The peculiar ejecta of V1425 Aql as seen by MUSE

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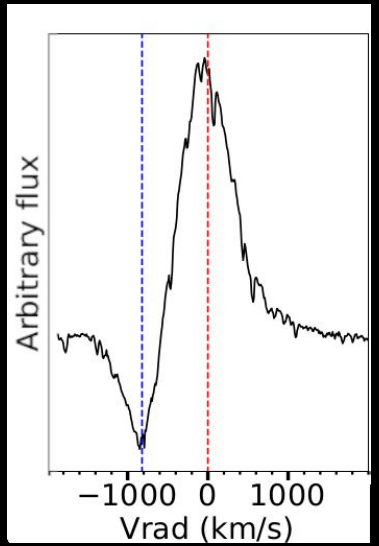
Symbiotic stars, weird novae, and related embarrassing binaries
Charles University, Prague

L.Celedón lientur.celedon@postgrado.uv.cl June 6, 2024

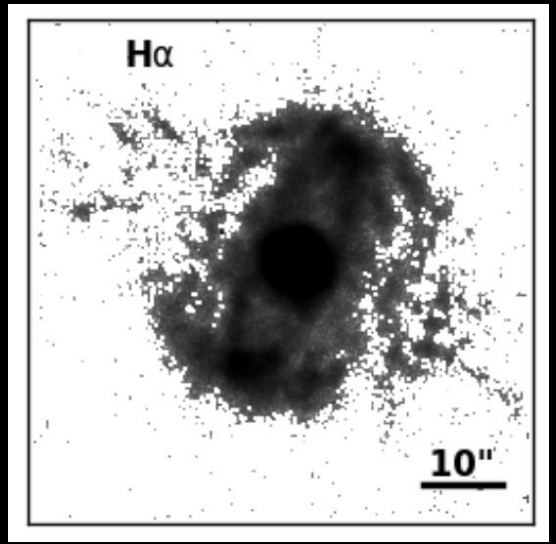
Nova shells, the remnant of a nova eruption

V1369 Cen (Hα)
~5 days after nova



Aydi et al, 2020

RR Pic
~100 yrs after nova



Celedón et al, 2024

Z Cam (Hα)
~2000 yrs after nova (?)

Shara et al, 2012

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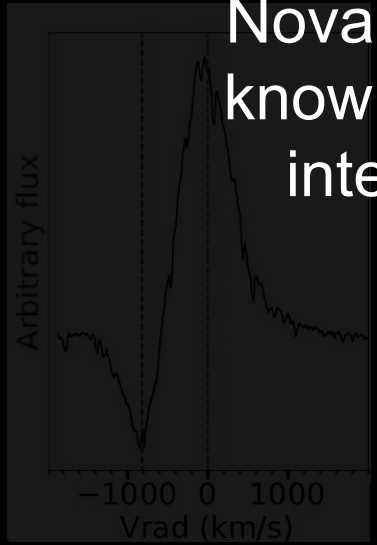
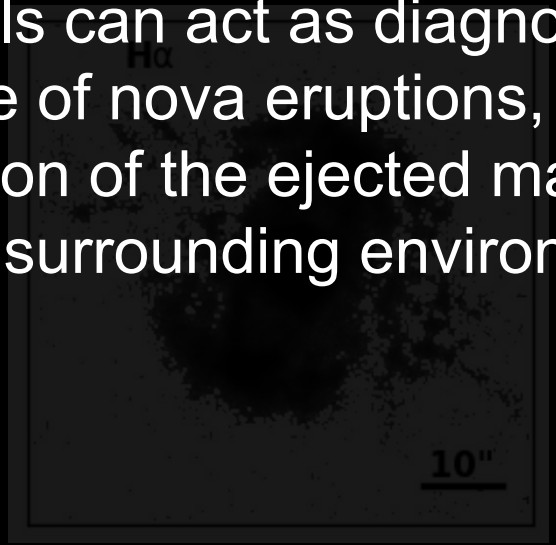
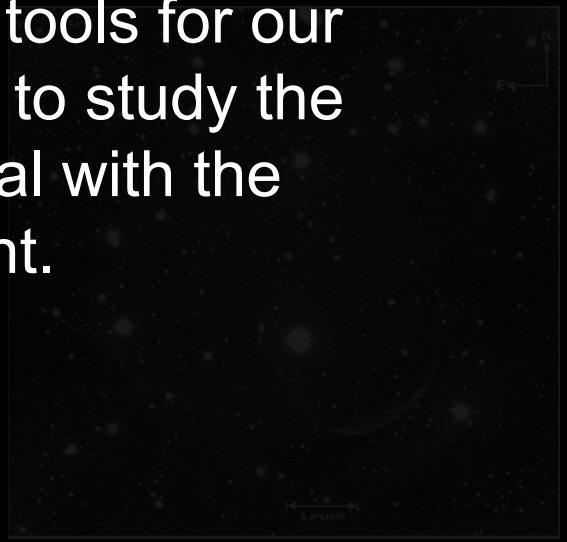
Nova shells, the remnant of a nova eruption

Nova shells can act as diagnostic tools for our knowledge of nova eruptions, and to study the interaction of the ejected material with the surrounding environment.







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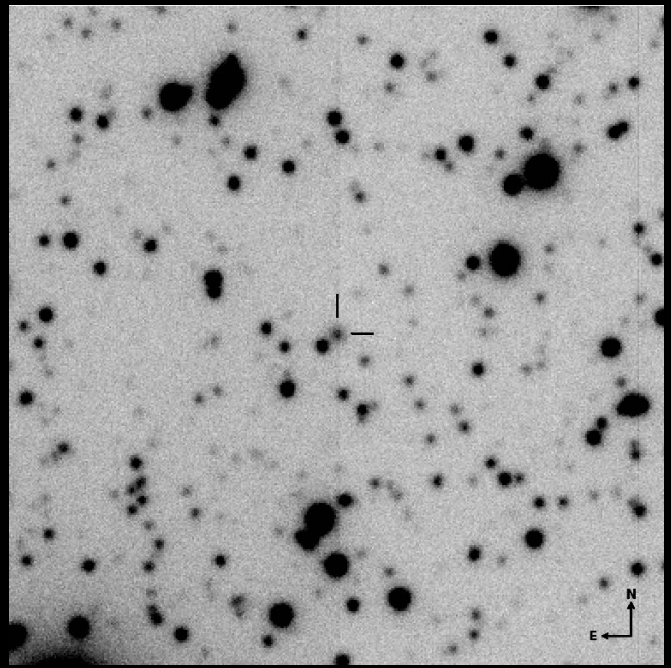
V1425 Aql

Non-eclipsing system and a **possible Intermediate polar**

Orbital period ~ 6 h [a]
WD spin ~ 1.5 h [a]
distance ~ 3.3 kpc [b]



Tappert et al, 2023

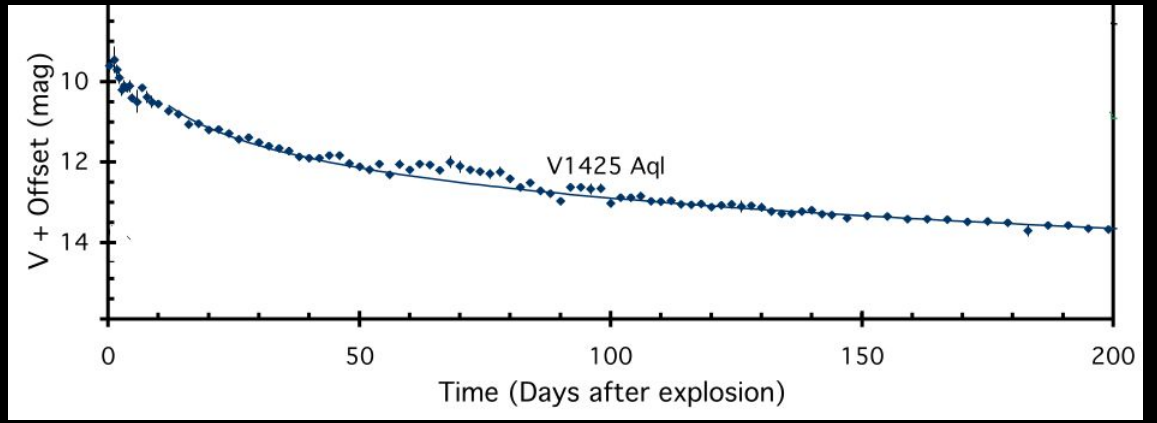
a) Retter et al, 1997
b) Tappert et al, 2023

V1425 Aql, the host of a weird shell

V1425 Aql erupted as a nova in Feb 2, 1995.

Subsequent spectroscopical observations* revealed dust, clumpy structures, CNO enhanced, among others.

* Mason et al, 1996, Kamath et al, 1997, Lyke et al, 2001

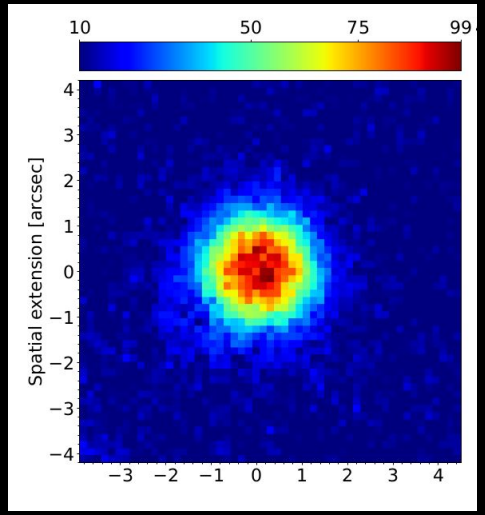


light curve of V1425 Aql (adapted from Strope et al, 2010)

Overall, a pretty common nova eruption

V1425 Aql, the host of a weird shell

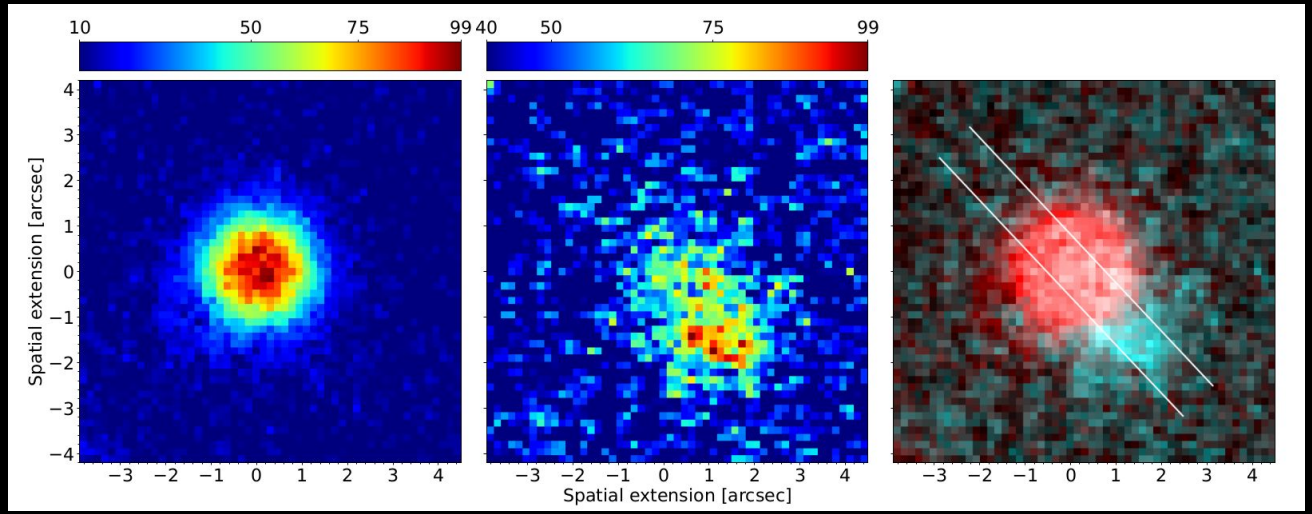
Narrow band images of 2019 show a spherical shell in Hα



Hα

V1425 Aql, the host of a weird shell

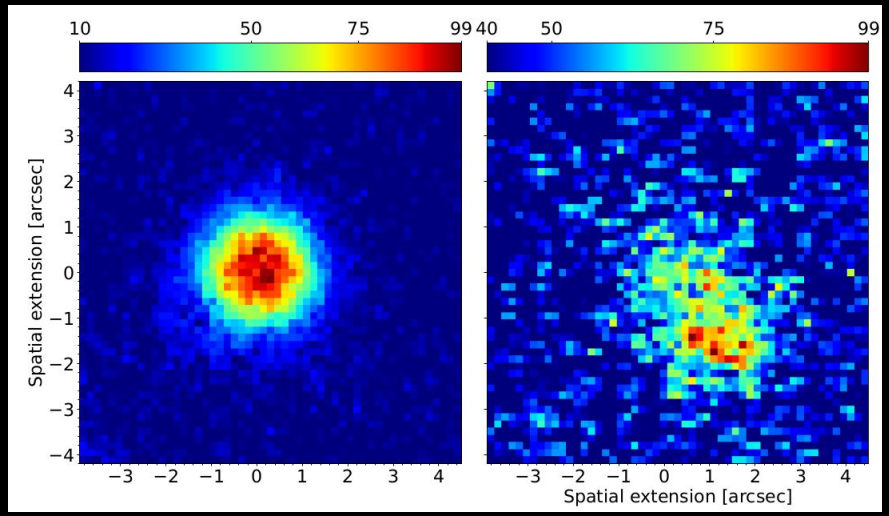
Narrow band images of 2019 show a spherical shell in Hα
While [OIII] presents a clear **axial asymmetry**



Hα [OIII]

Tappert et al, 2023

V1425 Aql, the host of a weird shell

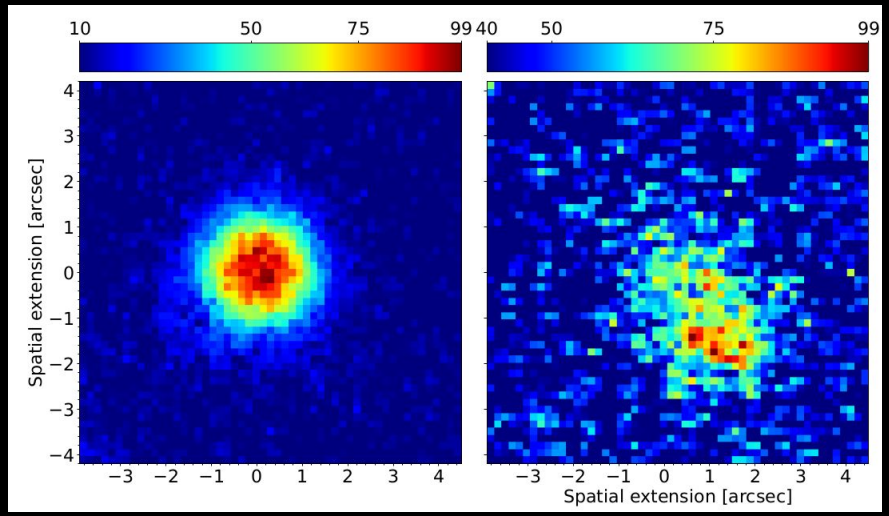


Hα [OIII]

Tappert et al, 2023

The spherical (inner) shell can be observed in **allowed** (Balmer, HeI) **and forbidden transitions** ([OIII], [NII]). The asymmetric (outer) shell **only in forbidden** ([OIII], [NII]).

V1425 Aql, the host of a weird shell



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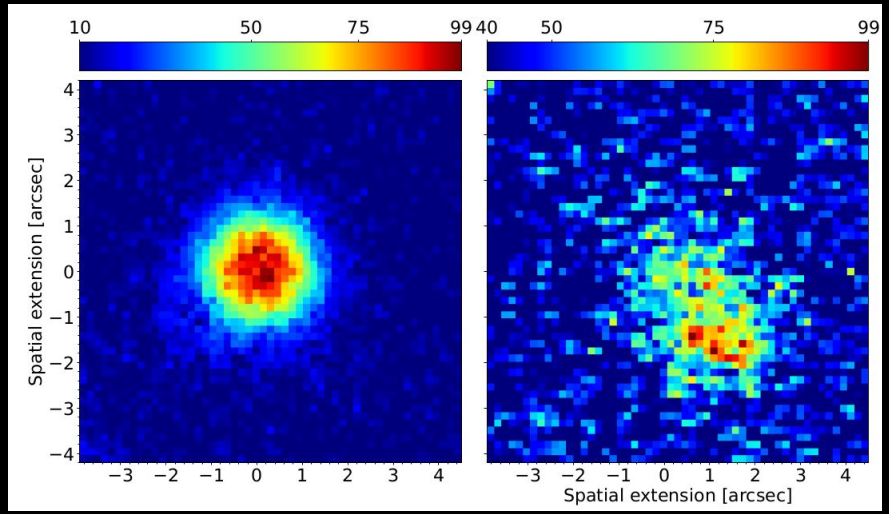
Inner shell corresponds to a **slow ejecta** (~450 kms^{-1}), while the outer shell to a **fast ejecta** (~1200 kms^{-1})

V1425 Aql, the host of a weird shell



Hα [OIII]

Tappert et al, 2023

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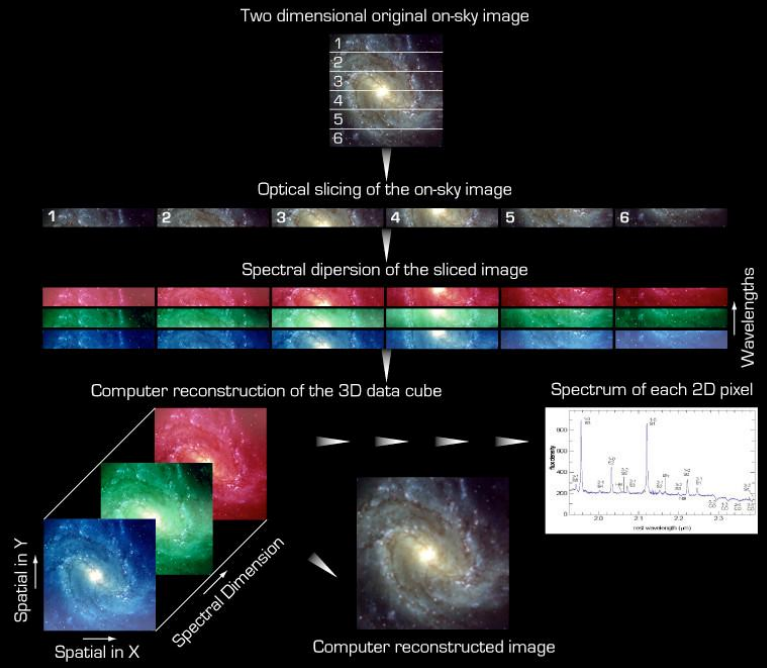
Inner shell corresponds to a **slow ejecta** (~450 kms^{-1}), while the outer shell to a **fast ejecta** (~1200 kms^{-1})

Both shells likely originated during the 1995 event, although the uncertainties in velocity and spatial extension allow for a difference of months.

2nd try, this time with MUSE!

Celedón et al, in prep

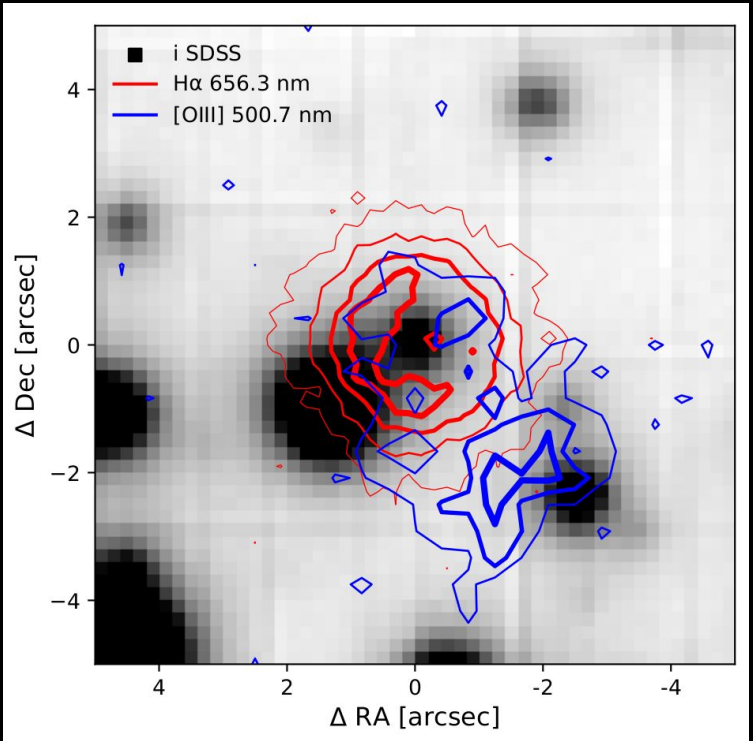


IFS scheme, credits ESO

An integral field spectrograph allows to have an image for each wavelength, or a spectrum per each pixel.

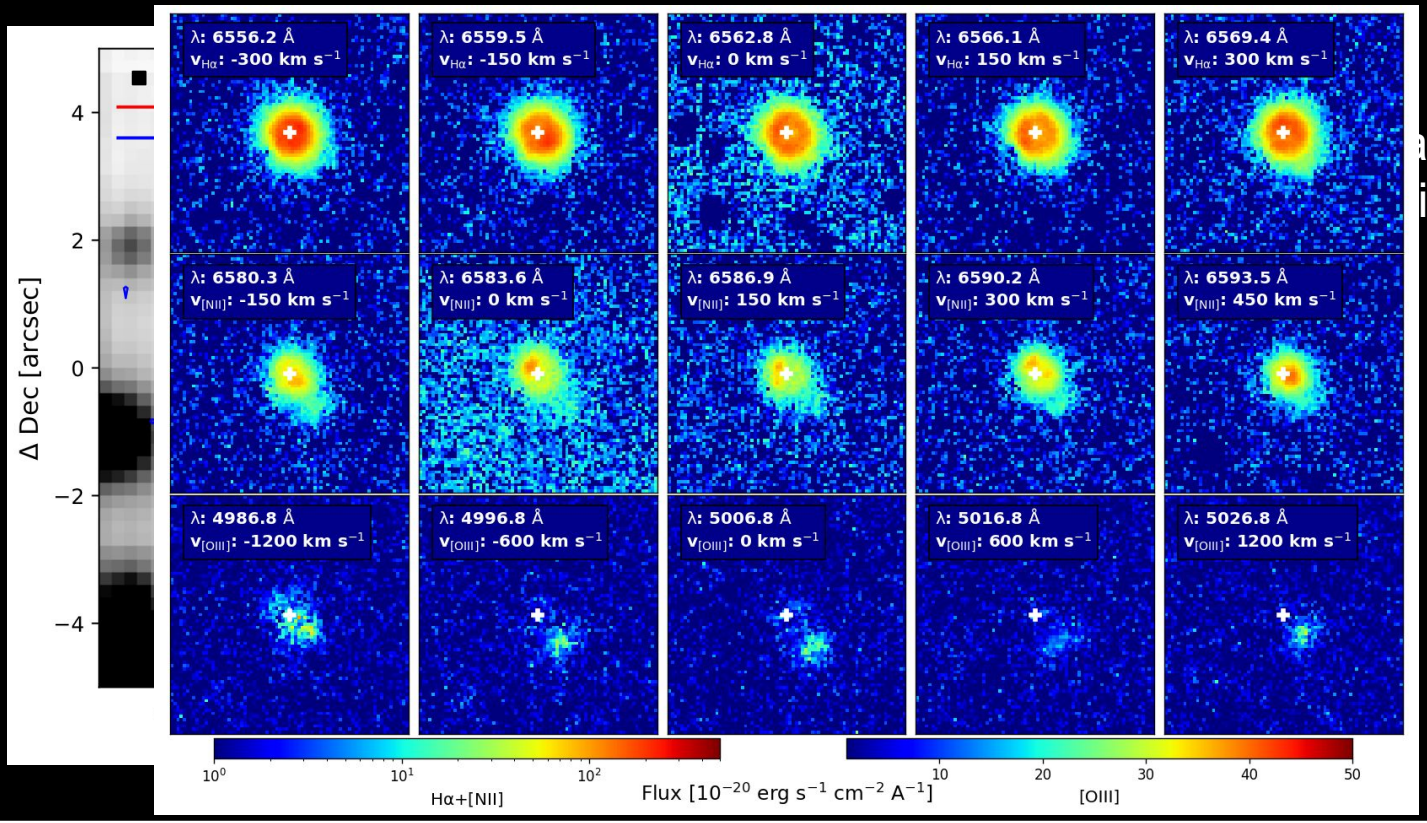
MUSE covers from 470 to 900 nm, a resolution of 1.25 A, a FoV of 1x1 arcmin, and a pixel sample of 0.2 “/pxl

Clumpy structures within the inner shell



The MUSE data reveal **clumpy structures** within the inner and outer shell.

Clumpy structures within the inner shell



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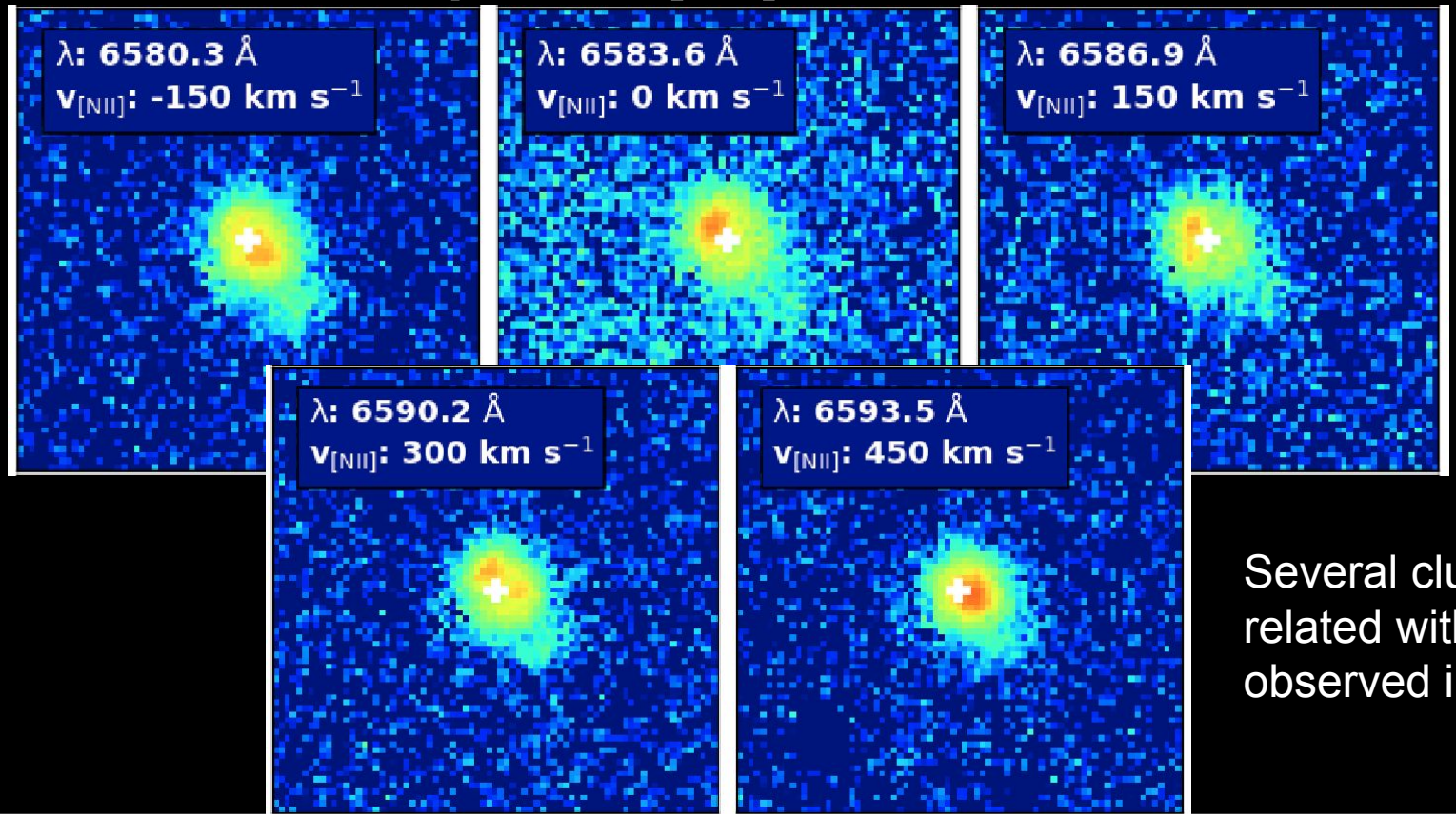
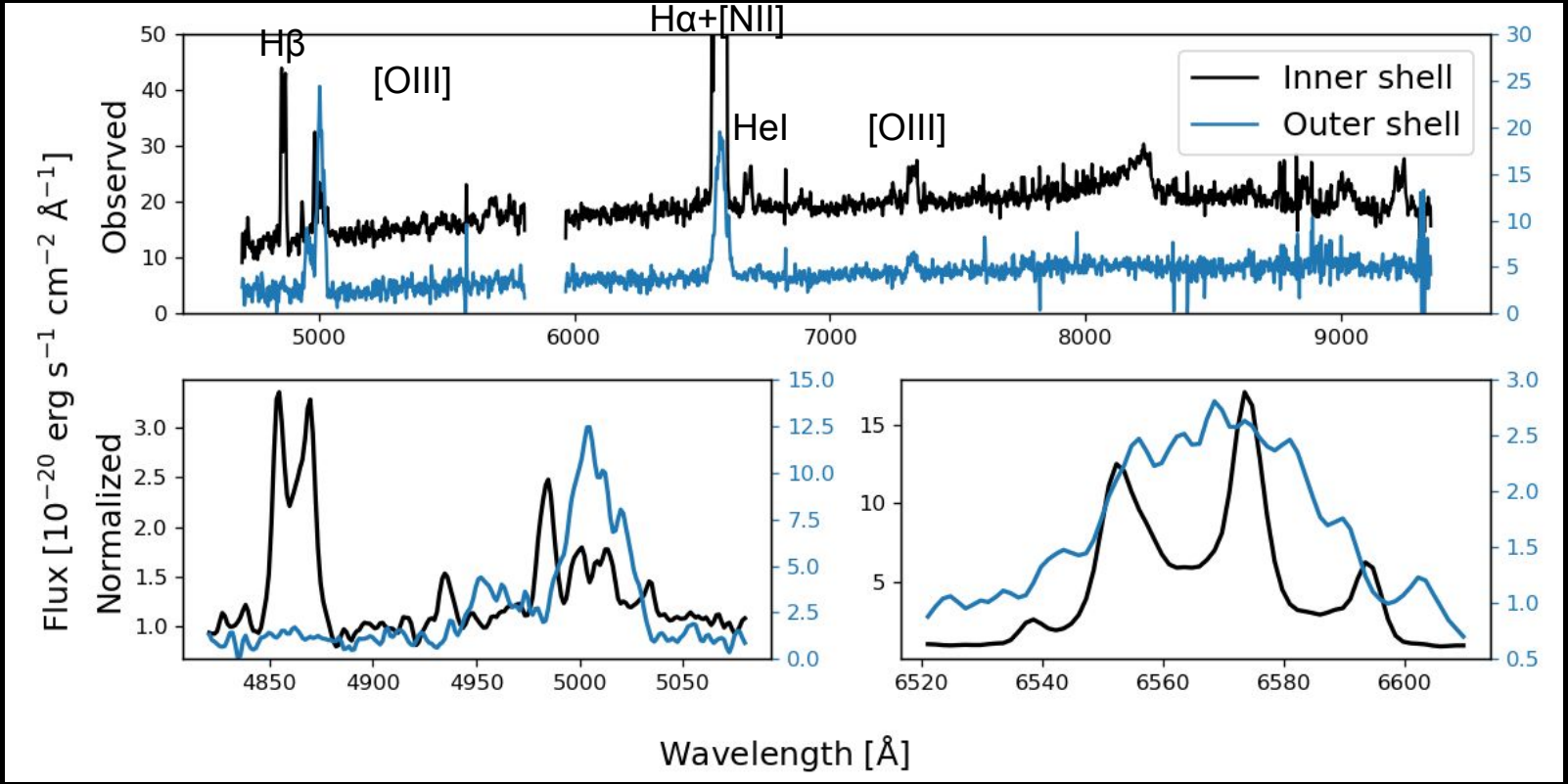
Channel maps, Hα+[NII]



Several clumps likely related with [NII] can be observed in the data

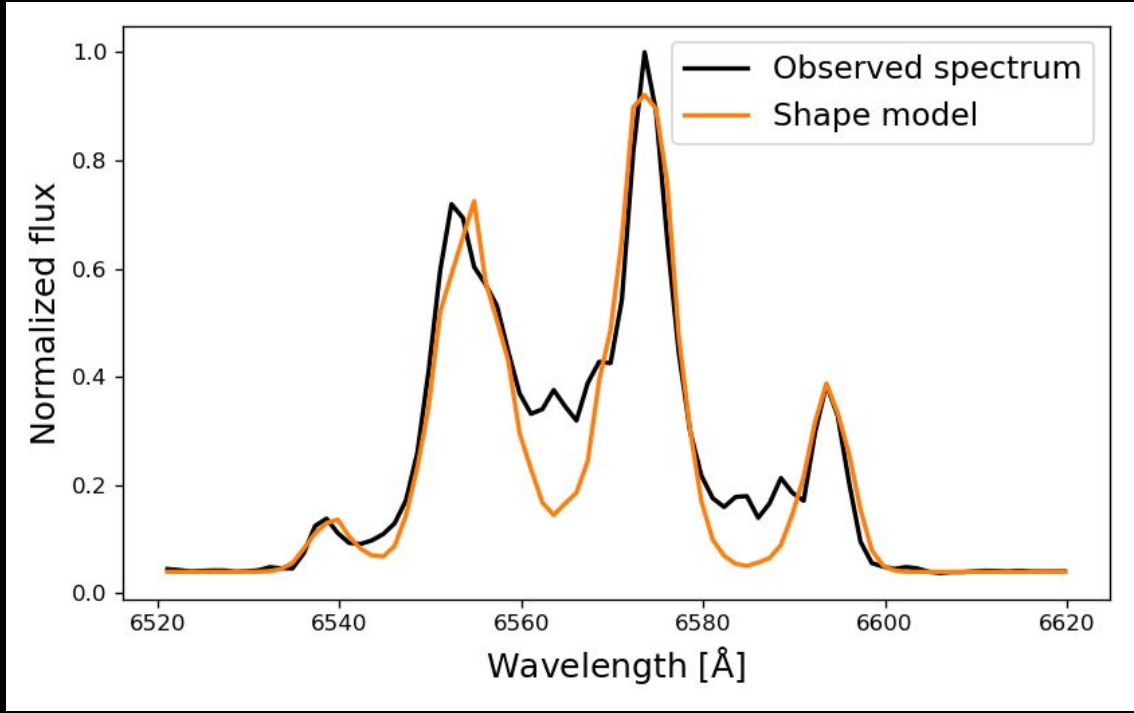
The spectra from MUSE



Attempting to model the inner shell

We attempt to model the geometry of the inner shell using SHAPE (Steffen et al, 2011).

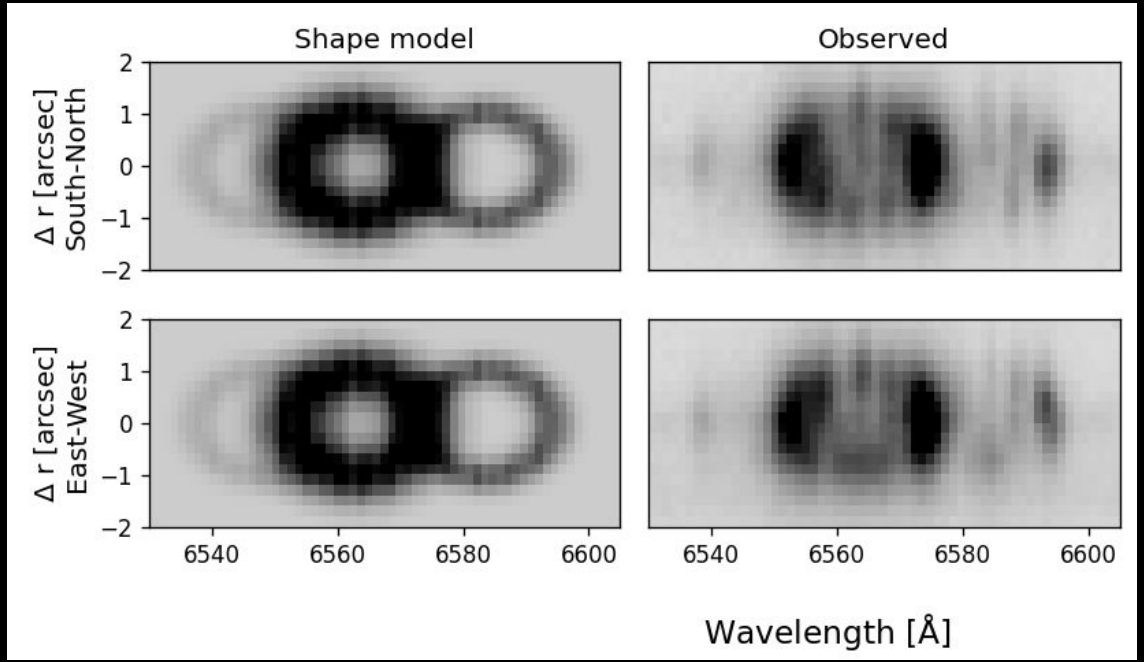
A simple geometry of spherical shells can reproduce part of the spectrum



Attempting to model the inner shell

But we failed to reproduce the Position-Velocity diagrams

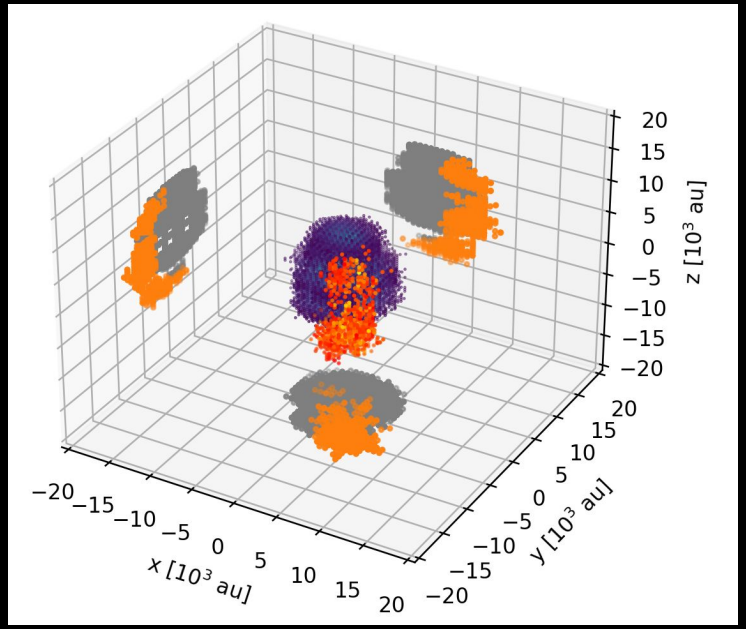
Other models must be tried (torus, clumps).



Outer shell 3D reconstruction

We reconstructed the 3D structure of the outer shell, assuming a radially and free-expanding shell.
(see Celedón et al 2024)

The reconstruction indicates **a narrow, arc-like structure** for the outer shell



Orange: [OIII] Blue: Hα+[NII]

What could be the reason for this asymmetry?

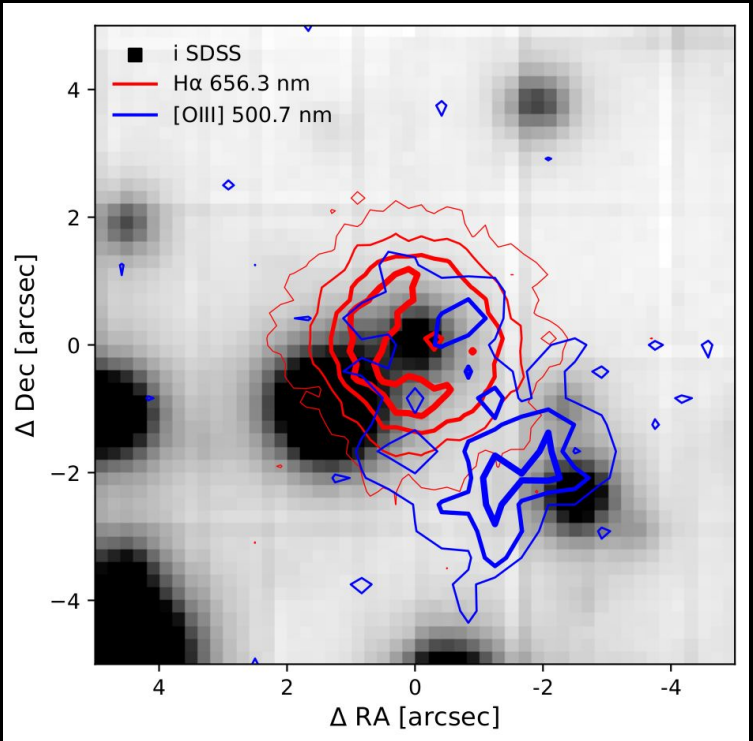
Extrinsic

Interaction with the surrounding ISM

Intrinsic

An asymmetric mechanism during the nova eruption

Asymmetry due to the ISM

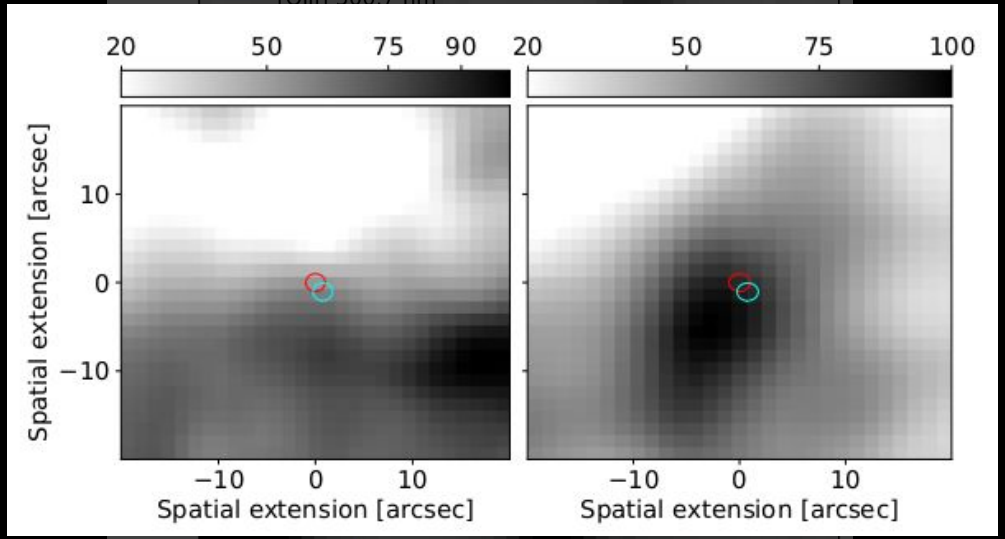


The asymmetry could be due to oscuration or quenching of the forbidden lines.

Asymmetry due to the ISM

WISE 3 (hot ISM)

WISE 4 (cold ISM)



Tappert et al, 2023

The asymmetry could be due to oscuration or quenching of the forbidden lines.

WISE data does not favour this scenario.
In addition, no evidence for obscuration of the inner shell in the northeast quadrant.

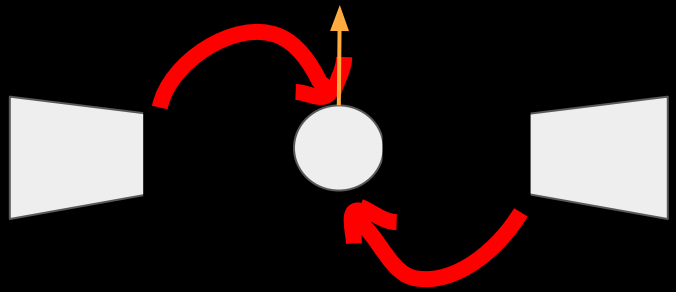
Unlikely scenario

Intrinsic scenario: asymmetric accretion?

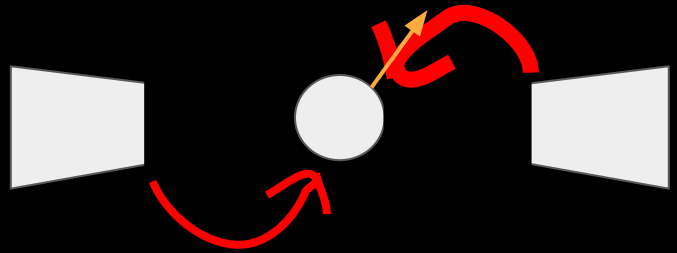
An asymmetric accretion from the disk to the poles?

If the magnetic axis is misaligned with respect the orbital plane, an **asymmetric accretion** through the poles can occur (e.g. Zhilkin et al, 2022)

aligned axis



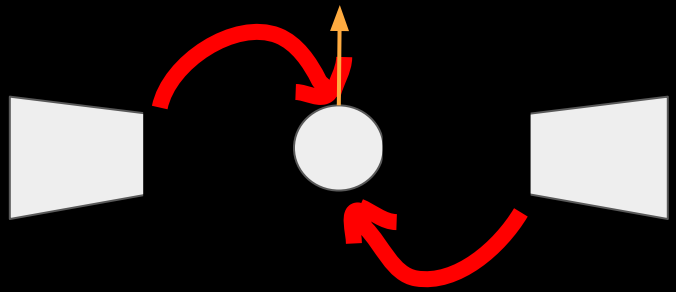
misaligned axis



Intrinsic scenario: asymmetric accretion?

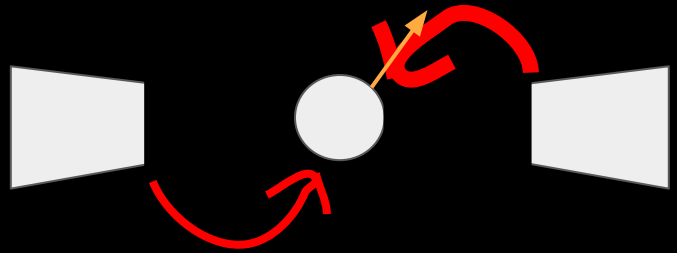
An asymmetric accretion from the disk to the poles?
Other shells involving intermediate polars does not show strange features
(e.g. DQ Her, CP Pup, GK Per)

aligned spins



A possible answer

misaligned spins



Intrinsic scenario: asymmetric TNR?

Asymmetric eruptions have been proposed to explain orbital period changes after a nova eruption (QZ Aur, Schaefer et al, 2019).

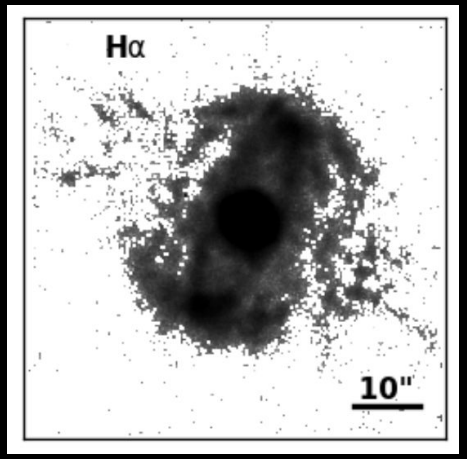
This could have happened during the ejection of the outer shell in V1425 Aql

A physical explanation of the phenomenon must be provided!

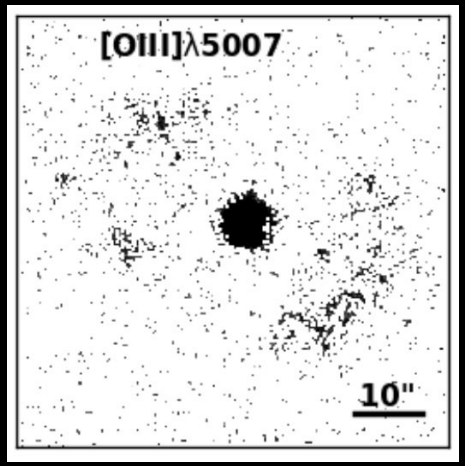
Outer shell: polar or equatorial origin?

High velocity ejecta are related to polar outflows, but its geometry could suggest an equatorial origin.

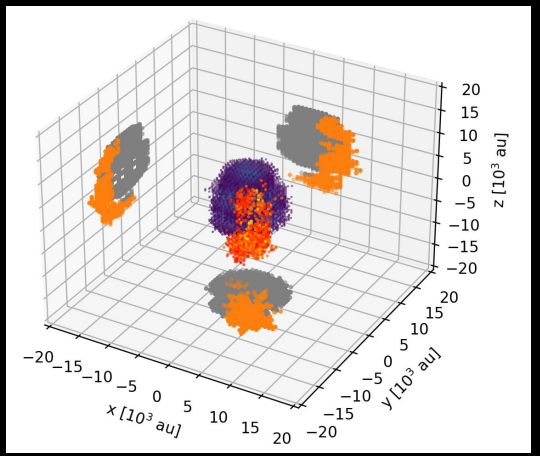
RR Pic, Hα



RR Pic, [OIII]



V1425 Aql, Ha,[OIII]

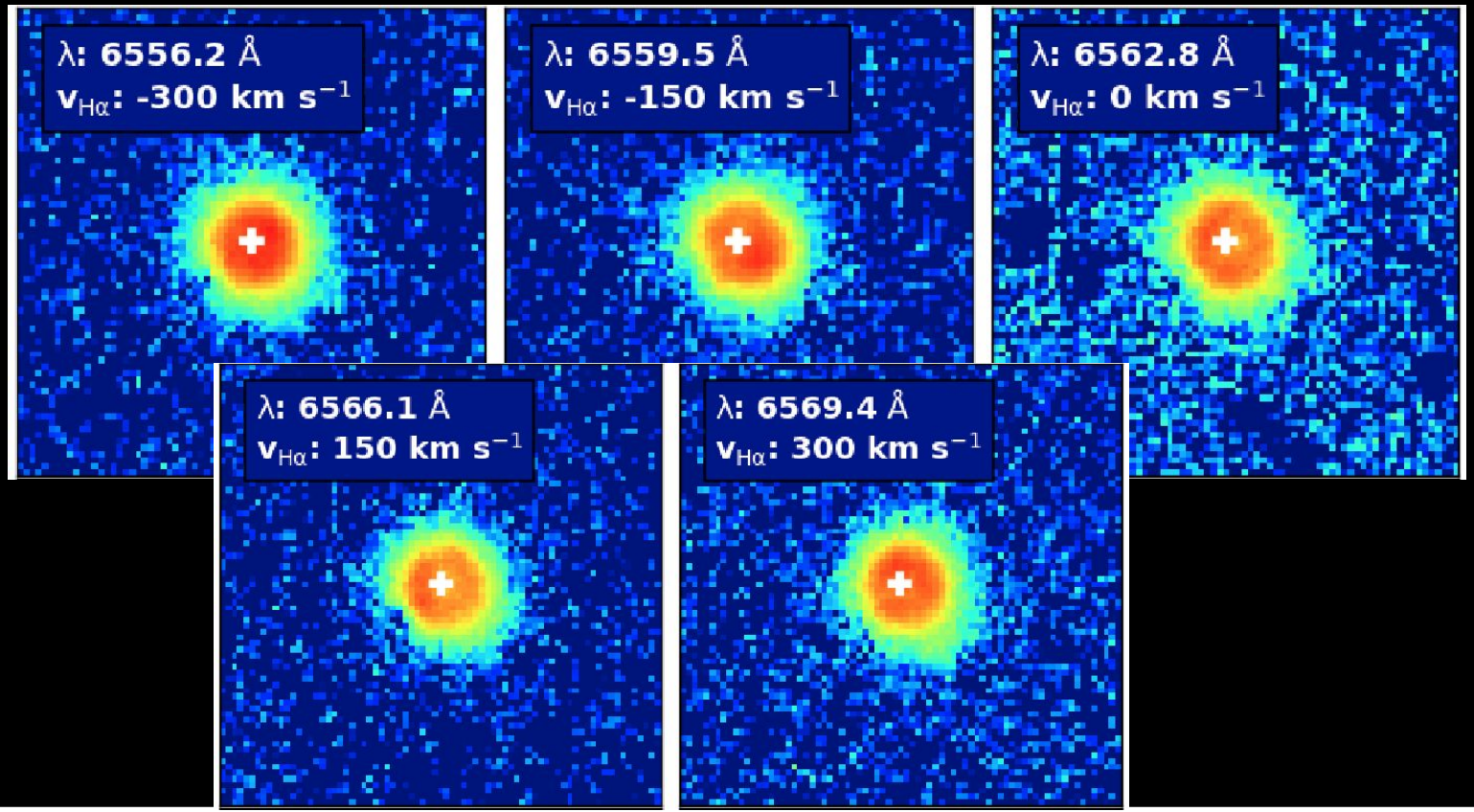


Summary

- Is the first time an asymmetry like the one observed in the outer shell of V1425 Aql is reported.
- The MUSE data allowed us to describe the geometry of the outer shell as a “arc-like” structure, while detecting several clumpy structures in the inner shell.
- We still do not have an answer for the origin of the outer shell, although we favor an intrinsic origin for it.

Thank you for your attention!

Channel maps, Hα+[NII]



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