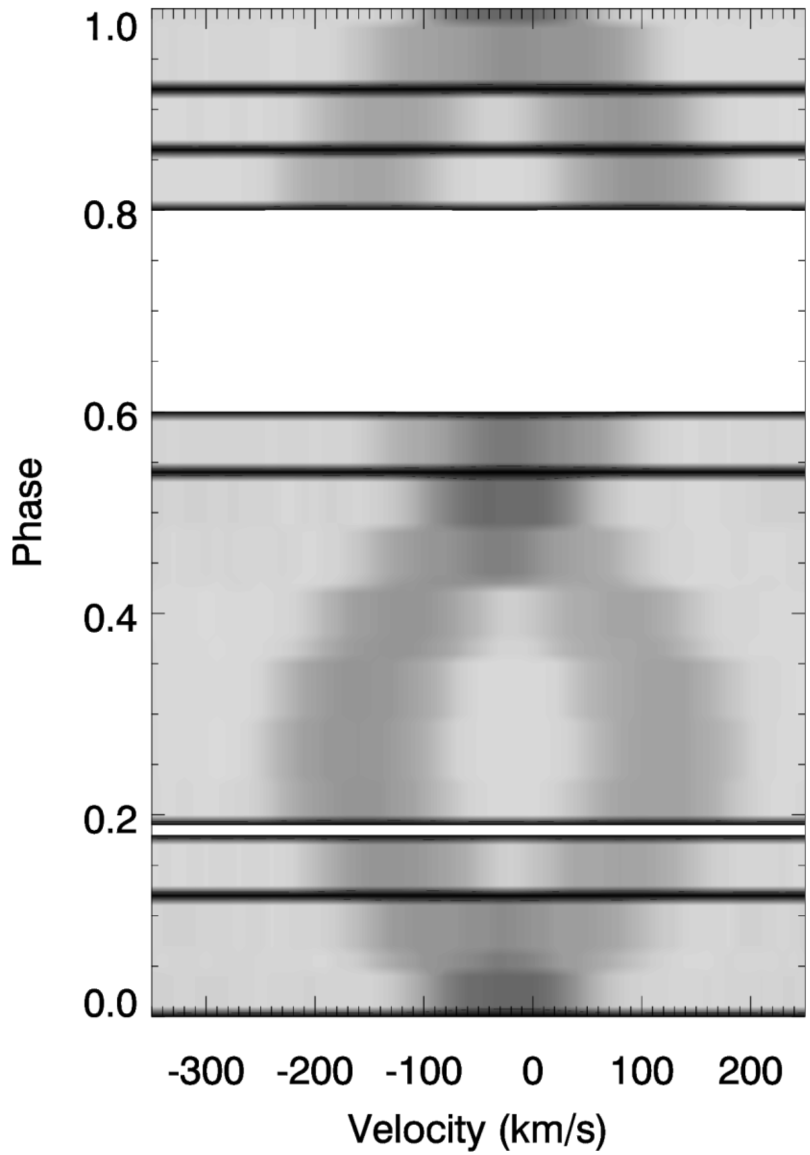
Because the two-temperature model is used in our image reconstruction, we also observed several inactive slowly rotating template stars by using the same instrument setup.

- Primary photosphere temp (6000 K) ==> HD 143761
- Secondary photosphere temp (5750 K) ==> HD 139777
- Spot temp (5000 K) ==> HD 32147



- In order to increase the S/N of the observed spectra, we used the Least - Squares Deconvolution technique (LSD; Donati et al. 1997)
- This technique to combine all available photospheric lines in each spectrum.
- The line list for ER Vul and standard stars were obtained from Vienna Atomic Line Database (VALD; Kupka et al. 1999).





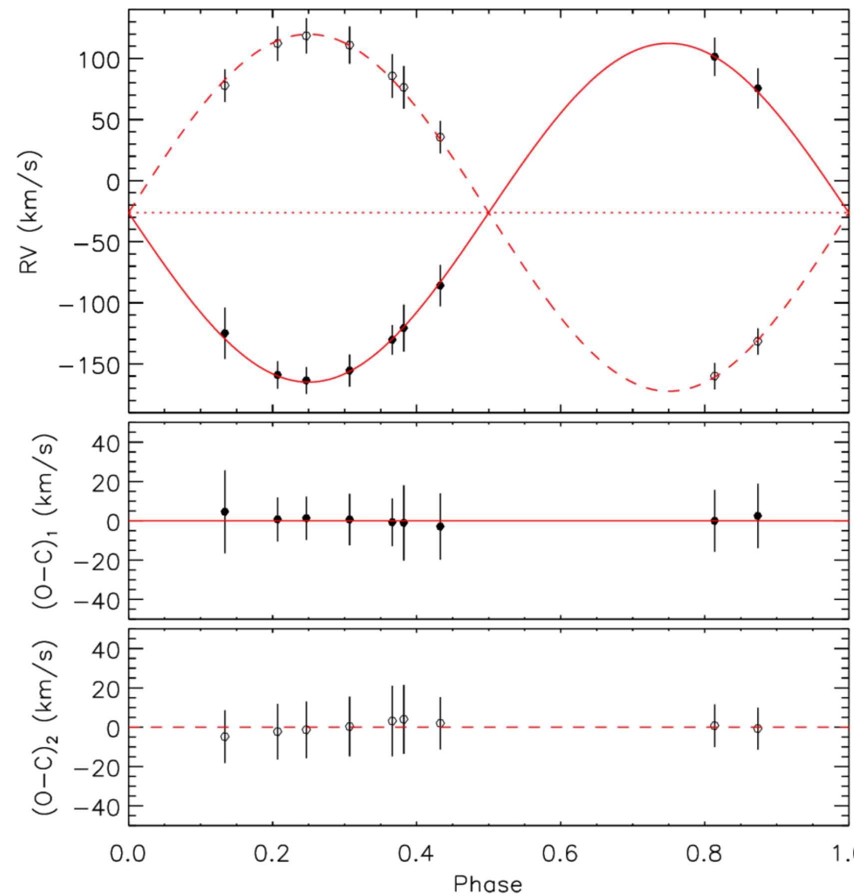
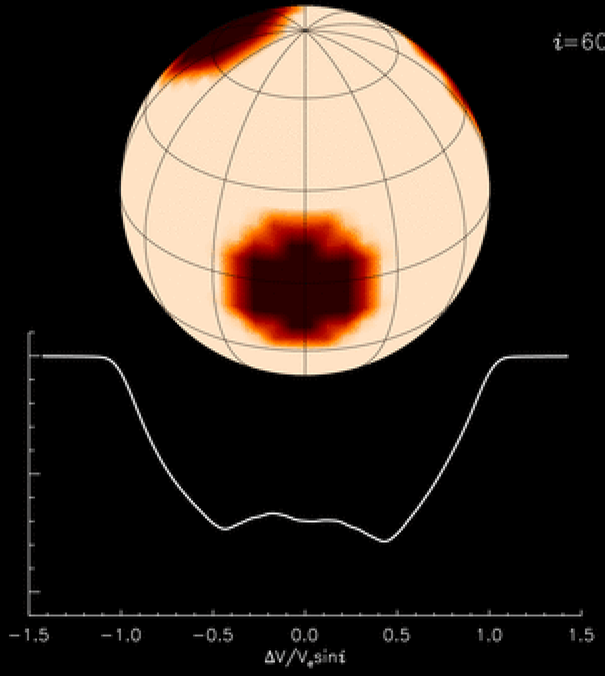


Table 2. Some parameters of ER Vul.

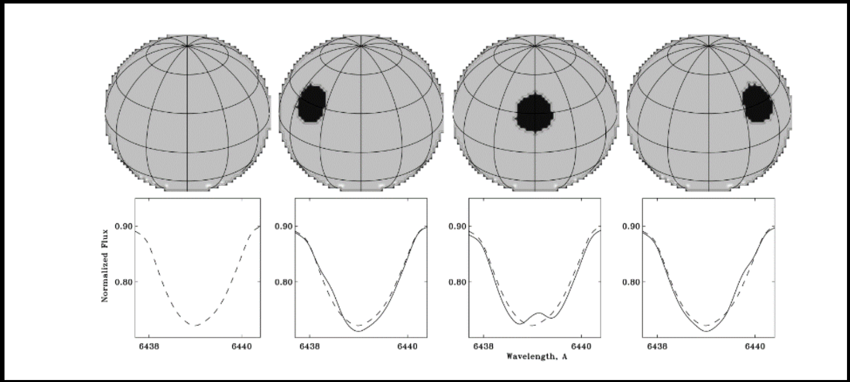
Parameter	Value	Reference[1]
$q = M_2/M_1$	0.949 ±0.056	This Study
$K_1(km/s)$	138.67 ±6.18	This Study
$K_2(km/s)$	146.13 ±8.70	This Study
i [°]	66.63	a
V_γ [km/s]	-26.26 ±3.72	This Study
$T_0(HJD)$	2445220.40964	This Study
$P(d)$	0.698095	This Study
$T_{\rm eff,1}(K)$	6000	a
$T_{\rm eff,2}(K)$	5750	a

Reference: a. Harmanec et al. (2004).

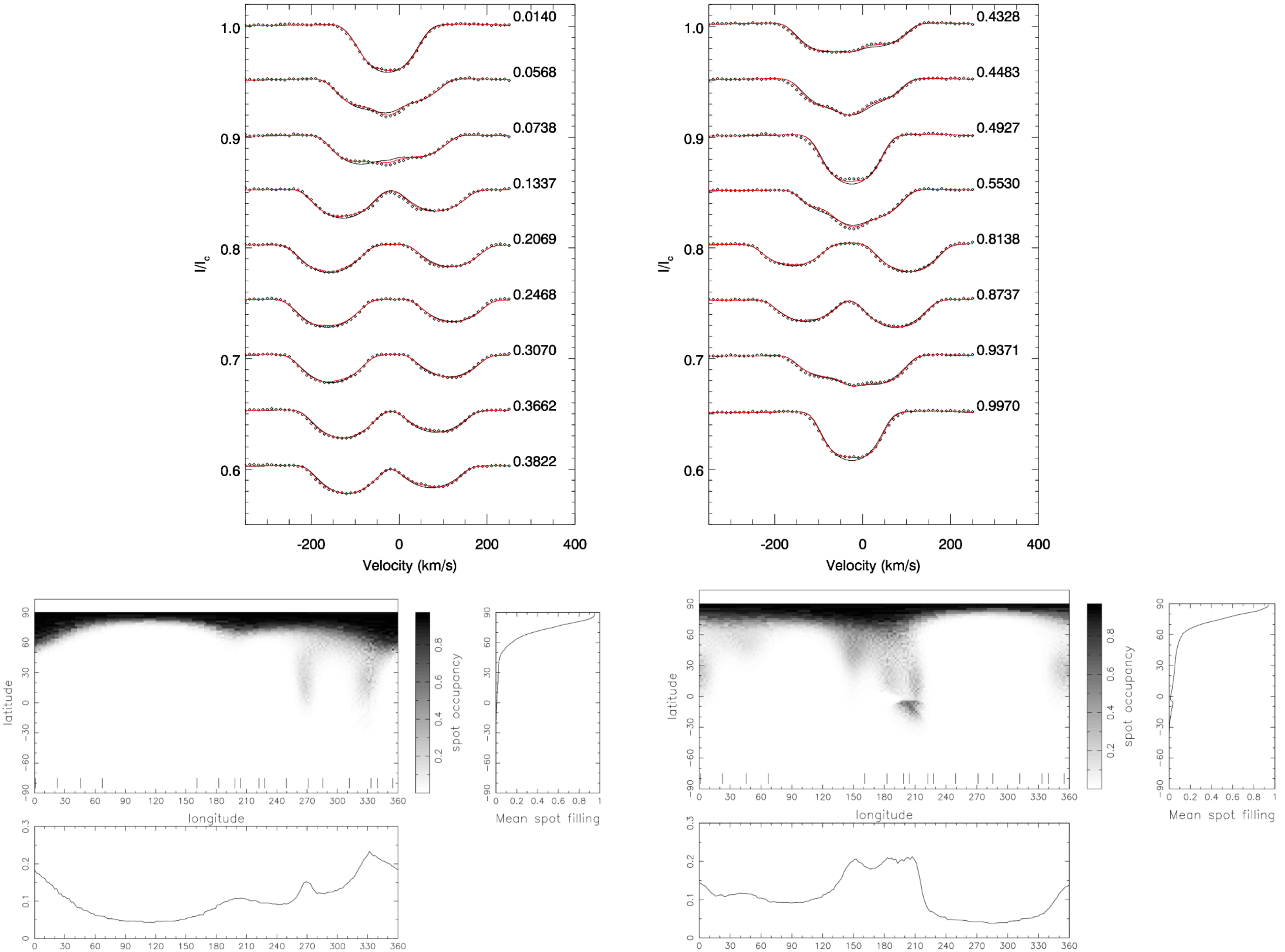
Doppler Imaging



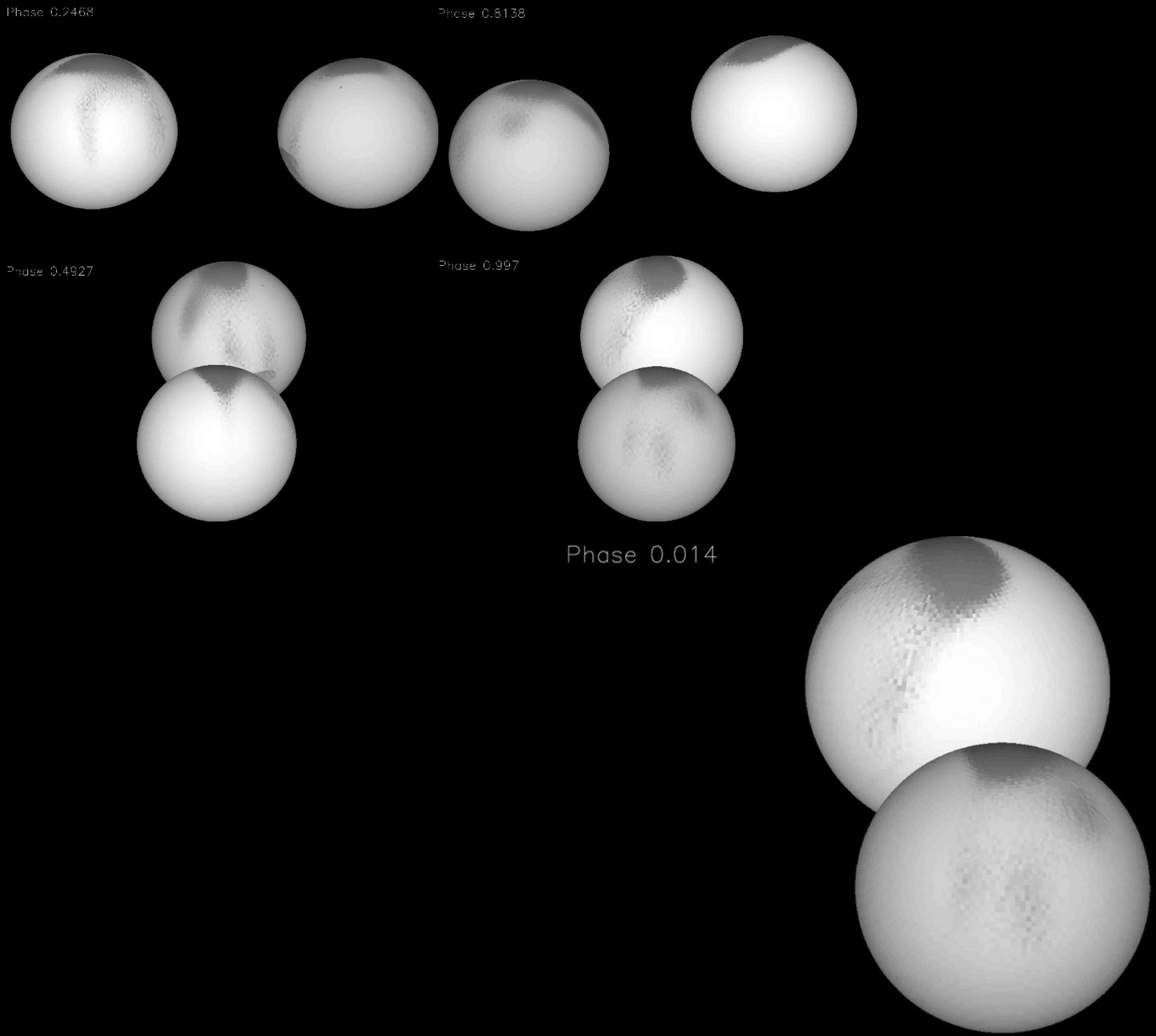
http://www.astro.uu.se/~oleg/di_scheme_a.html



Berdyugina 2005

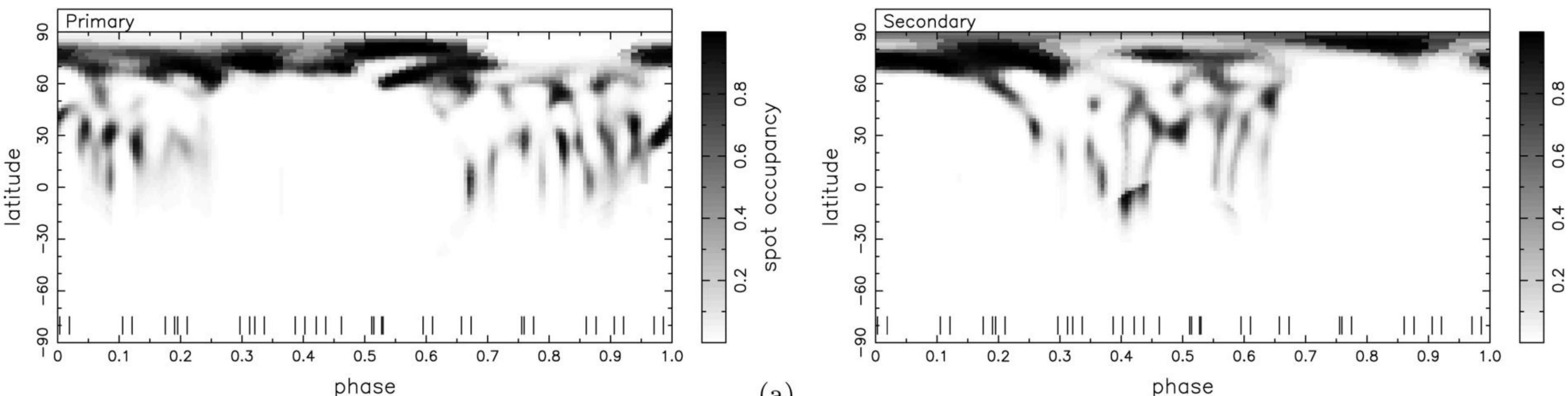


I/I_c
Velocity (km/s)
0.0140
0.0568
0.0738
0.1337
0.2069
0.2468
0.3070
0.3662
0.3822
0.4328
0.4483
0.4927
0.5530
0.8138
0.8737
0.9371
0.9970
latitude
longitude
spot occupancy
Mean spot filling

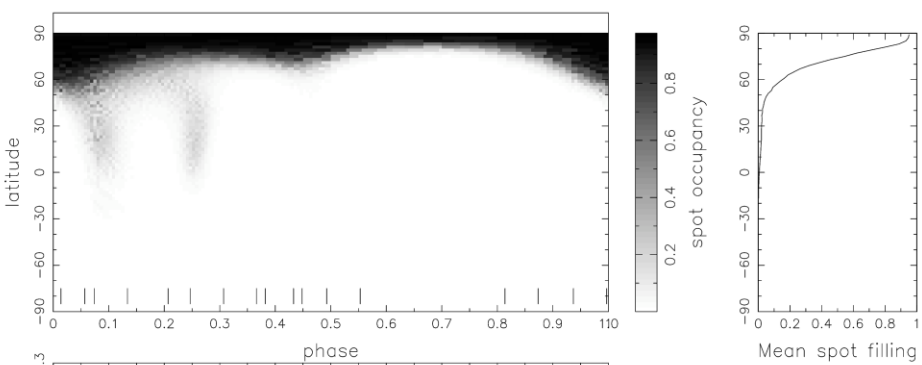

Phase 0.2468
Phase 0.8138
Phase 0.4927
Phase 0.997
Phase 0.014

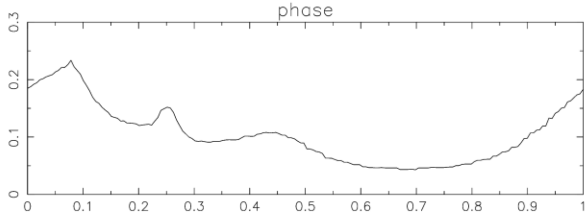
Comparison with latest surface maps from literature

Xiang et al. 2015

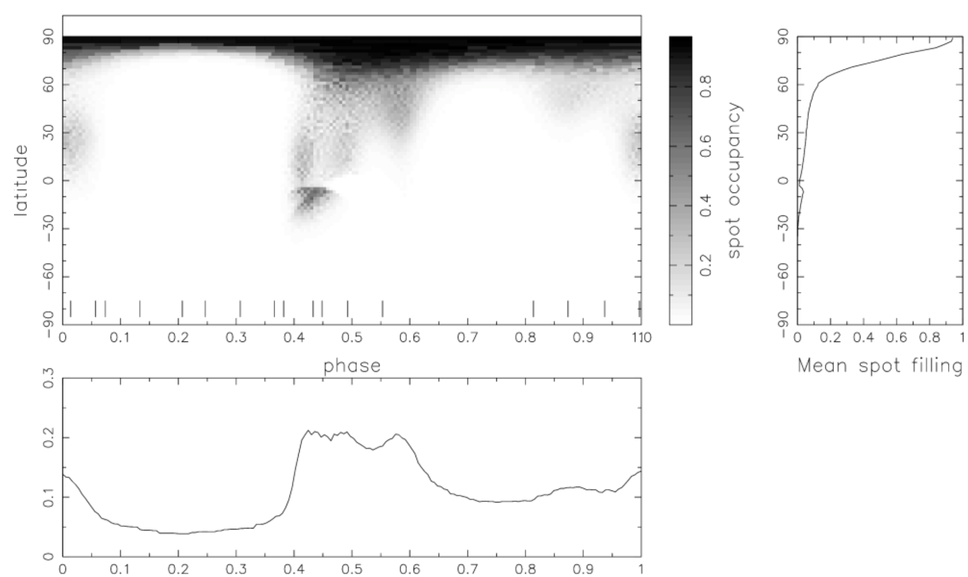


(a)

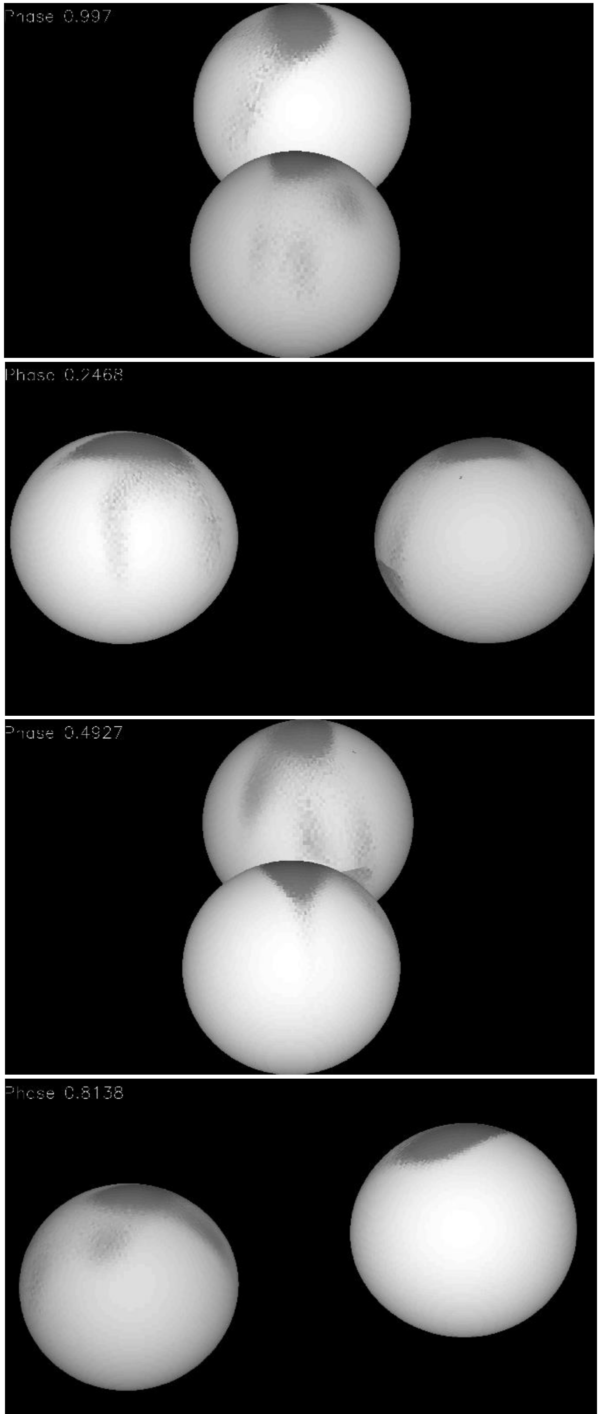




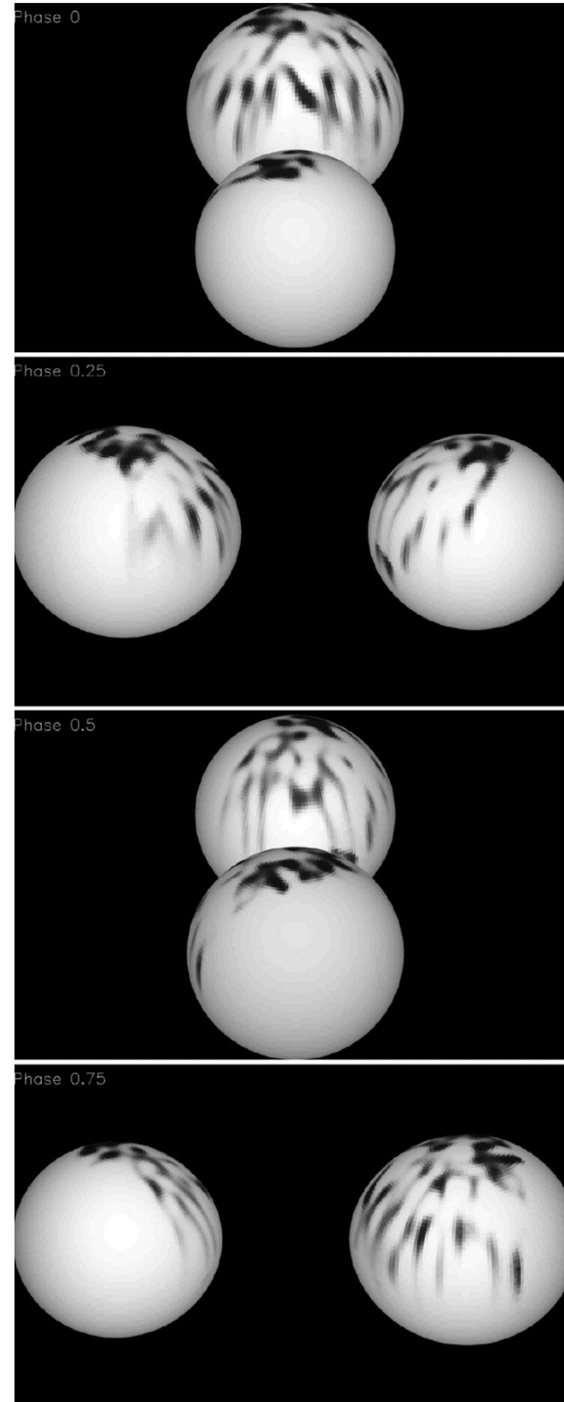
This study



This Study



Xiang et al. (2015)



Thank you very much for your patience…

☺

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