“On the variability of the AU Monocerotis accretion disk”

Lientur Celedón, Astronomy Department, U. of Concepción, Chile

Universe of Binaries, Binaries in the Universe, Telć

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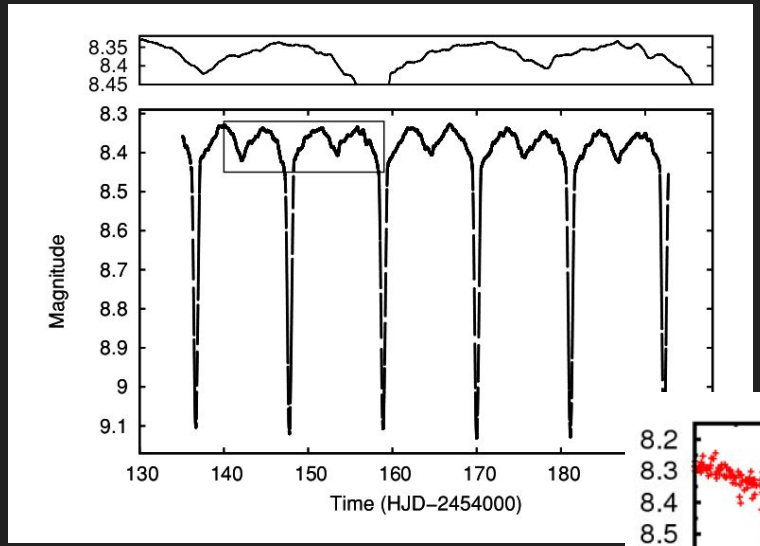
AU Monocerotis

A partially eclipsing Algol-type system with orbital period of 11.113 d.

7.0 solar masses B-type primary and a G-type secondary filling their Roche Lobe.

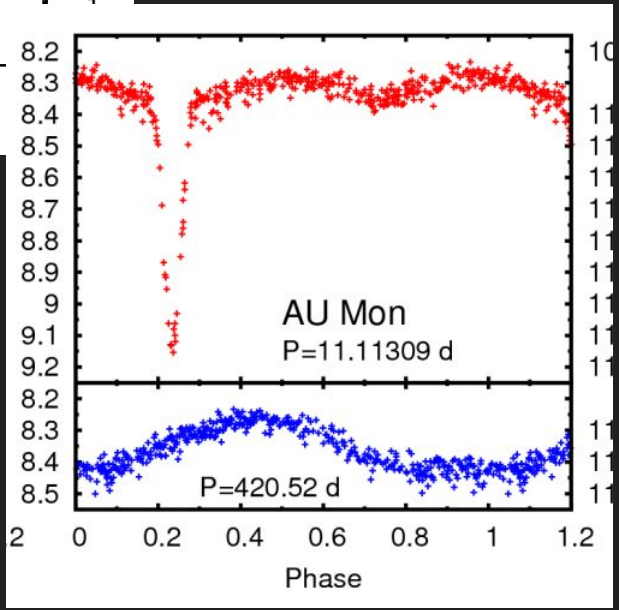
A long photometric cycle of 411 d.

One of the most studied galactic DPVs.



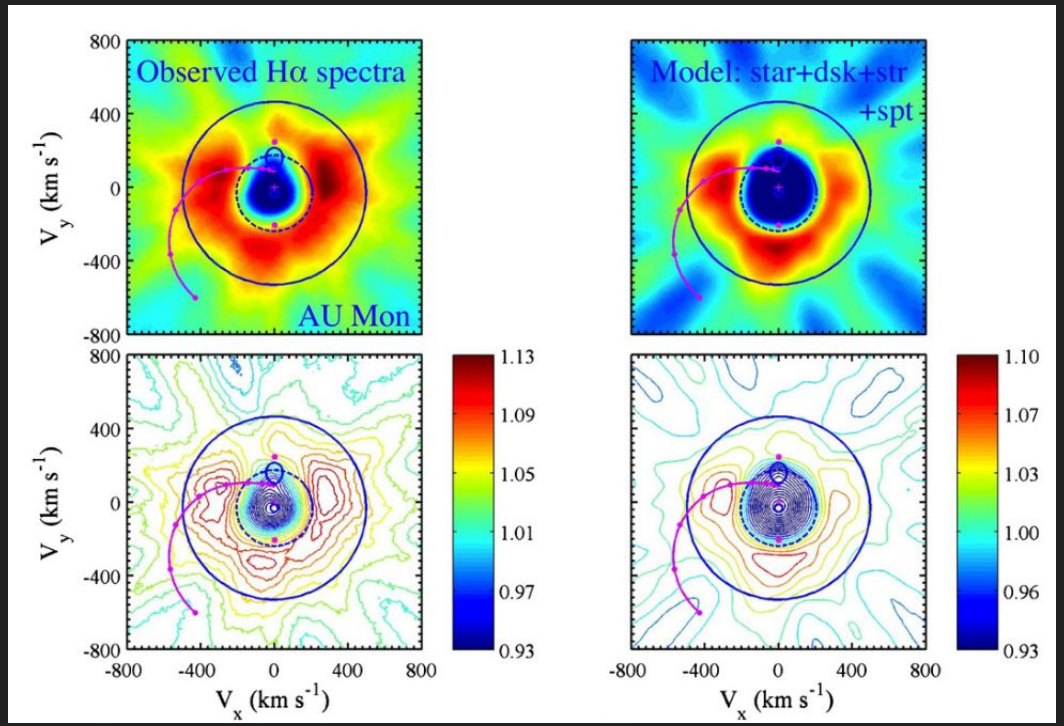
Light curve of AU Mon from the ASAS catalogue after disentangled both periods, G.Michalska, et al, 2009.

Light curve of AU Mon taken with COROT space telescope, Desmet et al, 2010



AU Monocerotis

Atwood et al, 2012, studied the accretion disk of AU Mon through doppler tomography, finding a complex structure.



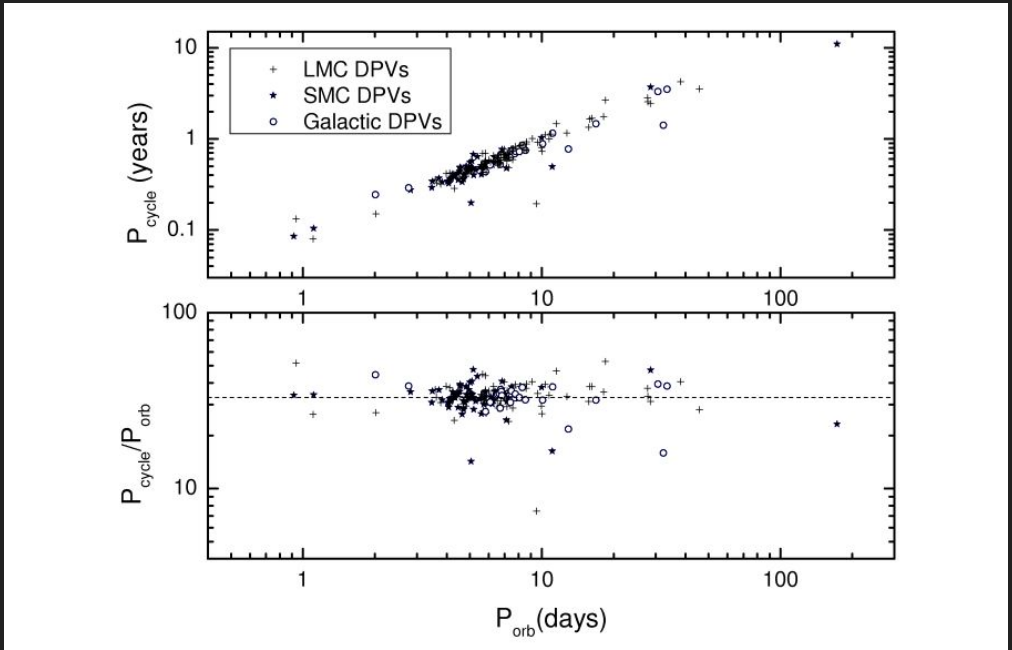
Doppler map of AU Mon (left) and the model (Right). Atwood et al, 2012

Double Periodic Variables

Semi-detached Algol systems, with a B-type dwarf primary accreting matter from a A/F/G type giant secondary through and accretion disk.

Photometric long cycle of unknown origin.

$P_{Lon} \sim 33\ P_{Orb}$

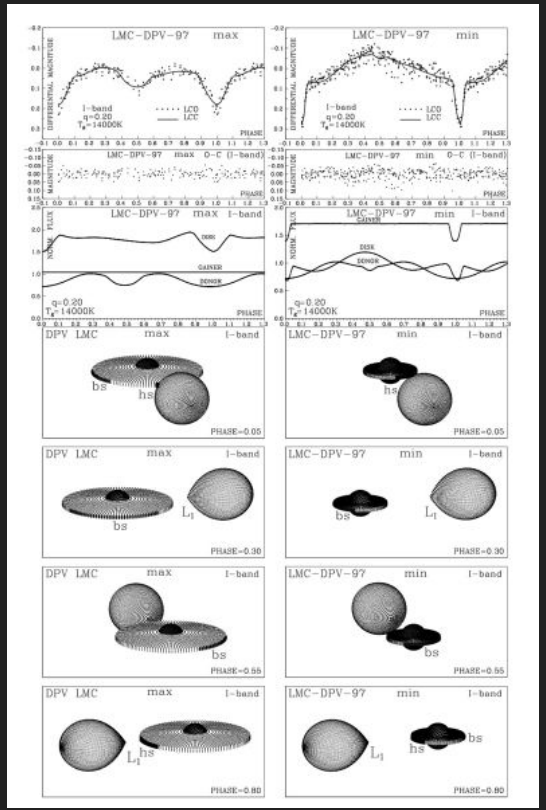


Relation between the orbital period and the long cycle length for Galactic and Magellanic DPVs, Mennickent, 2017.

Evidence for structural changes in DPVs.

Garcés et al. found evidence for structural changes in the accretion disk related with the long photometric cycle in some DPVs.

Could this phenomena occur in other DPVs?



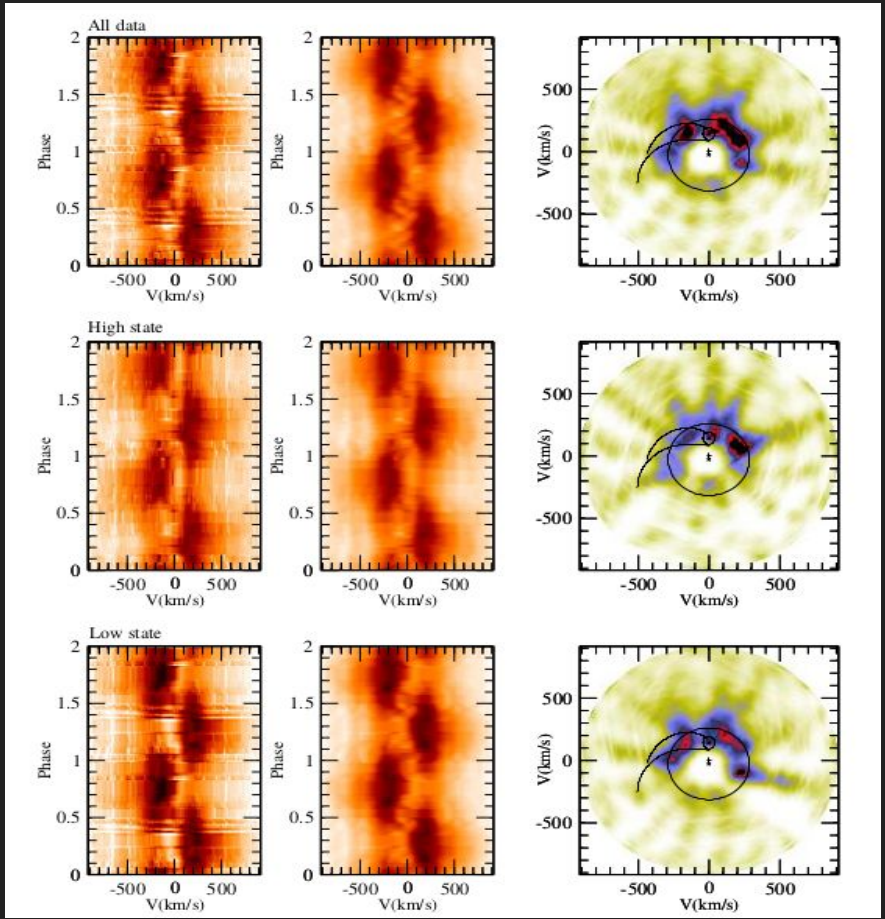
Model for lightcurve of OGLE-LMC-DPV-097 in high (left) and low (right) state, J.Garces et al, 2018

HD 170582

The only DPV with doppler maps in Hα for high and low state.

A horseshoe pattern with emission in the first and second quadrant .

Emission seems to be higher during the low state of the long cycle.



Doppler maps for HD 170582 in high (middle) and low (bottom) state, Mennickent et al, 2016.

Data

Our data include 225 spectra from:

SPM (R~18000) (172)

CORALIE (R ~ 60000) (39)

HARPS (R ~ 115000) (7)

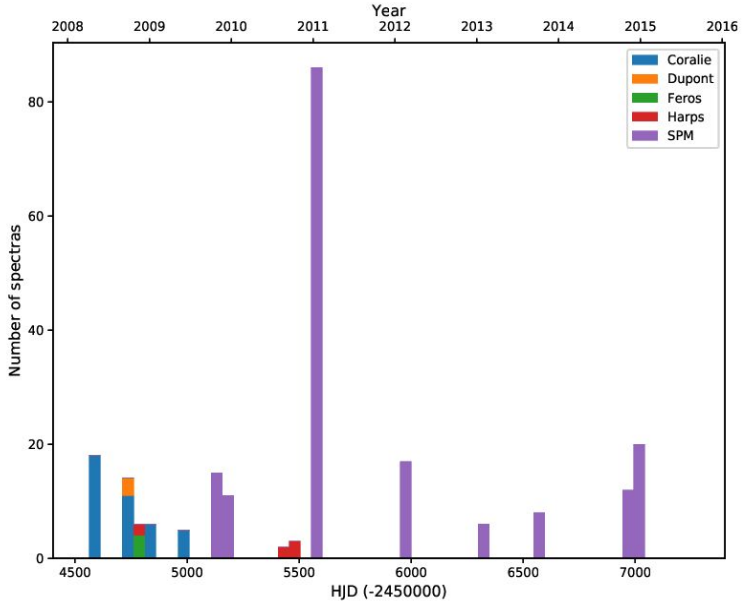
FEROS (R ~ 48000) (4)

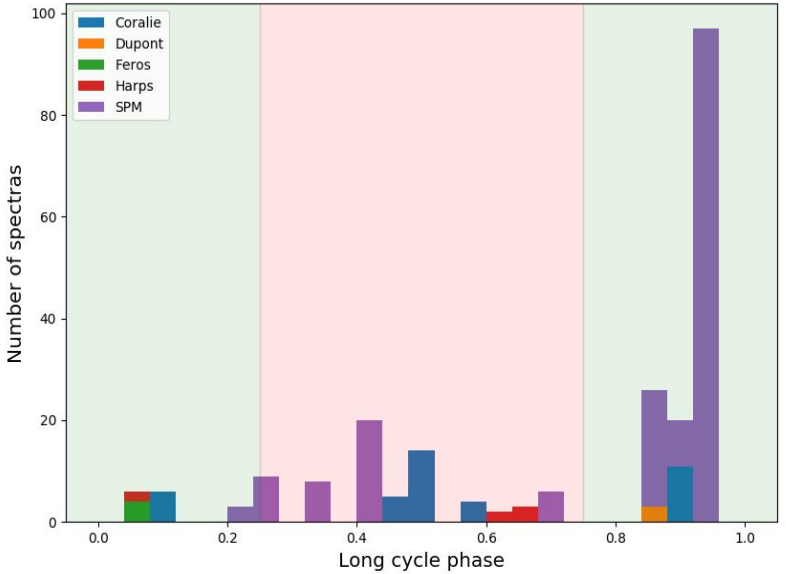
DUPONT (R ~ 40000) (3).

Visual region covered: 3800-7000 Å.

Spectras from 2008 to 2015.

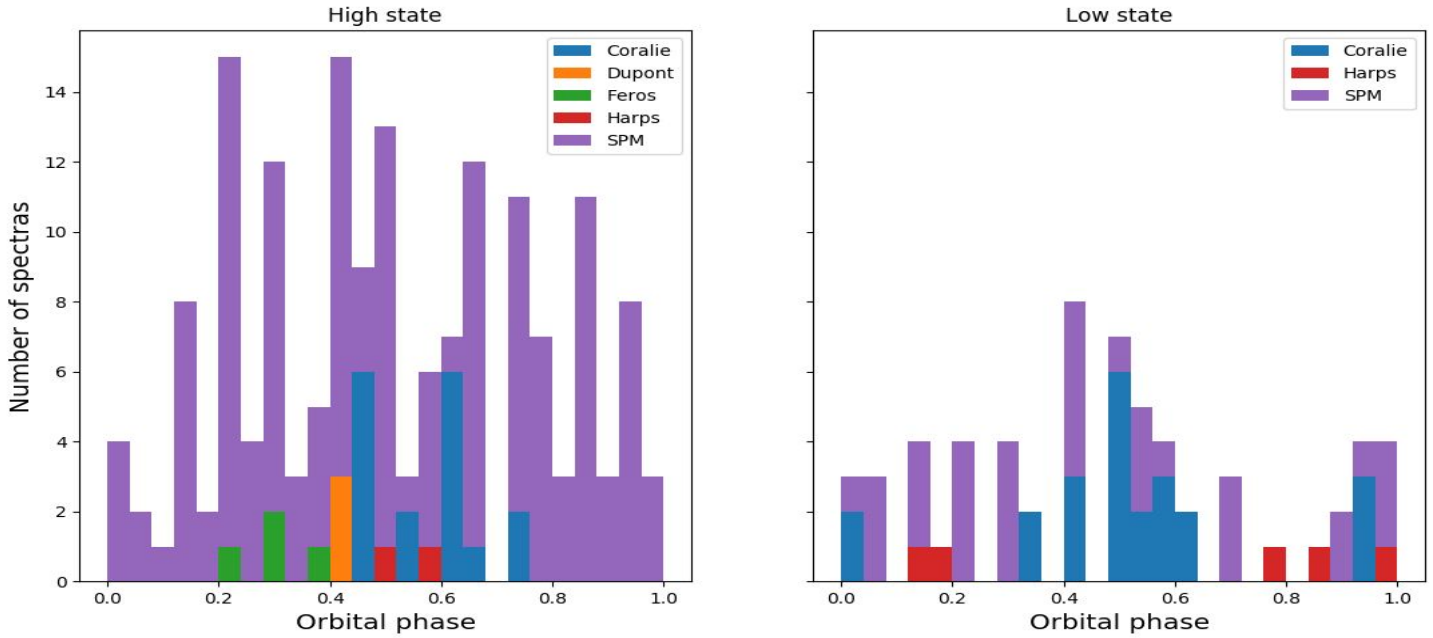
Data





Distribution of the spectra with the HJD and the long cycle. Green and red zones refer to high and low state of the cycle.

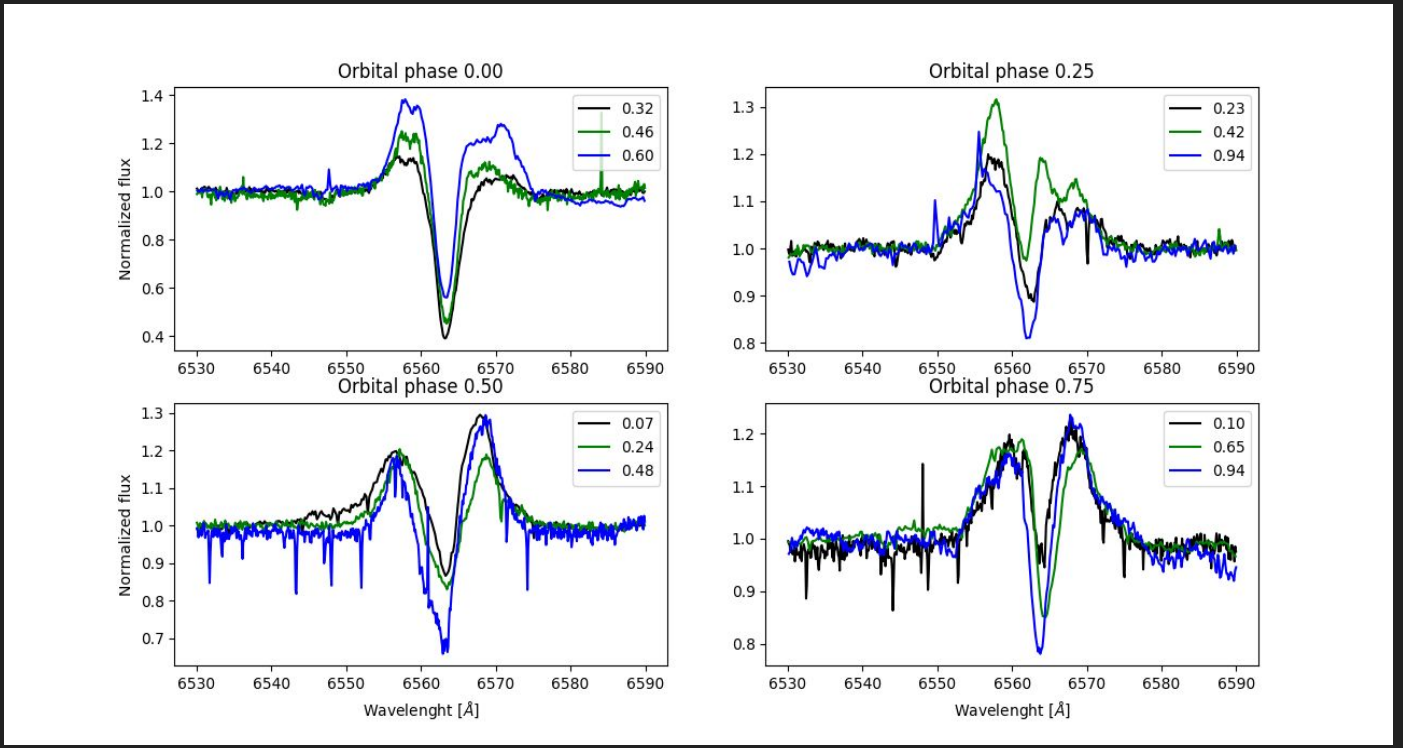
Data



Distribution of the spectra with the orbital cycle for high and low state spectras.

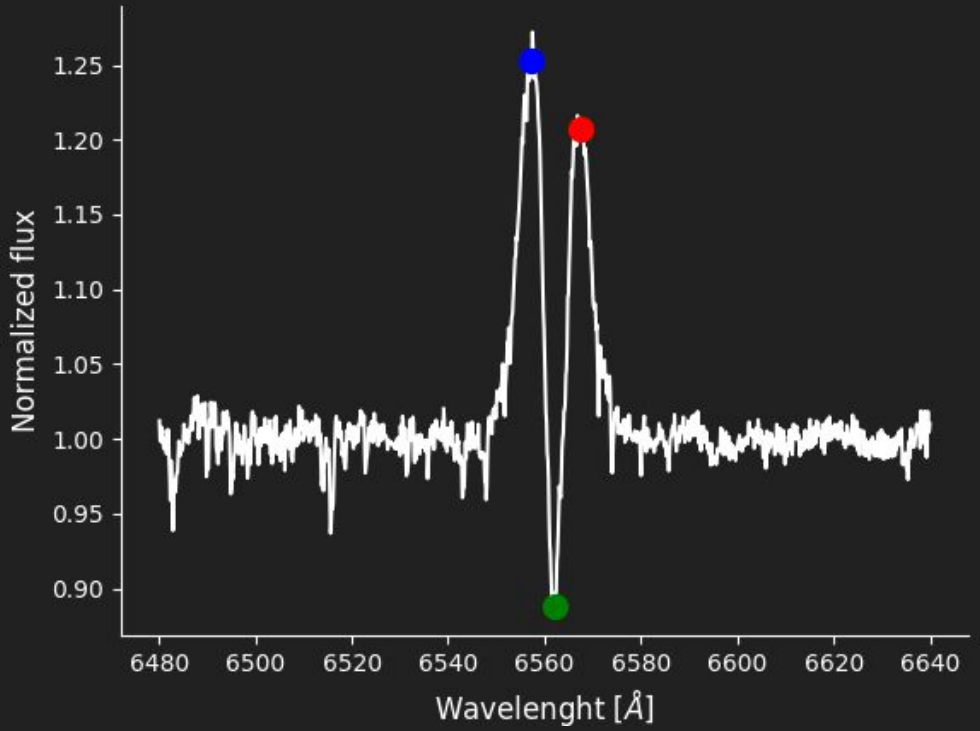
Spectral variability

The Hα profile show a double peak profile, which varies with the epoch (Plavec & Polidan 1976; Richards & Albright 1999; Desmet et al 2010; Barria & Mennickent 2011; Atwood et al 2012).



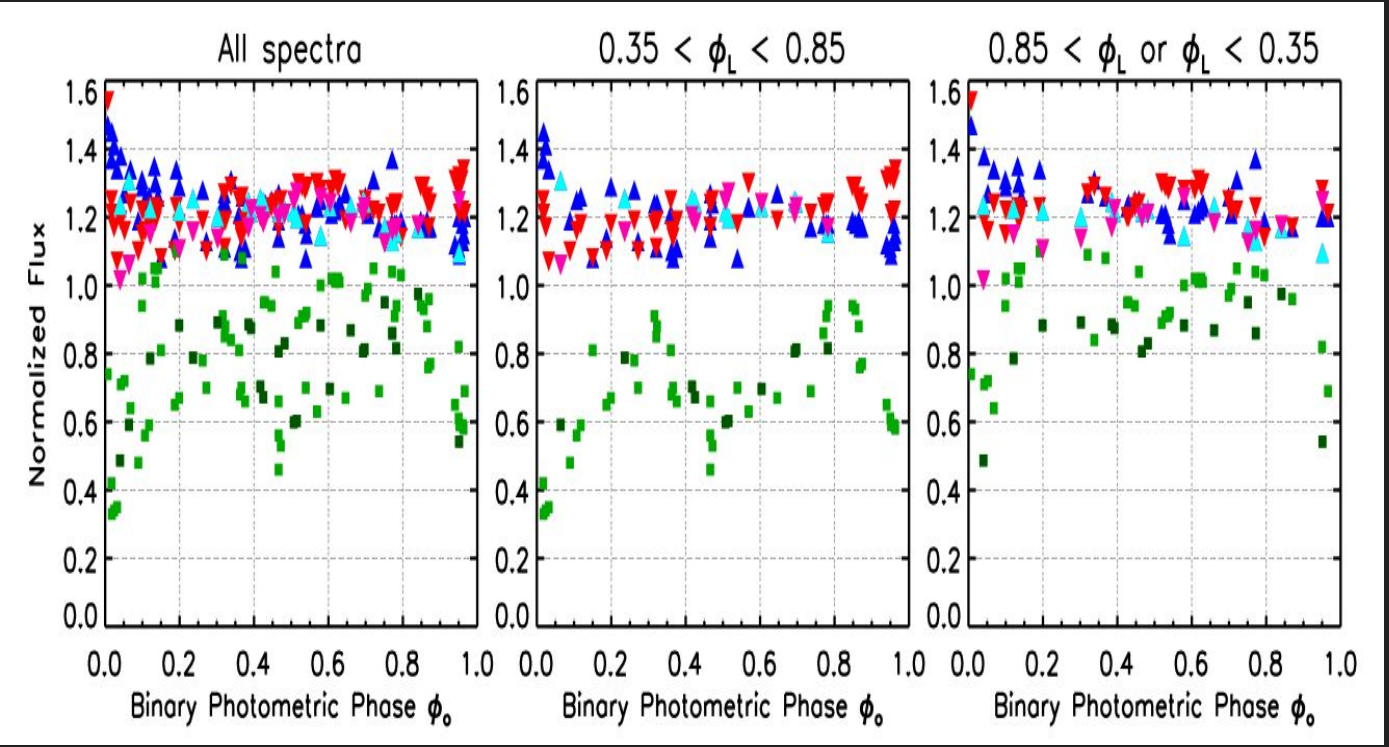
Variability of the Hα profile near to the orbital phases 0, 0.25, 0.5 and 0.75.

REBECA Diagrams



Red Emission, Blue Emission, Central Absorption.
A good tool to analyze the changing profile of the line during the orbital cycle.

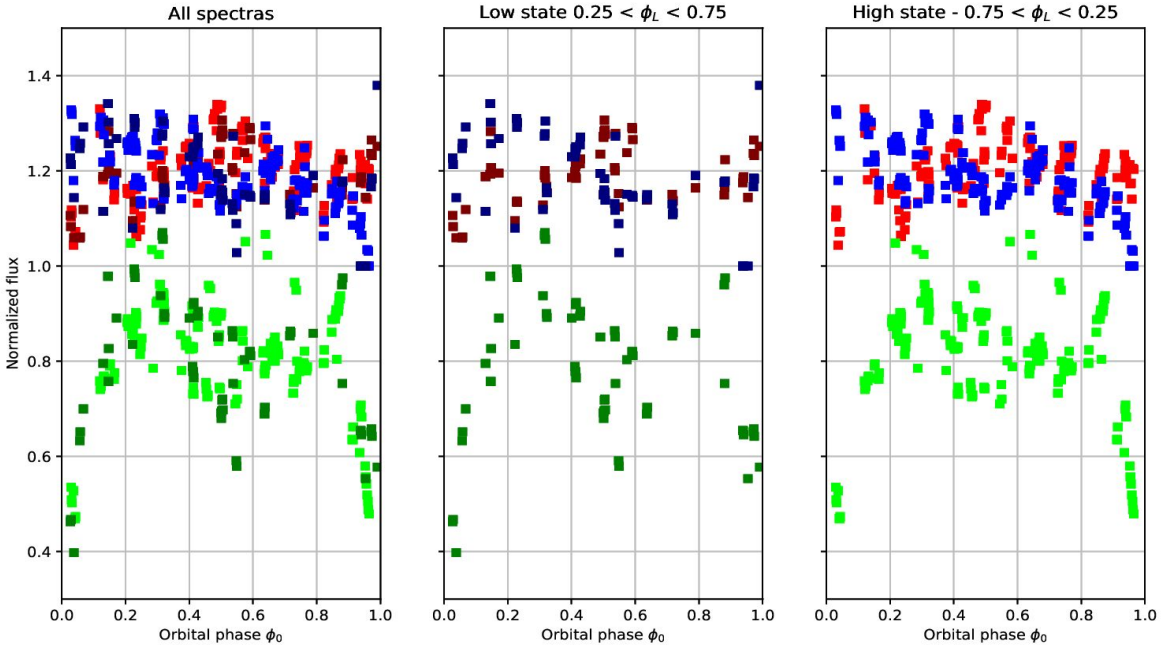
REBECA Diagrams



REBECA Diagram for AU Mon, Atwood et al, 2012

Atwood et al 2012 found a stronger central absorption near to the secondary eclipse during the low state of the long cycle.

REBECA Diagrams

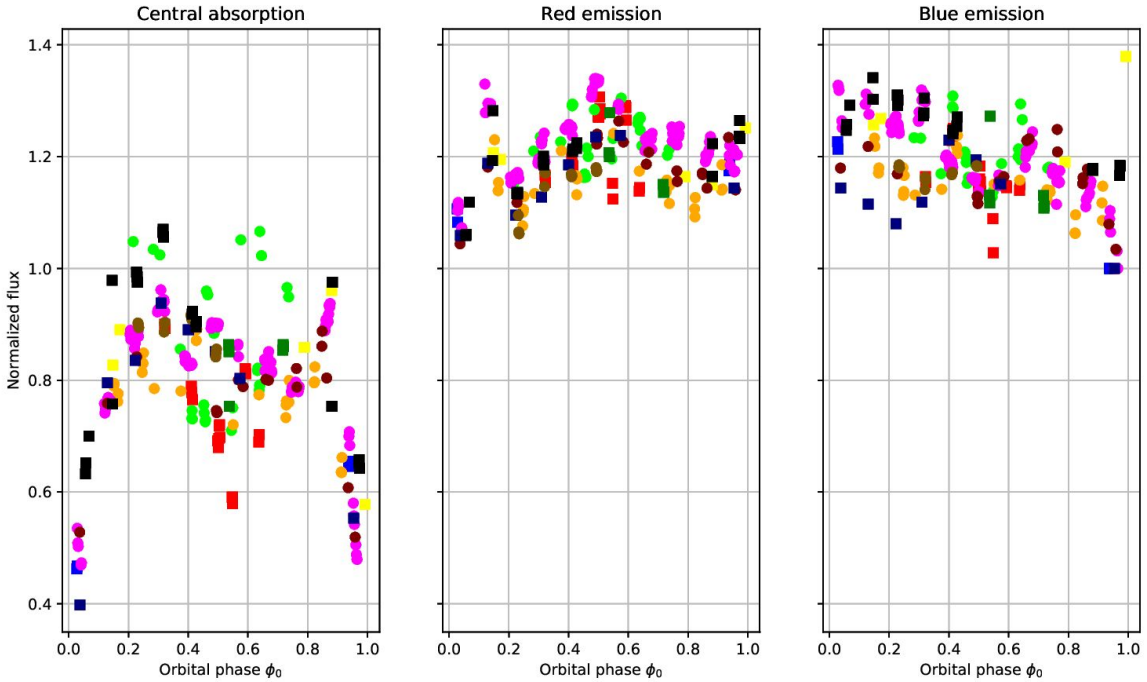


Rebeca Diagram for AU Mon in Hα (our data).

We found a similar behaviour near to the secondary eclipse.

Greater scatter in our data.

REBECA Diagrams



Rebeca Diagram for AU Mon in Hα (our data) separated by epochs.

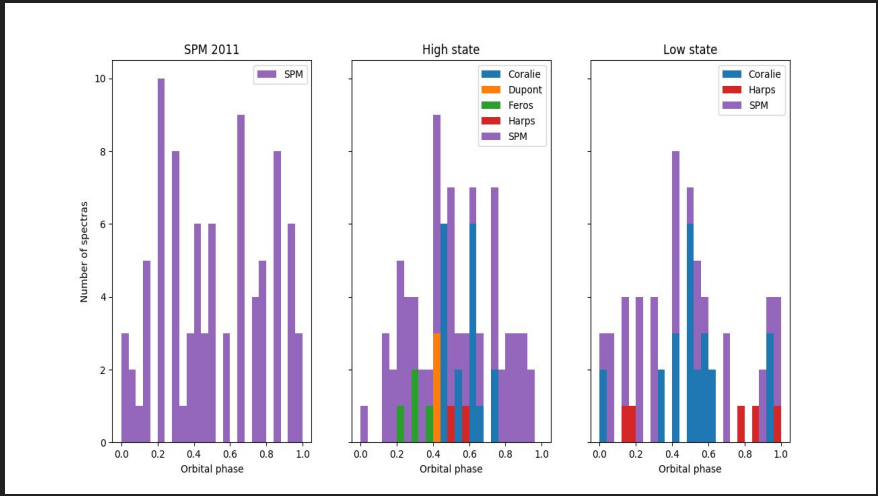
We observe significant variability between epochs of observation.

A strong peak in the red emission at phase ~0.15.

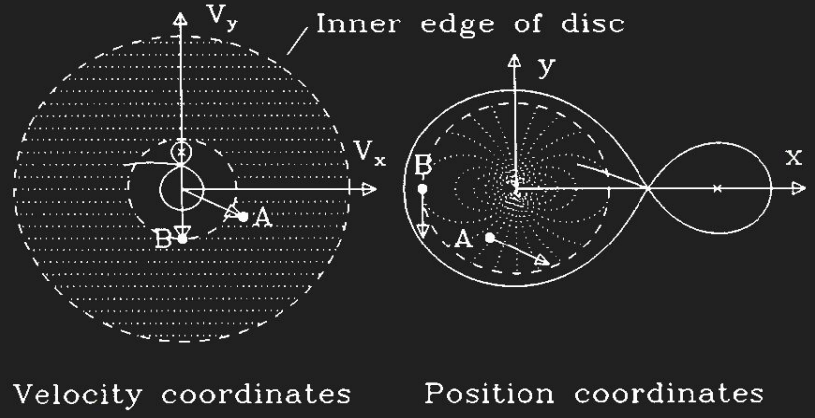
Doppler maps

We made use of the Doppler Tomography by Total Variation Minimization (DTTVM), developed by M.Uemura, 2015 (https://home.hiroshima-u.ac.jp/uemuram/dttvm/).

3 set of data: SPM 2011, High and Low state.

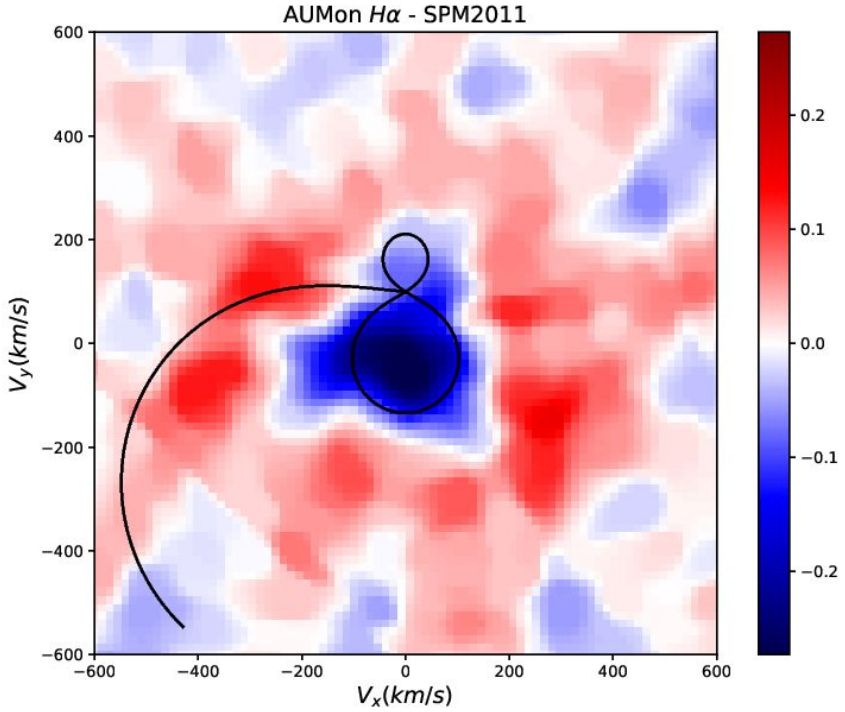


Orbital distribution for the 3 set of data



Marsh & Horne, 1988

Doppler maps - SPM2011

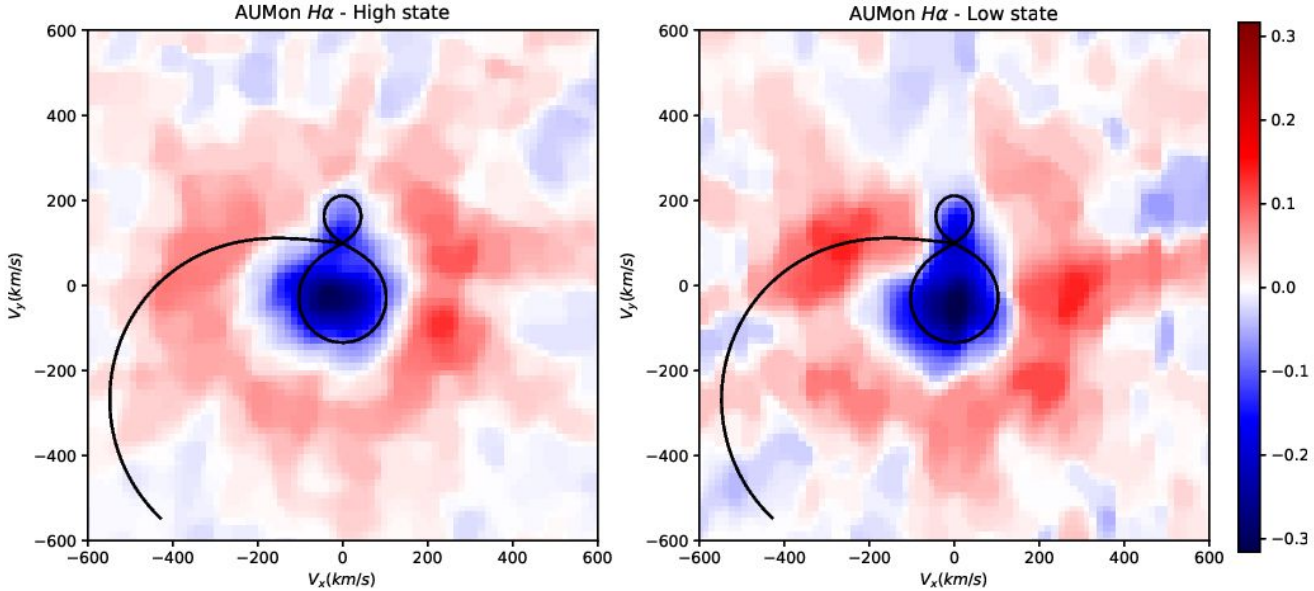


Doppler map for SPM2011 in Hα

Emission zones in second and fourth quadrant.

Absorption bulge near to the primary Roche Lobe.

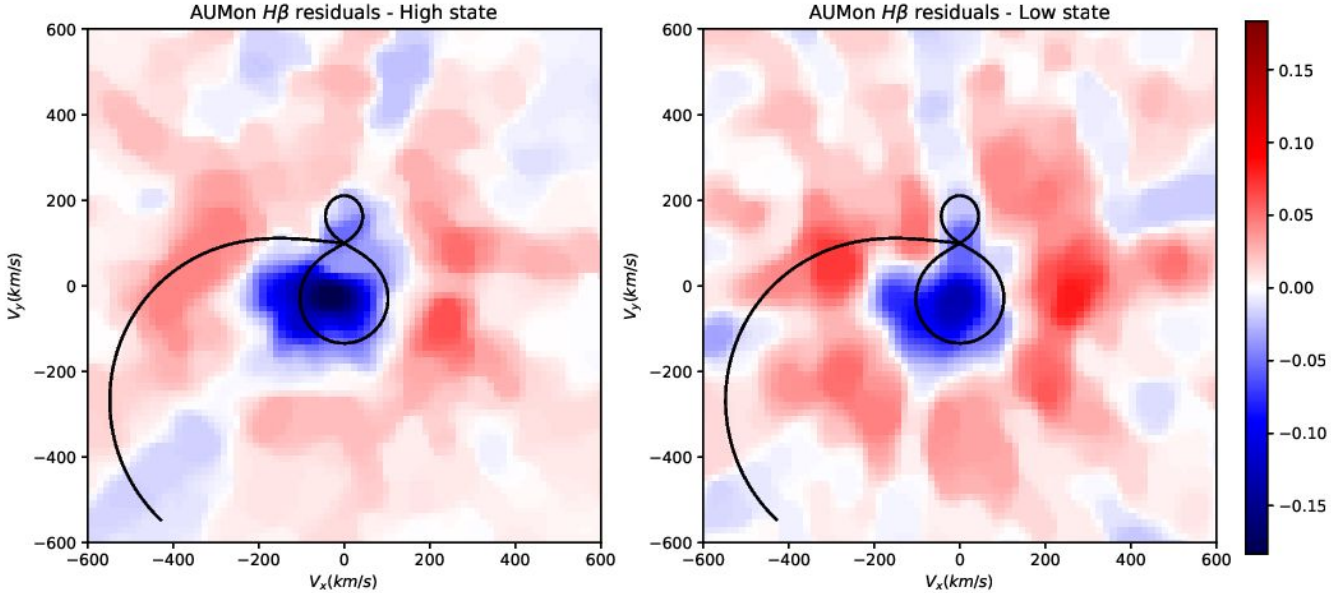
Doppler maps - High vs Low state (Hα)



Doppler Map for Hα in High and Low state.

The disk seems to be more active during the low state. Higher emission in high state like in HD 170582.

Doppler maps - High vs Low residuals (Hβ)



Doppler map of the residual spectras for Hβ during the high (left) and low (right) states.

Synthetic Spectra

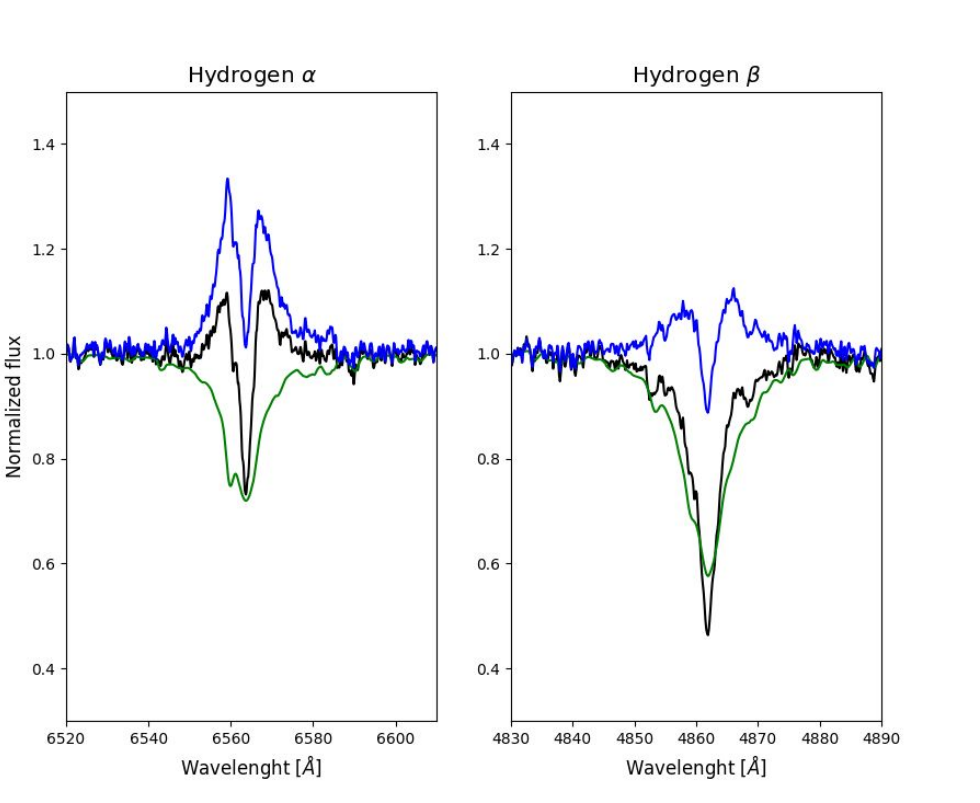
Synthetic spectra of the components were created using *Shellspec 3.9*[1] (Budaj & Richards, 2004) and *Spectrum 2.77*[2] (Gray & Corbally, 1994).

The parameters determined by Atwood et al 2012 were utilized.

	Primary	Secondary
Temperature [K]	17000	5750
log g	3.5	2.5
Mass [$M_\odot$]	7.0	1.2
Radius [$R_\odot$]	5.1	10.1
V_{Rot} [Km s^{-1}]	118.3	44.7
V_{Orb} [Km s^{-1}]	-30.9	161

[1] http://www.astro.sk/~budaj/shellspec.html
[2] http://www.appstate.edu/~grayro/spectrum/ftp/download.html

Synthetic spectra



Examples of the synthetic spectra.
Black: observed, Green: synthetic,
Blue: Residual.

Synthetic spectra - Accretion disk

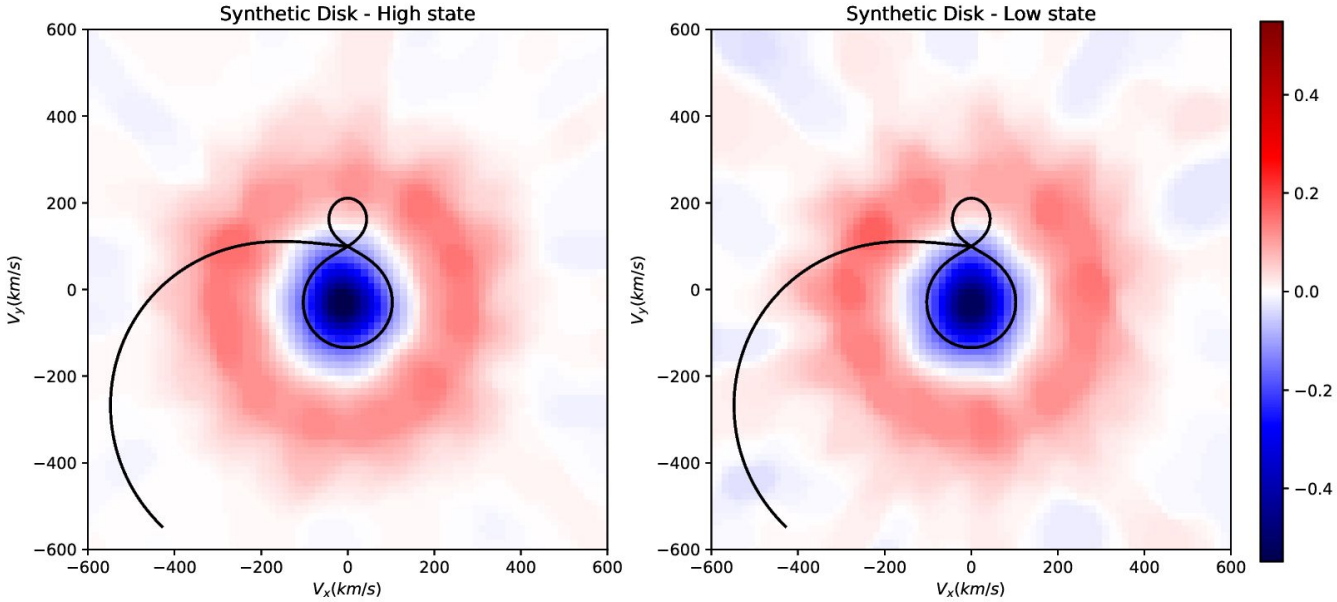
To test which features a due to sampling of the data, we created a synthetic spectra of an accretion disk using *Shellspec 3.9*.

We map this synthetic data emulating the sampling of the different data set.

Parameters taken from Atwood et al 2012.

Temperature [K]	14000
Radius [$R_{\odot}$]	5.1,23
Disk Thickness [$R_{\odot}$]	5.2
Density [g cm^{3}]	1e-13
V_{Turb} [Km s^{-1}]	30
V_{Orb} [Km s^{-1}]	-30.9

Doppler maps - synthetic disk



Comparison for the synthetic disk in high (left) and low (right) state.

Summary

We found a considerable variation of the Hα profile as was reported by many authors in the past.

We corroborate the behaviour of the central absorption in Hα reported by Atwood 2012

For first time we present doppler maps for AU Mon taking account the long photometric cycle.

The disk seems to show higher Hα and Hβ line emission during the low state of the long cycle, similarly to case of HD170582. This is consistent with an optically thinner disk at low state.

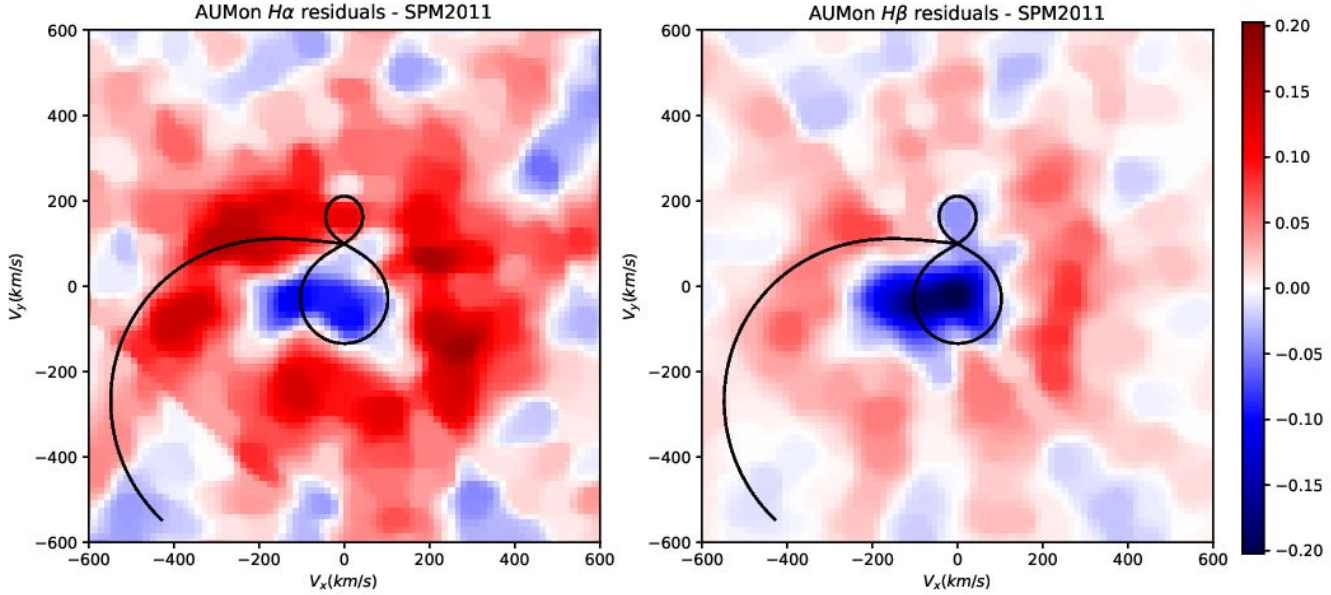
Acknowledges

L.C. acknowledge CONICYT Programa de Astronomía Fondo ALMA-CONICYT 2017 31170002, University of Concepción and Astronomy Department for the economic support.

And you for listening me today,

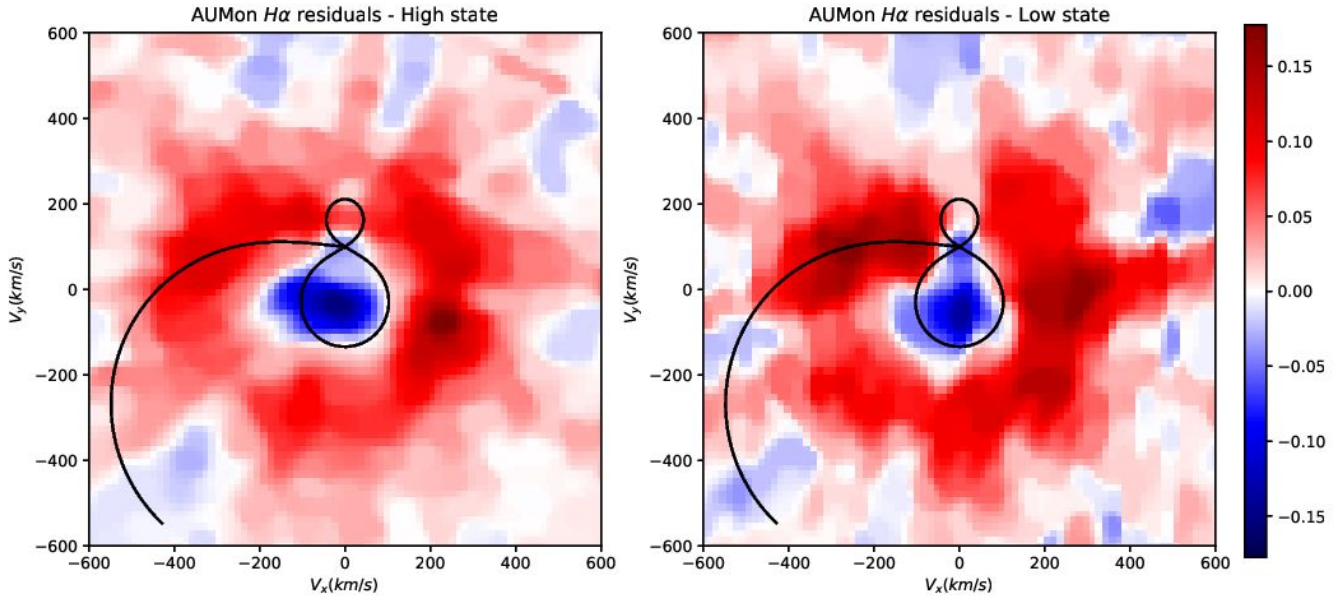
Thank you!

Doppler maps - SPM2011 residuals



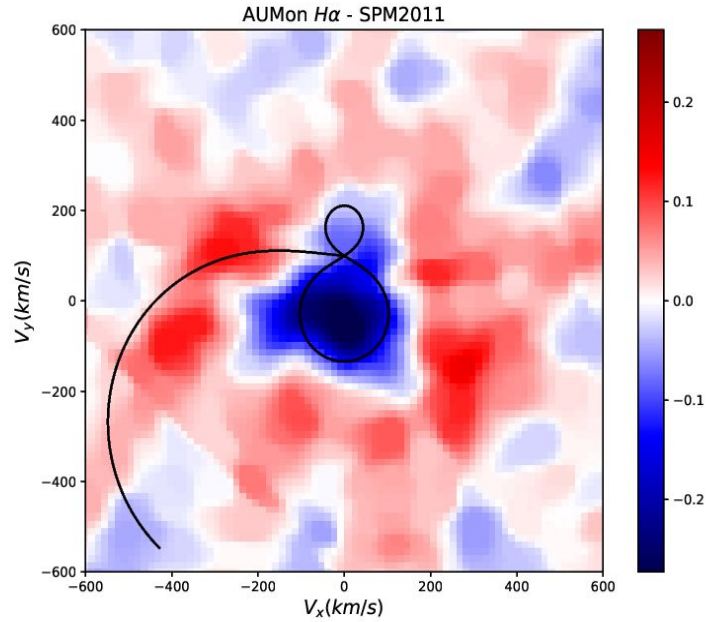
Doppler maps of the residual spectras for SPM2011 in Hα (left) and Hβ (right),

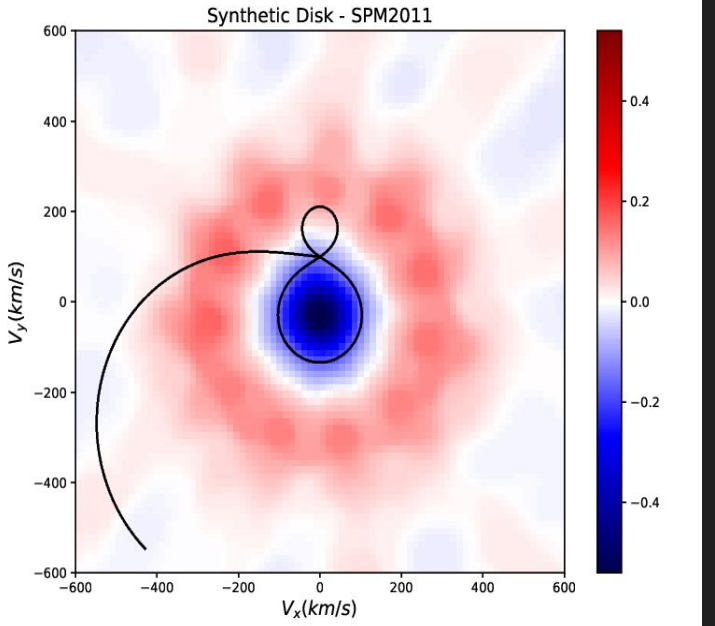
Doppler maps - High vs Low residuals



Doppler map for the residuals spectra in Hα for high (left) and low(right) state.

Doppler maps - SPM2011





Doppler for SPM2011 in Hα (left) versus the synthetic disk (right).