Modelling intermediate polars using the CYCLOPS code

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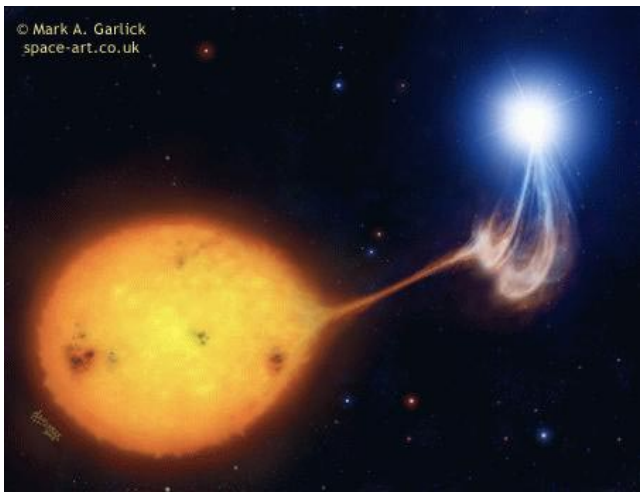
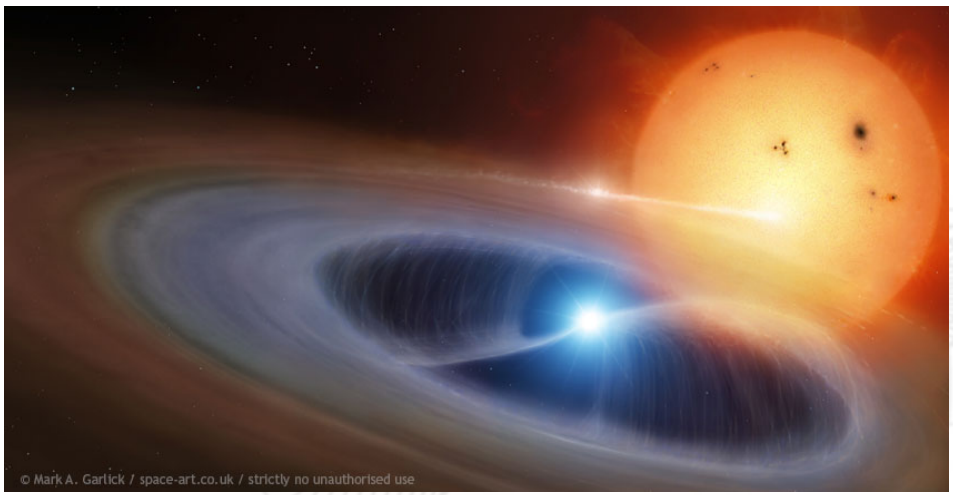
FAPESP
FUNDAÇÃO DE AMPARO À PESQUISA DO ESTADO DE SÃO PAULO

Magnetic cataclysmic variables



(a) Polar



(b) Intermediate polar

Source: Garlick M., 1998 and 2002.

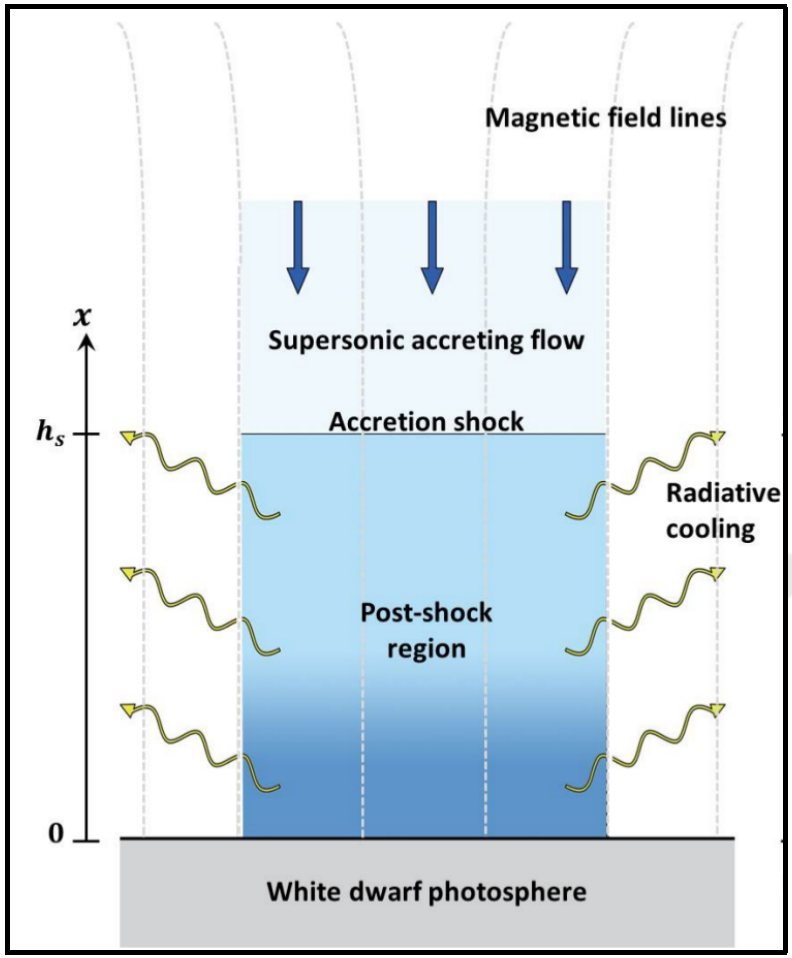
⟨http://www.space-art.co.uk/⟩

Intermediate polars

Observational characteristics

- At least two stable and coherent periods in light curves and/or spectra from X-ray and/or optical data.
- Circular polarization in optical and infrared emission of few percent in some objects.
- X-ray hard emission and signatures of absorption in low energy X-ray.
- Soft X-rays excess in some IPs.
- Optical spectrum of high ionization, e.g. He II 4686Å line.

Post-shock region



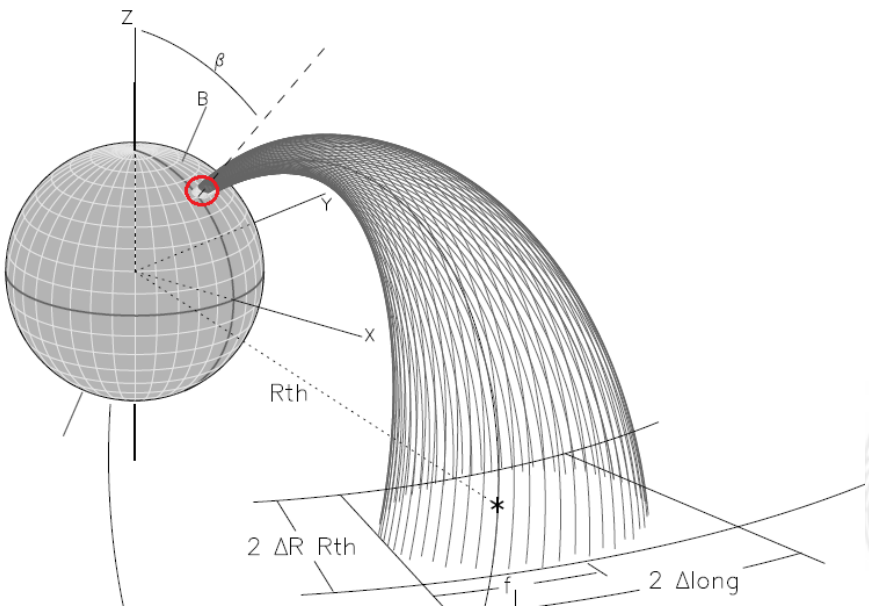
Source: Van Box Som, L., 2018, MNRAS, 473, 3158.

Our purpose

- **Our main goal is to study the accretion structure and geometry of intermediate polars using the CYCLOPS code.**

- **We intend to use CYCLOPS to reproduce X-ray emission and optical polarization of our preliminary sample: V405 Aur and UU Col.**

CYCLOPS code



Source: Costa & Rodrigues, 2009, MNRAS, 398, 240.

Geometry parameters

i – inclination.

β – colatitude.

B_{lat} e B_{long} – direction of the magnetic dipole axis.

Δ_{long} e Δ_R – size of the threading region.

h – height of emitting region.

Physical parameters

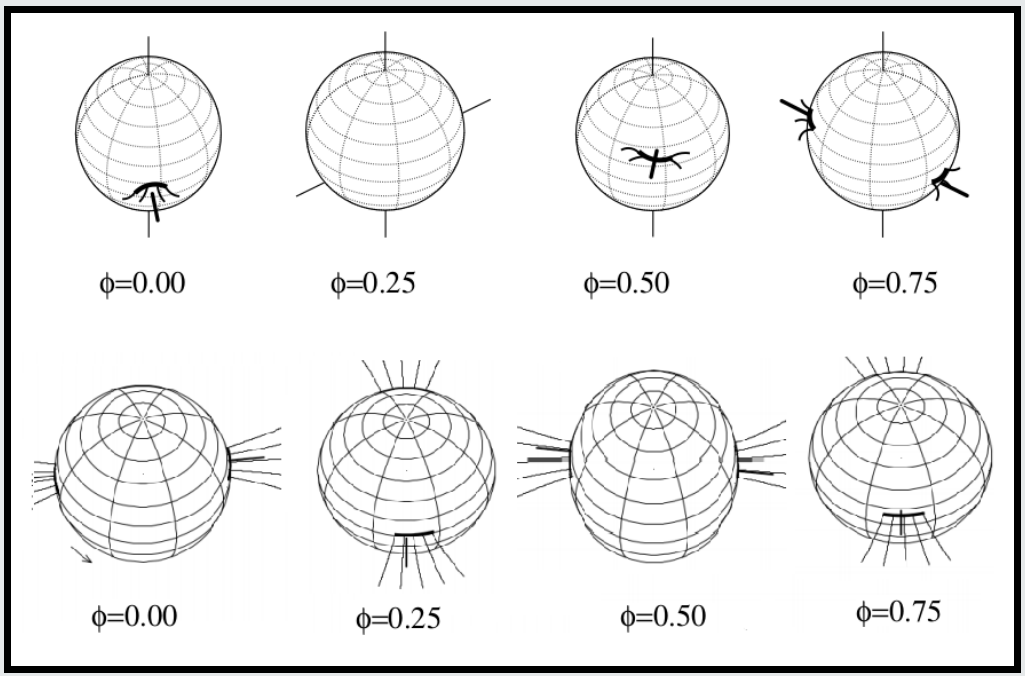
T_{max} e N_{max} – maxima of the electron temperature and density.

B_{Pole} – intensity of the magnetic field.

V405 Aurigae

Optical versus X-rays

$i = 38^\circ$ and $\beta = 82^\circ$. Source: Evans & Hellier, 2004, MNRAS, 353, 447



$i = 65^\circ$ and $\beta = 60^\circ$. Source: Piirola et al., 2008, ApJ, 684, 558

CYCLOPS modelling

Parameters of V405 Aur models

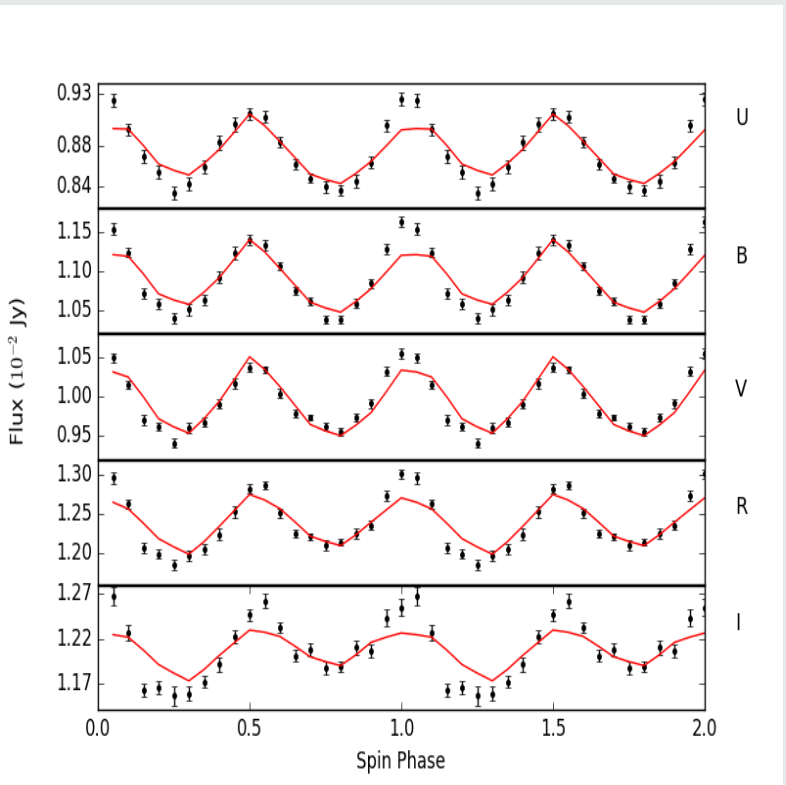
CYCLOPS input parameters	Fitted values
i	52°
β	52°
Δ_{long}	2.0°
Δ_R	0.05
h	0.11 R_{WD}
f_l	0.5
B_pole	33 MG
B_lat	78°
B_long	288°
T_{max}	174 keV
$log(N_{max})$	12.5 cm^{-3}

[a] M_{WD}: maximum temperature.
[b] M_{WD}: mean temperature.
[c] M_{WD}: weighted temperature.
R_s: radius of spot base.
A_s: spot area. H_s: spot height.

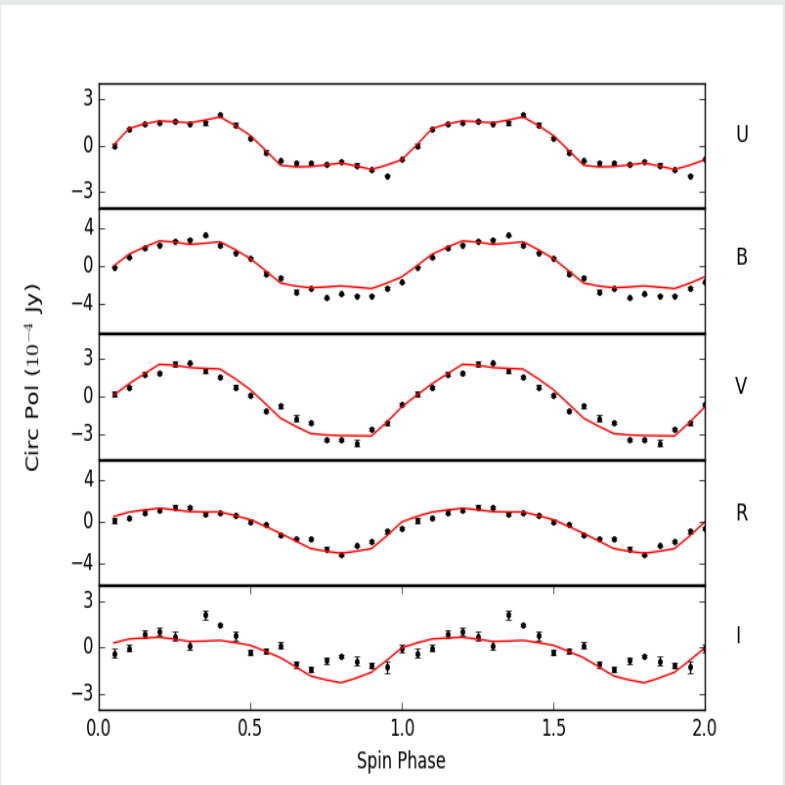
Model result	Value
B_{reg}	24 –34 MG
$\langle\ T\ \rangle$	71.4 keV
T_{pond}	35.5 keV
T_{range}	14 – 174 keV
δ_{phase}	0.194
$N(H)$	$1.41 \times 10^{21}\ cm^{-2}$
$Att(ISM)$	0.158
$Att(int)$	0.000
M^a_{WD}	1.35 $M_{\odot}$
M^b_{WD}	1.08 $M_{\odot}$
M^c_{WD}	0.79 $M_{\odot}$
χ^2_{pond}	1381.4
χ^2_{norm}	0.121
R_s	2.25×10^7 cm
A_s	4.96×10^{14} cm^2
H_s	7.01×10^7 cm

CYCLOPS modelling

Simultaneous modelling of UBVRI light and polarization phase diagrams of V405 Aur



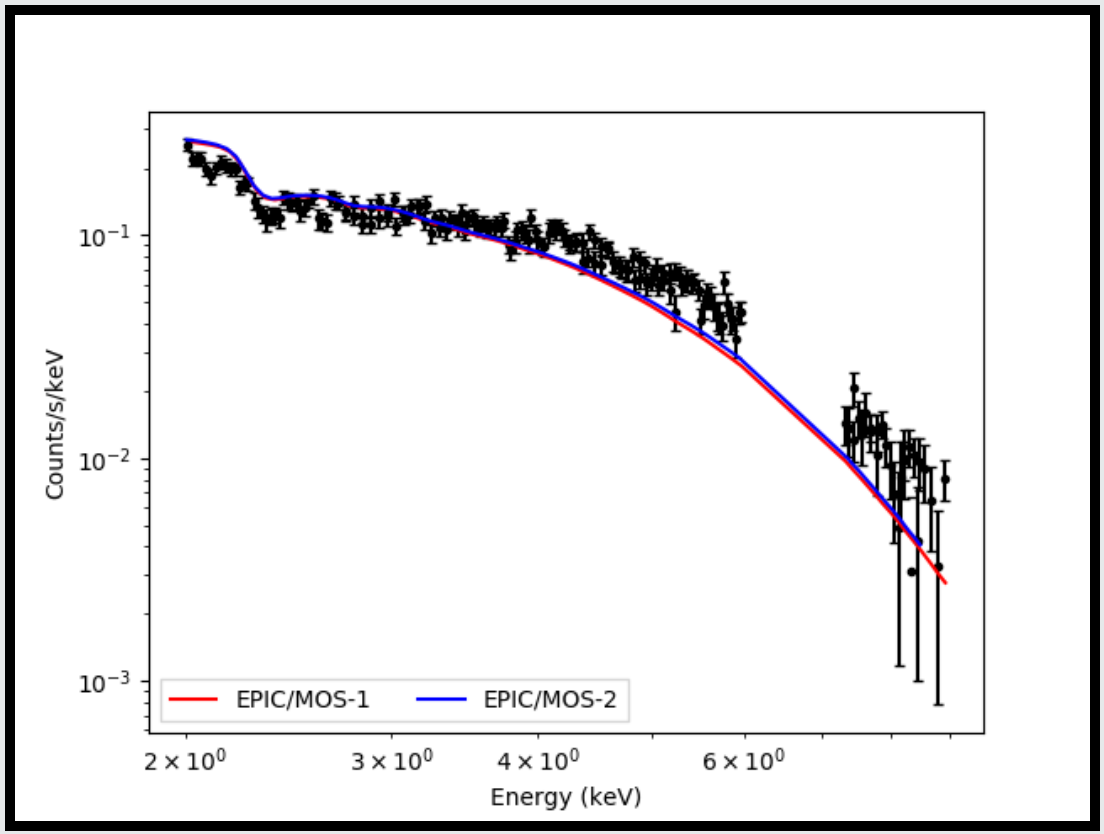
Photometry



Polarimetry

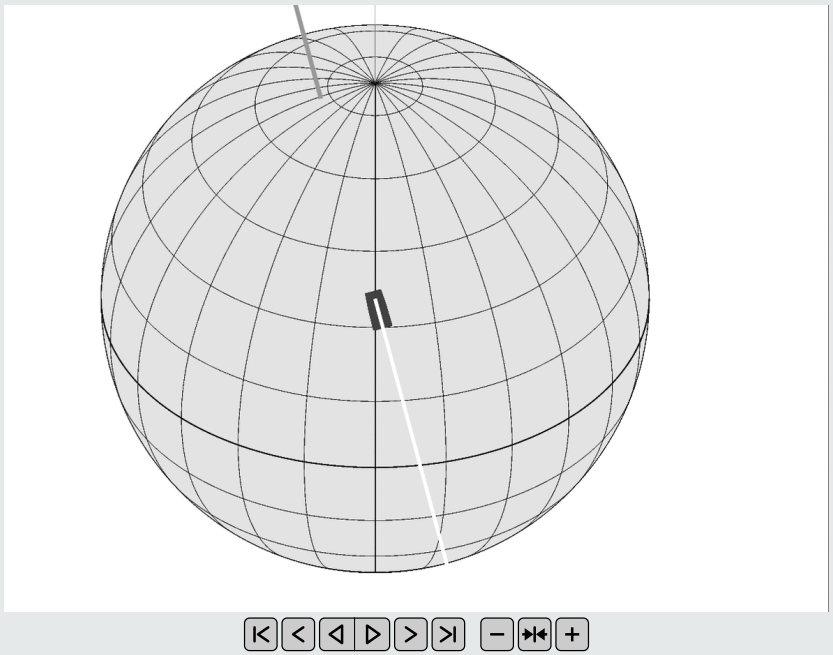
CYCLOPS modelling

X-rays spectra of V405 Aur from XMM-Newton



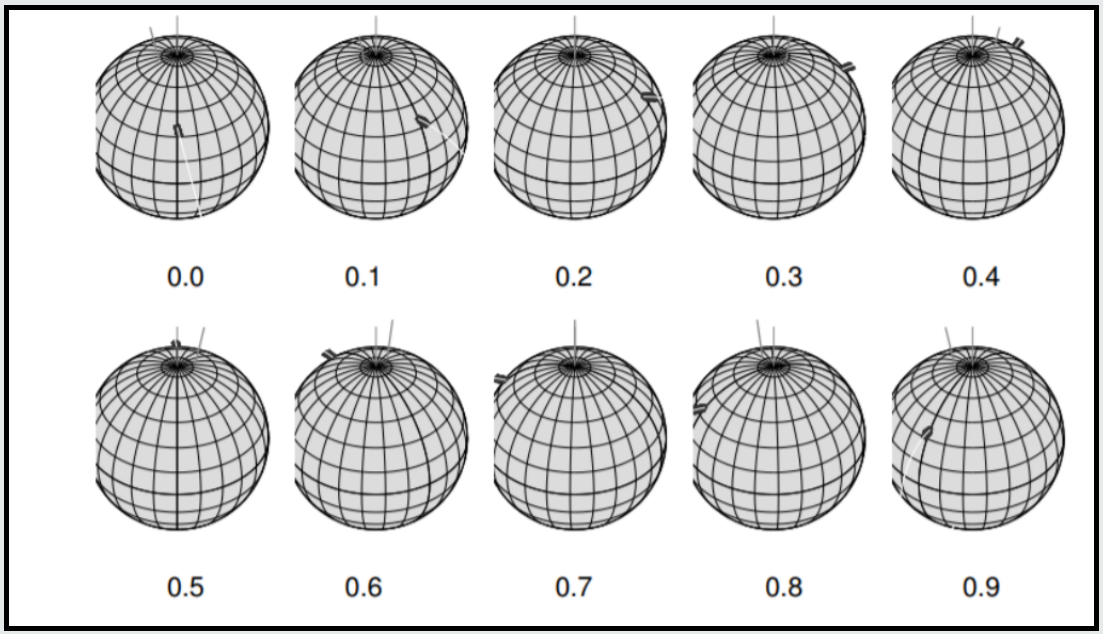
CYCLOPS modelling

Geometry of the emitting region



CYCLOPS modelling

Geometry of the emitting region



Discussion

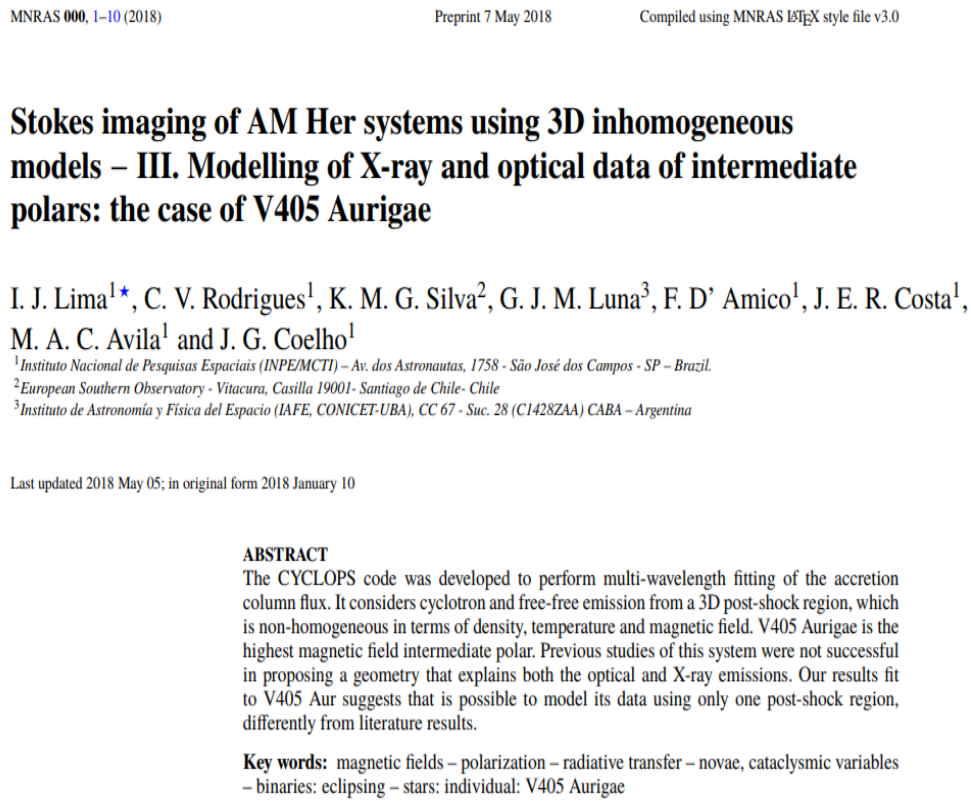
1. The proposed simultaneous modelling is reasonably good as shown in figures.
2. Unlike previous studies, we are able to fit V405 Aur data using only one post-shock region.
3. We model simultaneous UBVRI photometry of spectral energy distribution (SED).
4. We will perform simultaneous optimization with integrated X-ray spectra and folded light curves.

The accomplished steps

1. CYCLOPS tests.
2. CYCLOPS implementations.
3. We obtained preliminary results on V405 Aur.
4. Qualification exam.
5. PhD thesis proposal.
6. Submission of the Research Internships Abroad (BEPE) Program: Magnetic accretion in cataclysmic variables: SW Sextantis stars and a search for new objects.
7. I remade the reduction of X-ray data in order to obtain folded light curves on the Piirola's ephemeris.
8. I participated in schools, workshops, and others events.

The future steps

1. Write and submit V405 Aur paper. vvvvv
2. We will model using the CYCLOPS code another intermediate polar: UU Col.
3. I will develop the research internships abroad (BEPE) awarded by FAPESP with Dr. Paula Szkody.



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Stokes imaging of AM Her systems using 3D inhomogeneous models – III. Modelling of X-ray and optical data of intermediate polars: the case of V405 Aurigae

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ABSTRACT
The CYCLOPS code was developed to perform multi-wavelength fitting of the accretion column flux. It considers cyclotron and free-free emission from a 3D post-shock region, which is non-homogeneous in terms of density, temperature and magnetic field. V405 Aurigae is the highest magnetic field intermediate polar. Previous studies of this system were not successful in proposing a geometry that explains both the optical and X-ray emissions. Our results fit to V405 Aur suggests that is possible to model its data using only one post-shock region, differently from literature results.

Key words: magnetic fields – polarization – radiative transfer – novae, cataclysmic variables – binaries: eclipsing – stars: individual: V405 Aurigae

THANKS