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The accretion column of AE Aqr

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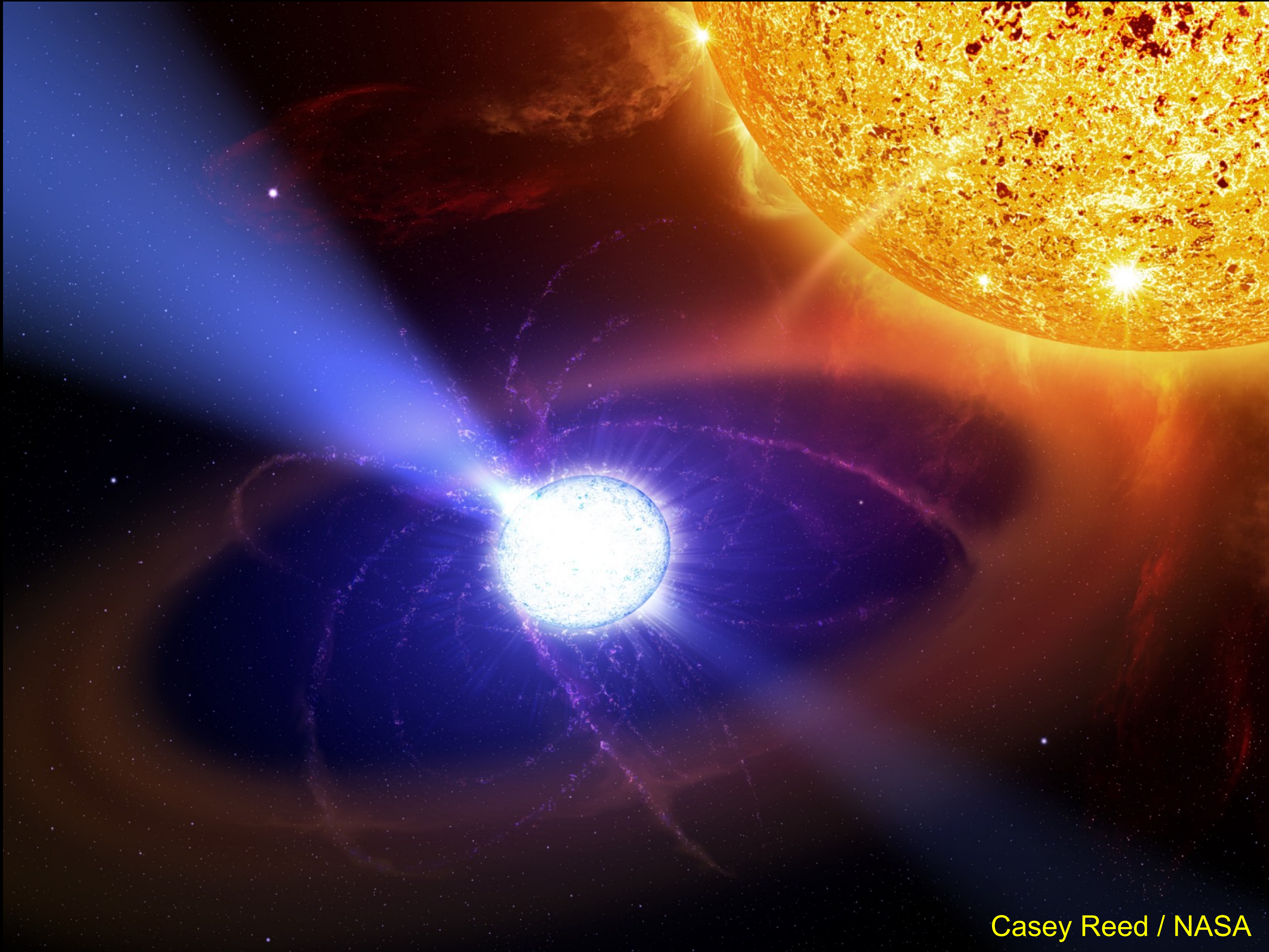
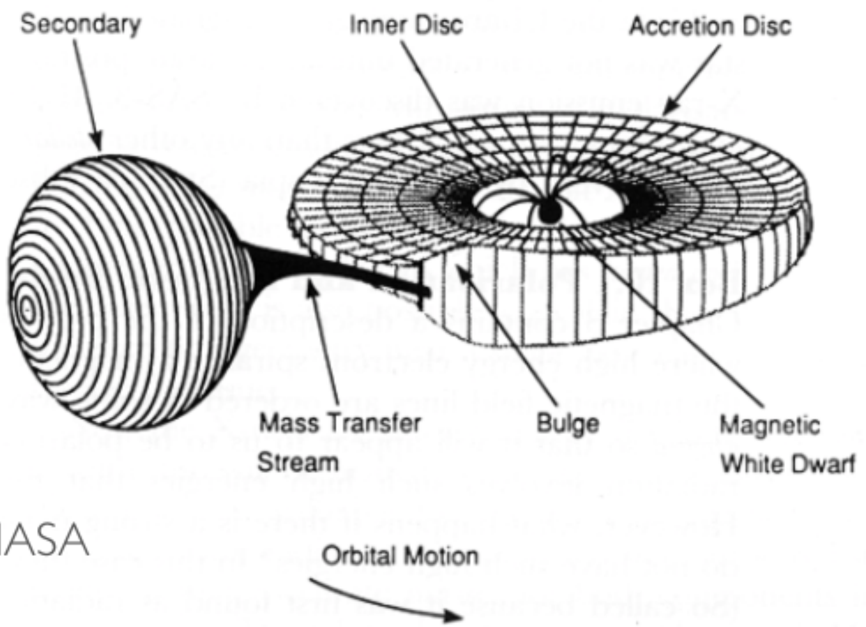

Casey Reed / NASA

AE Aqr

- AE Aqr is classified as a cataclysmic variable
  - ⇨ compact binary system - primary is a white dwarf
    - ✓ orbital period = 9.88 h
    - ✓ orbit is a bit larger than the Sun...
  - ⇨ secondary
    - ✓ is a K4-5 V, a bit massive for a CV…
    - ✓ loses mass from Roche Lobe overflow
  - ⇨ no disk detected
  - ⇨ magnetic white dwarf

Magnetic cataclysmic variables

- In magnetic CVs, the white-dwarf magnetic field prevents the formation of the accretion disk or truncates it internally



NASA

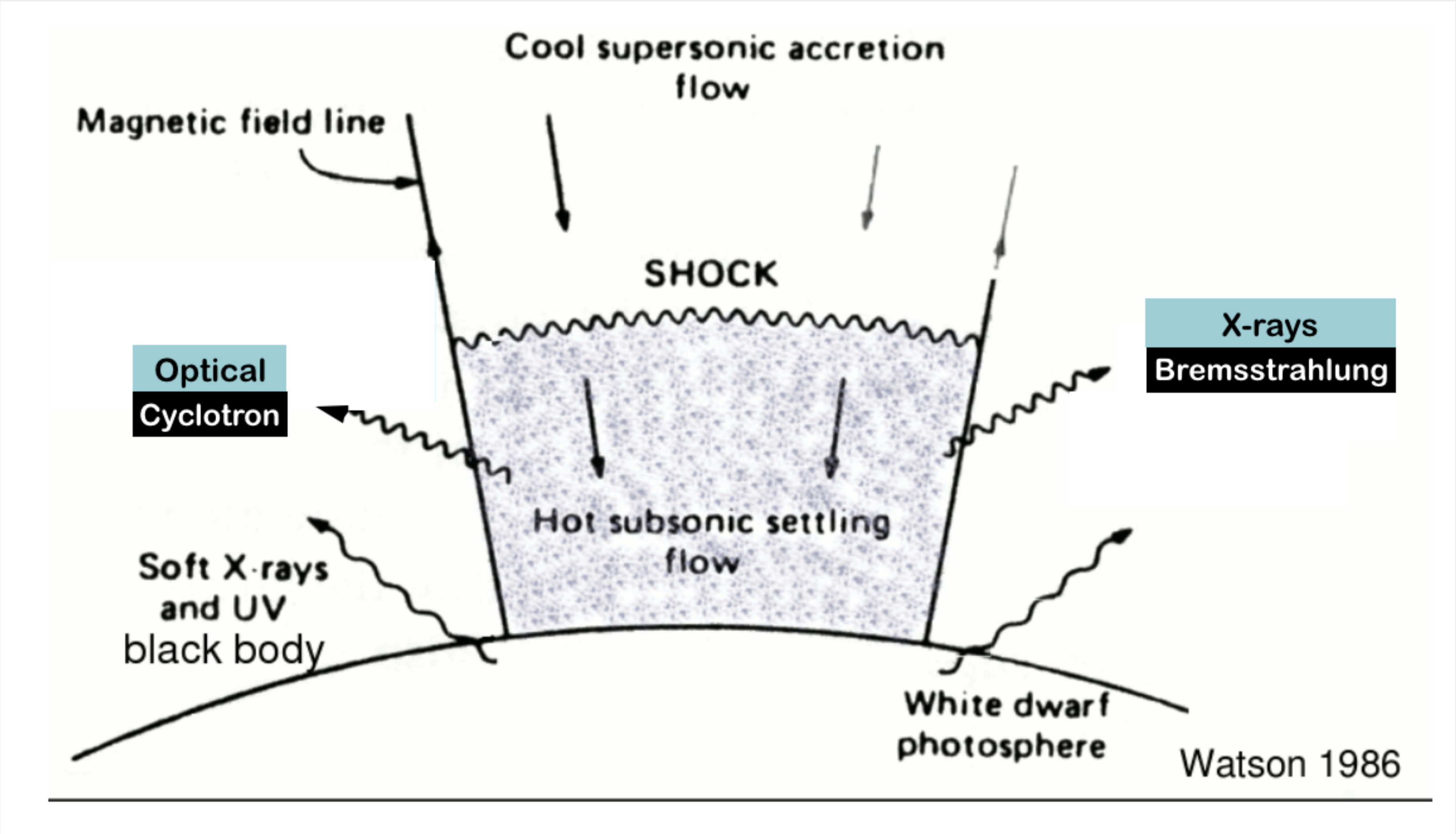
DQ Her
Intermediate polars
Asynchronous

Accretion on white dwarf occurs by an magnetic accretion structure

A geometry similar to X-ray binaries….

The post-shock region in MCVs

- It dominates the high-energy emission and it is important also in optical regime



What makes AE Aqr different?

- ⇨ **its white dwarf rotates at the very fast rate of 33 s**
  - ✓ flux modulated at this frequency from high-energies to optical wavelengths

- ⇨ origin of the pulsed emission
  - ✓ propelled material?
  - ✓ accretion material?
  - ✓ location?
  - ✓ emission process? pulsar-like emission?

Is this fast rotation preventing the accretion on the white dwarf – propeller?

What makes AE Aqr similar to bonafide CVs?

- ⇨ No gamma-ray emission from MAGIC and Fermi (Aleksic+ 2014, Li+ 2016)
  - ✓ discarding propeller models similar to transitional pulsars
- ⇨ **Thermal** soft and hard X-ray emission
  - ✓ for instance, Swift and NuSTAR data (Kitaguchi+ 2014)
- ⇨ Optical and UV light curves (Eracleous+ 1994)
  - ✓ fitted by a polar cap model = hot spots on the white-dwarf surface

This (on going) work aims to...

- Verify if AE Aqr emission can be explained by an accretion scenario

- Fitted data (by now)
  - ⇨ NuSTAR spectrum and light curve of AE Aqr (Kitaguchi et al. 2014)

- Modelling tools: **Cyclops**

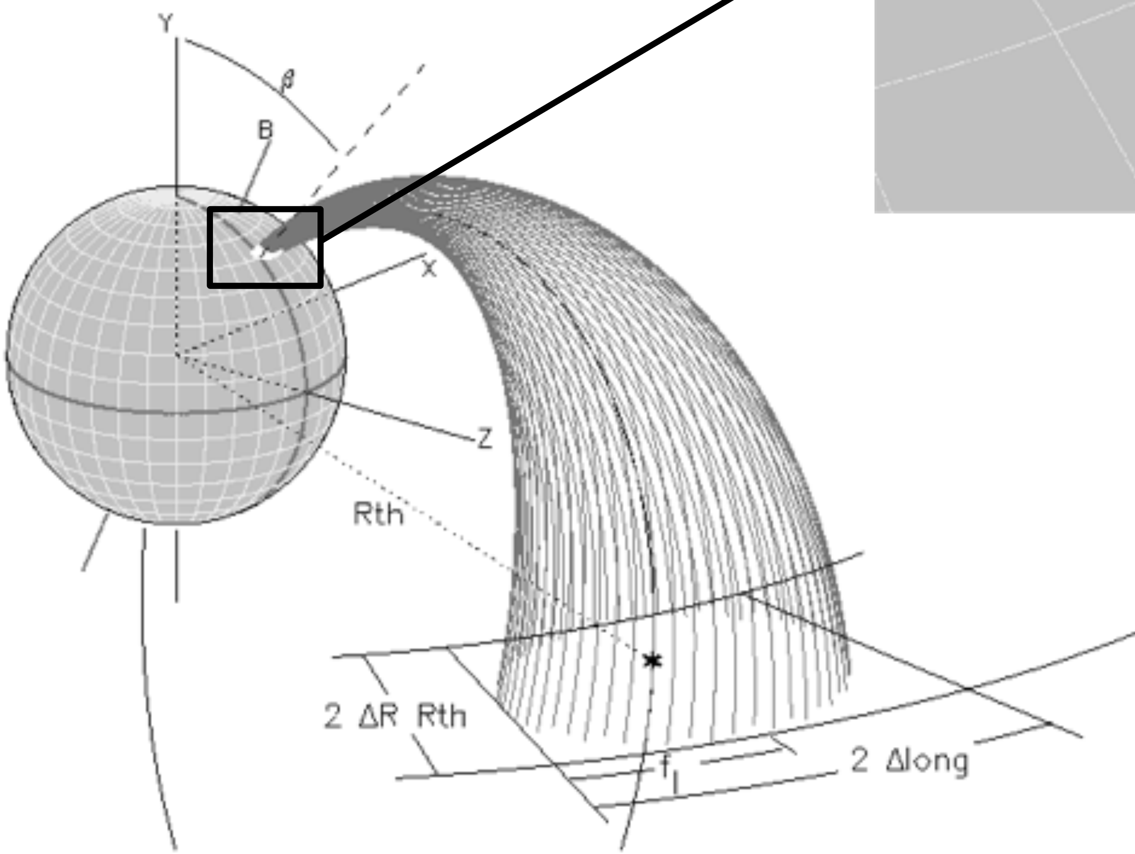
Cyclops
Cyclotron Emission of Polars

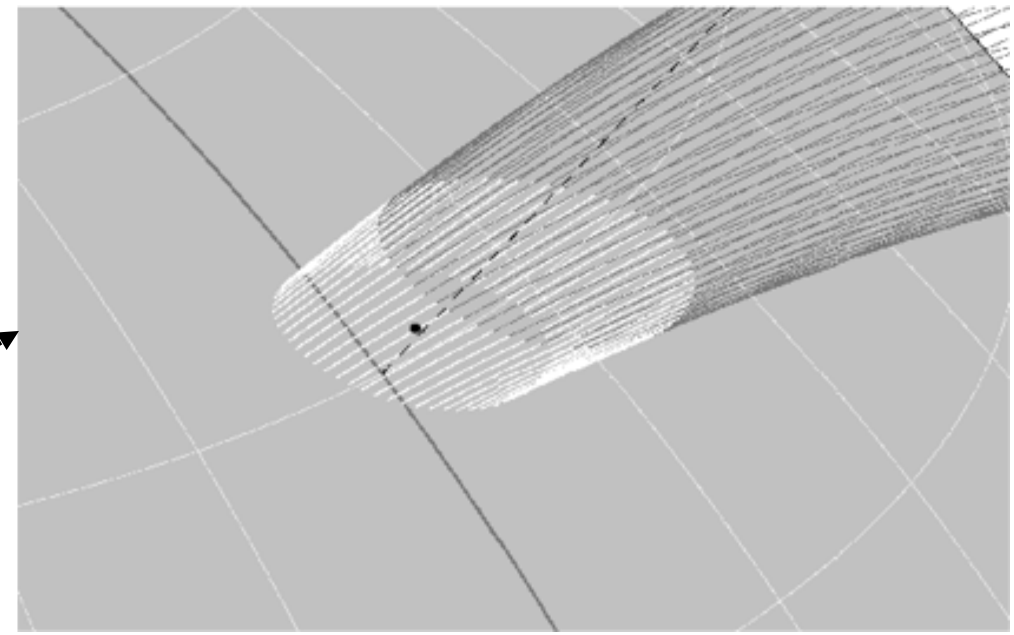
Cyclops simulates the continuum emission from post-shock regions in magnetic cataclysmic variables.

It considers a 3D geometry!

Costa & Rodrigues (2009); Silva+ (2013)

The accretion column, post-shock and pre-shock regions, is represented by a grid of elements used to calculate the radiative





Costa & Rodrigues 2009

Cyclops
Cyclotron Emission of Polars

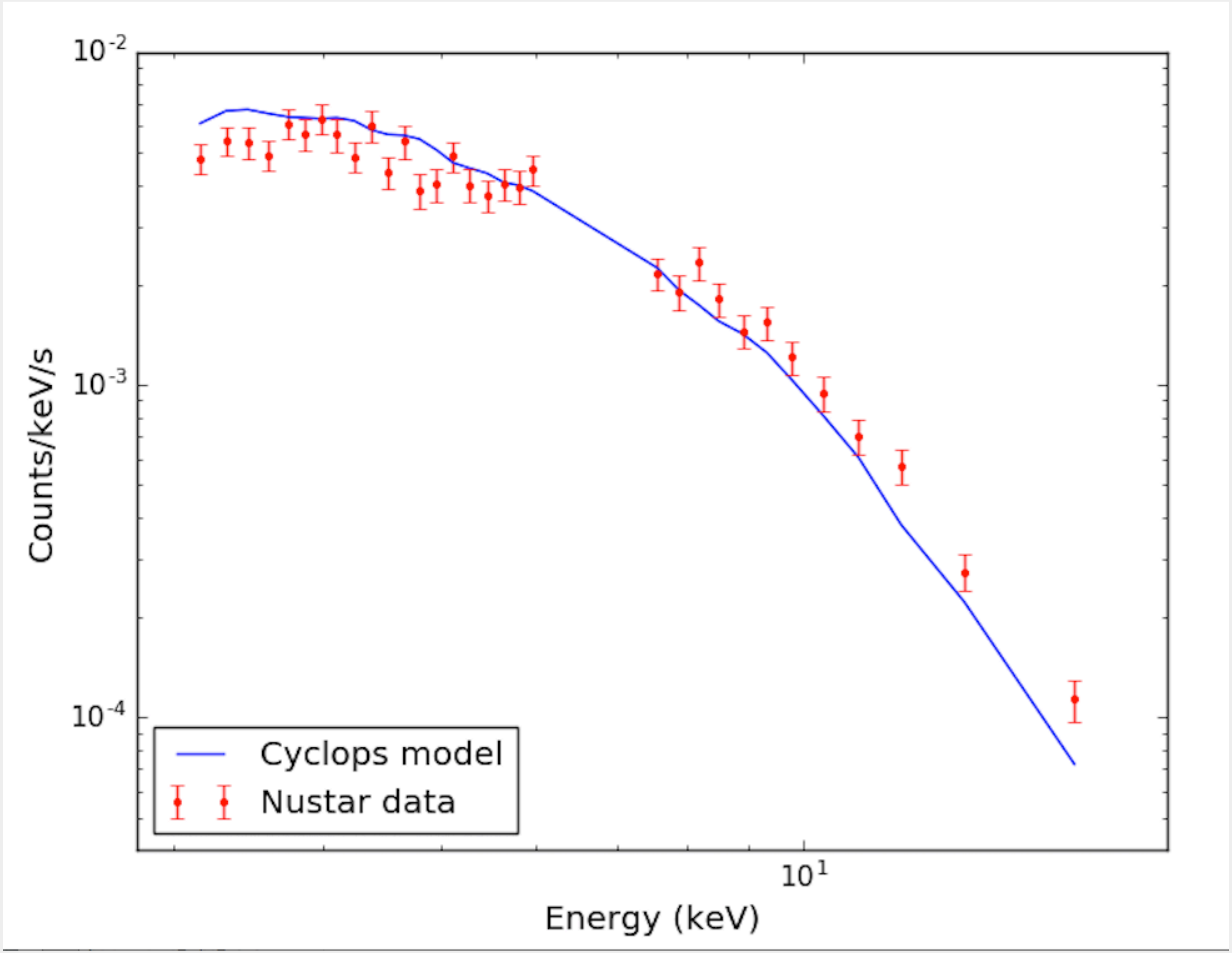
- some advantages of **3D treatment**
  - ✓ self eclipse
  - ✓ shock structure
- emission processes
  - ✓ cyclotron (optical)
  - ✓ bremsstrahlung (X rays)
    - ➡ possible to implement other radiative process
- extinction processes
  - ✓ Thomson scattering internal to the binary (optical)
  - ✓ photo-absorption internal to the binary and interstellar (X-rays)
    - ➡ interstellar reddening in optical (being implemented)
- routines to fit optical and X-ray data
  - ✓ high-energy instrumental files are also considered in the procedure

Costa & Rodrigues (2009); Silva+ (2013)

Preliminary results

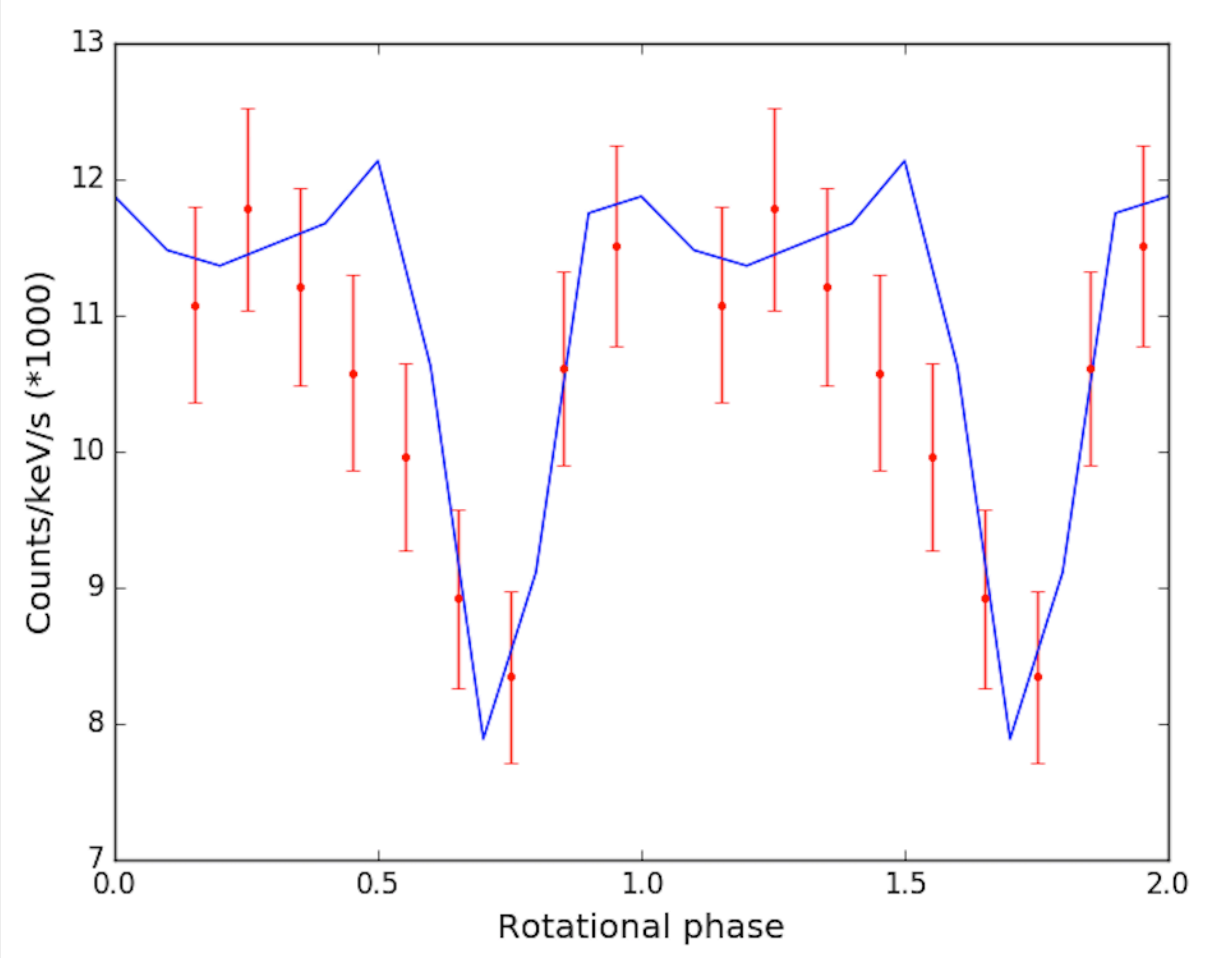
- We present a fit for AE Aqr X-ray spectrum and light curve
  - ⇨ it should be considered as one possibility, since the domain of space parameters is huge and it was not completely explored yet
    - ✓ Cyclops has more than ten geometrical and physical parameters…

- The time-integrated **spectrum** of AE Aqr can be fit by many combinations of geometrical parameters, but it constrains the temperature distribution.



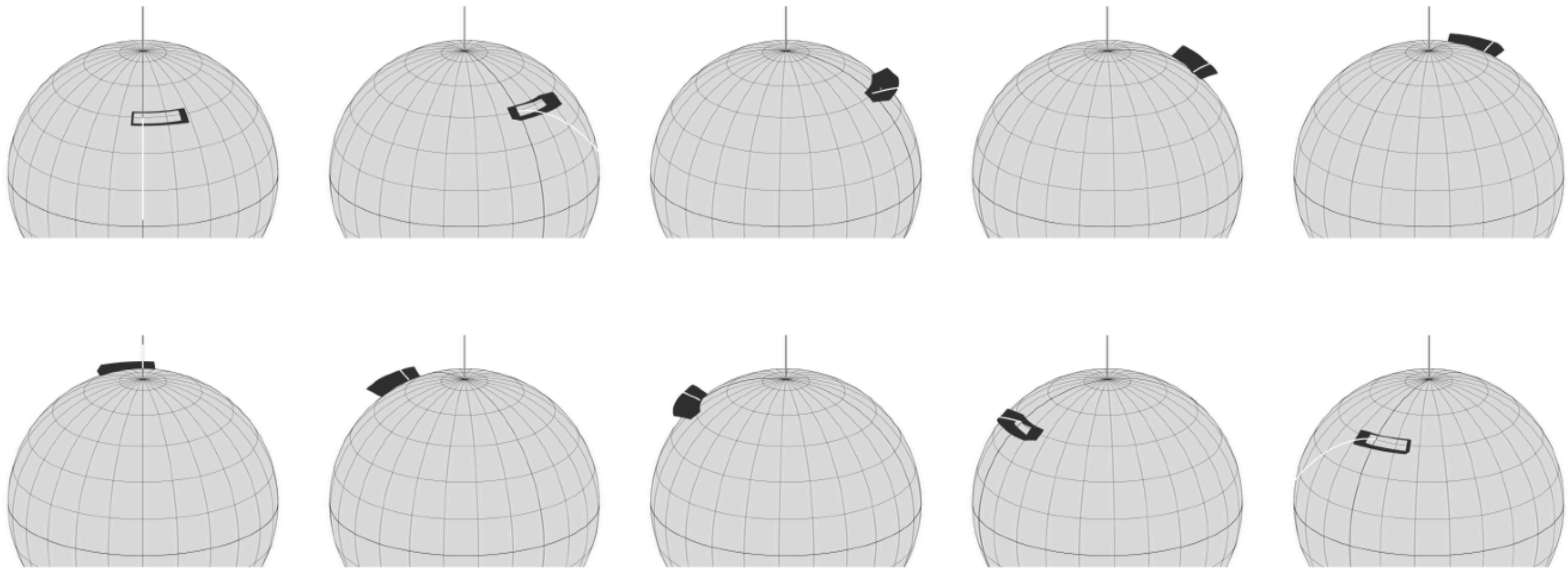
NuSTAR spectrum and the Cyclops spectrum for a shock structure with Tmax = 19.5 keV.

- We are able to reproduce the overall shape of the **light curve** of AE Aqr from 3 to 20 keV.
  - ⇨ The modulation is caused by **partial self eclipse** of the accretion column by the white dwarf.



- Main geometrical parameters used in the fitting:
  - ⇨ inclination: 67°;
  - ⇨ emission region located 42° from the pole, extended by 30° in longitude, and having 0.12 white-dwarf radius in height;
  - ⇨ magnetic field axis parallel to the rotation axis.

The top left figure represents the phase of maximum counts/s.



Only walls are shows, but region is filled with eletrons.

Conclusions and future work

- We present a preliminary physical and geometrical scenario for AE Aqr high-energy emission.
  - ⇨ It is based on a post-shock region near the white-dwarf surface created by magnetic accretion.
  - ⇨ It explains AE Aqr spectrum and rotational flux variation.
  - ⇨ As far as we know, this is the first model to the X-ray light curve of AE Aqr.

- We intend to improve this study by:
  - ⇨ a better exploration of the parameter space (understand degeneracy of parameters);
  - ⇨ checking consistency of the luminosity produced the model;
  - ⇨ extending the model to optical wavelengths.

See also Poster C06 - Lima et al.

X-ray spectrum and optical polarization of another IP, V405 Aur fit using Cyclops

Thank you!!

- Acknowledgements

  - ⇨ CNPq: 306701/2015-4 (CVR).
  - ⇨ Fapesp: 2017/05610-2 (CVR); 2015/24393-7 (IJL/CVR); 2013/26258-4 (CVR,JGC, ISL); 2013/15088-0 (JGC).
  - ⇨ FONCyT/PICT: 2014/0478 (GJML).

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