Wind accretion in Supergiant X-ray Binaries

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& the X-Wind collaboration

CmPA – KU Leuven

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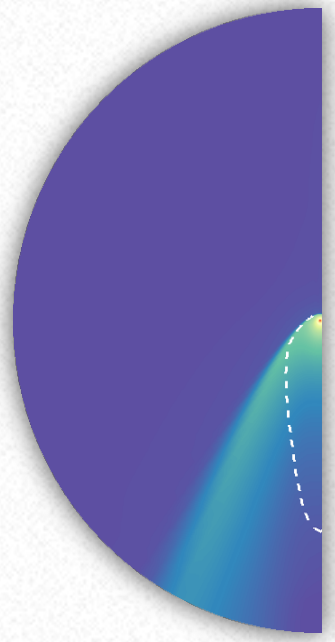
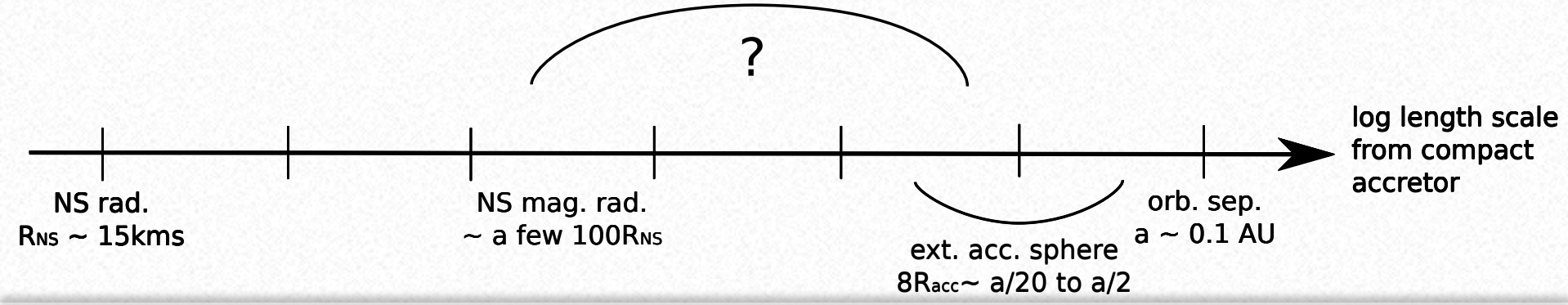
The challenge of scales

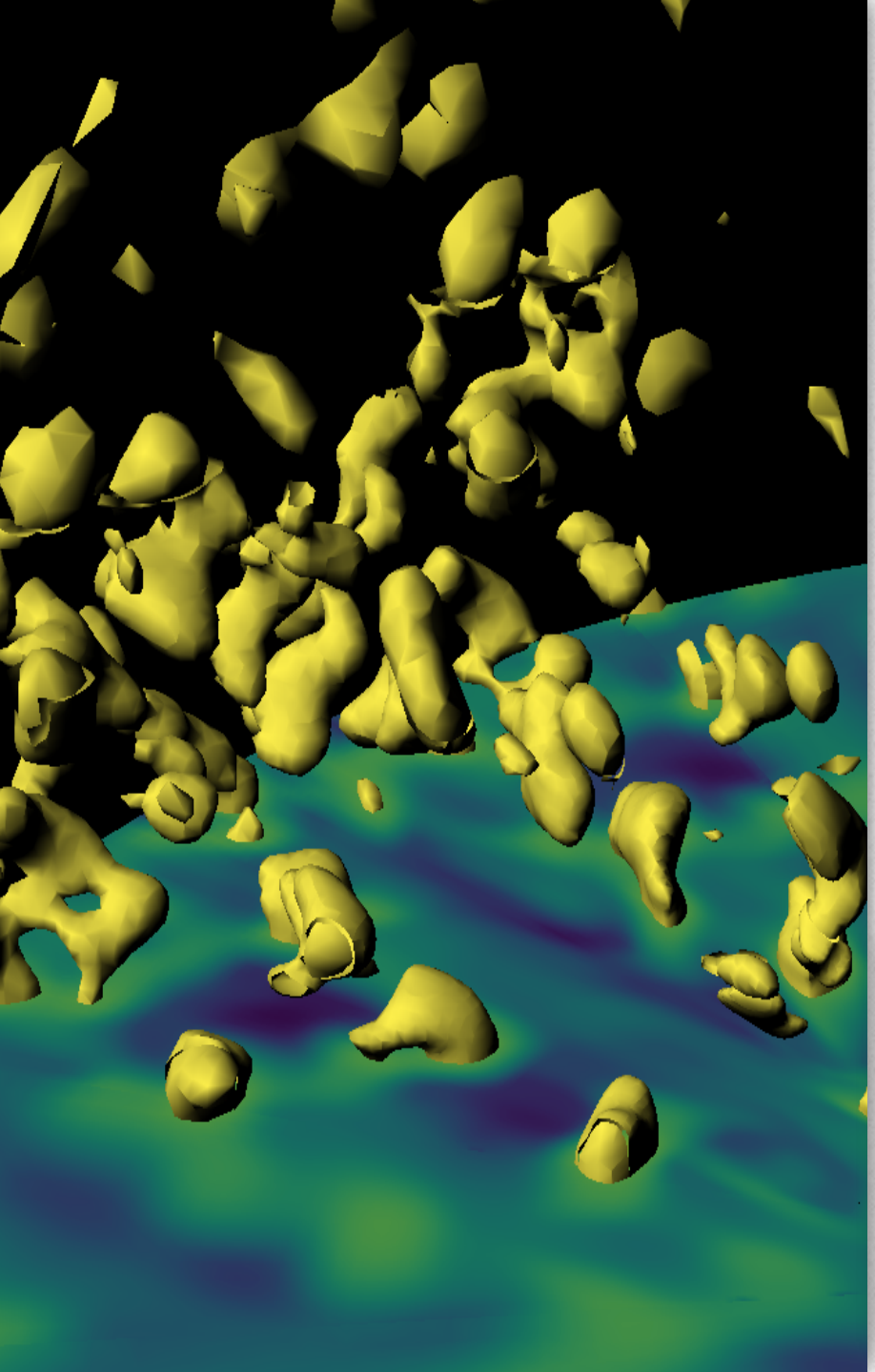
1. clumps capture?

2. disc-like structure?



3 orders of magnitude





Clumps in the wind

Accretion from a clumpy massive-star wind in SgXB, MNRAS 2018

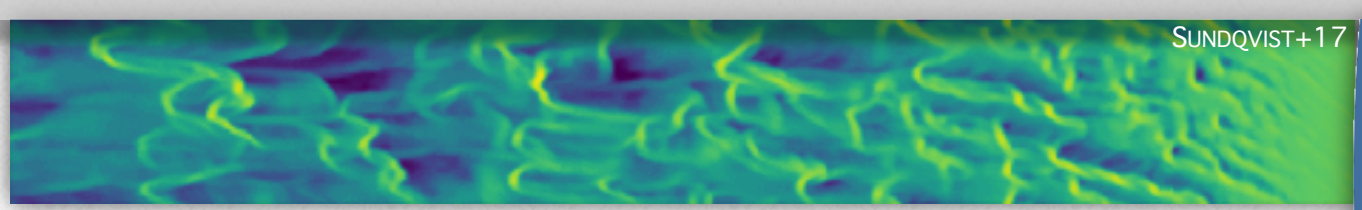
IEM, Jon Sundqvist, Rony Keppens

Clump dimensions

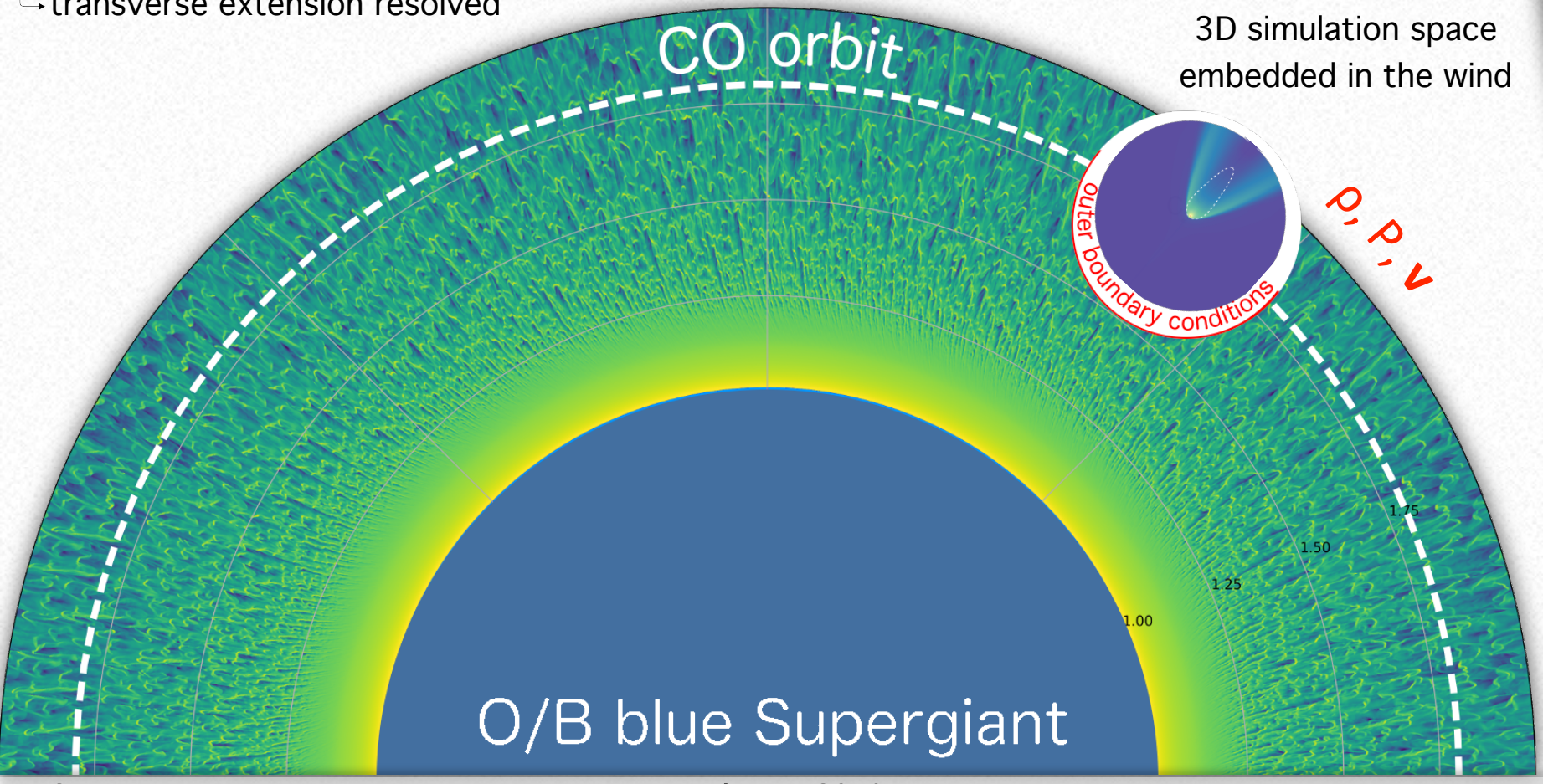
Line-driven winds

Internal shocks
=> **clumps**

Pseudo-planar 2D simulations
↳transverse extension resolved

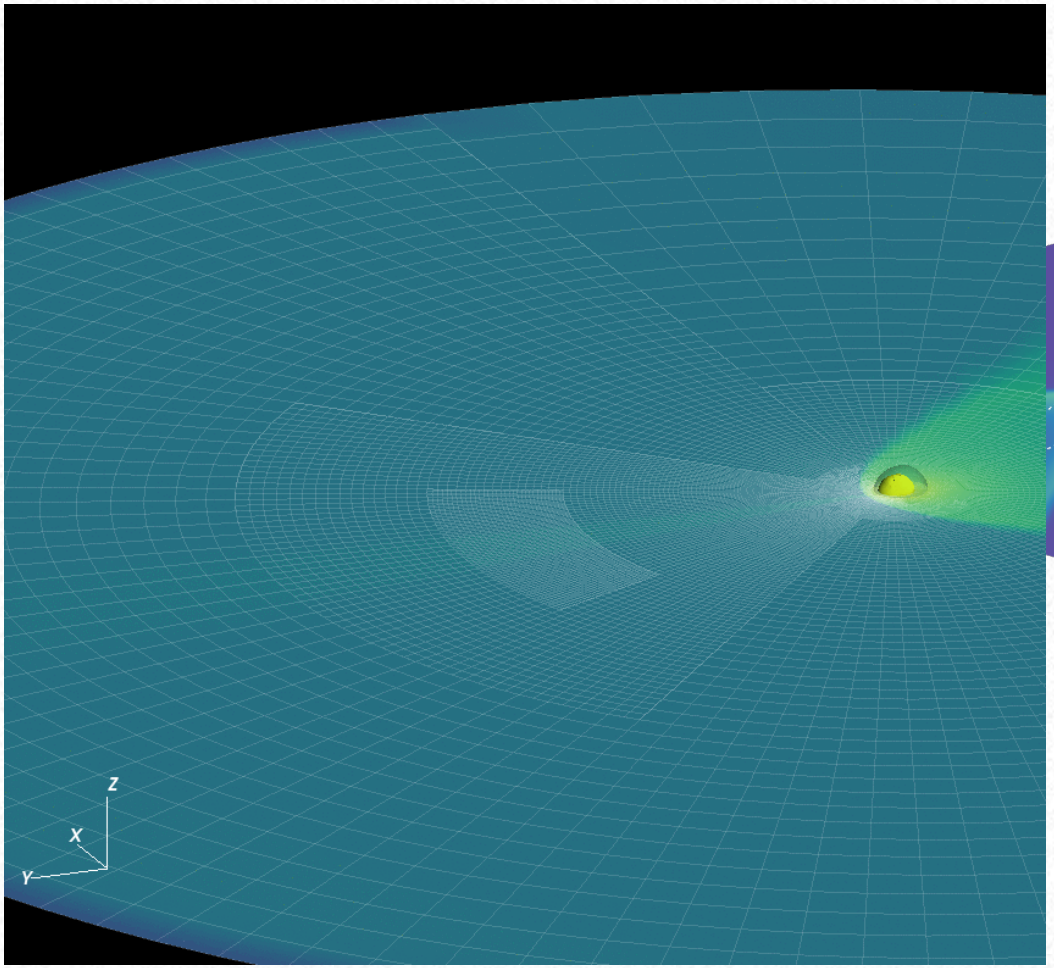


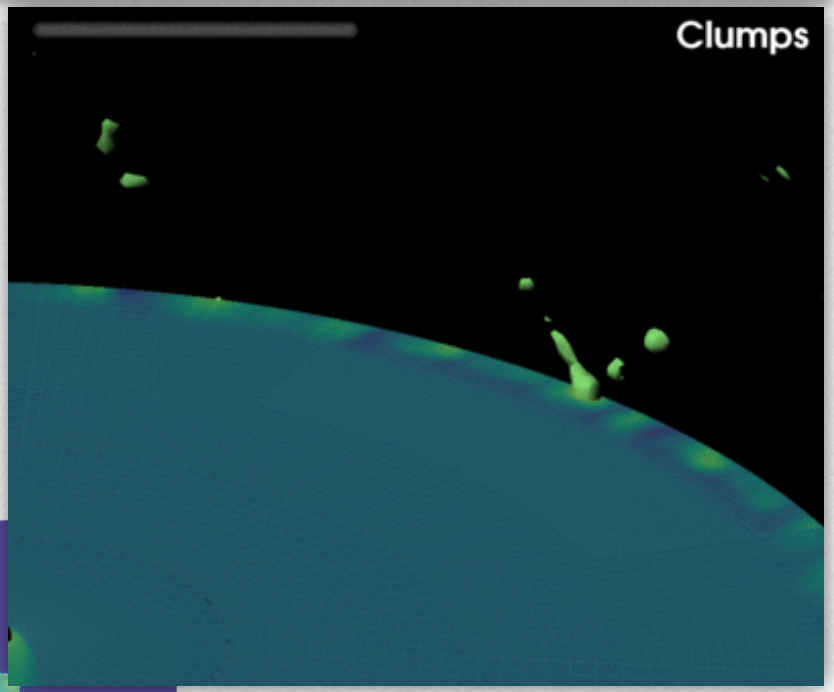
Supergiant star



Structure of the flow and time variability of the mass accretion rate

Ballistic clumps



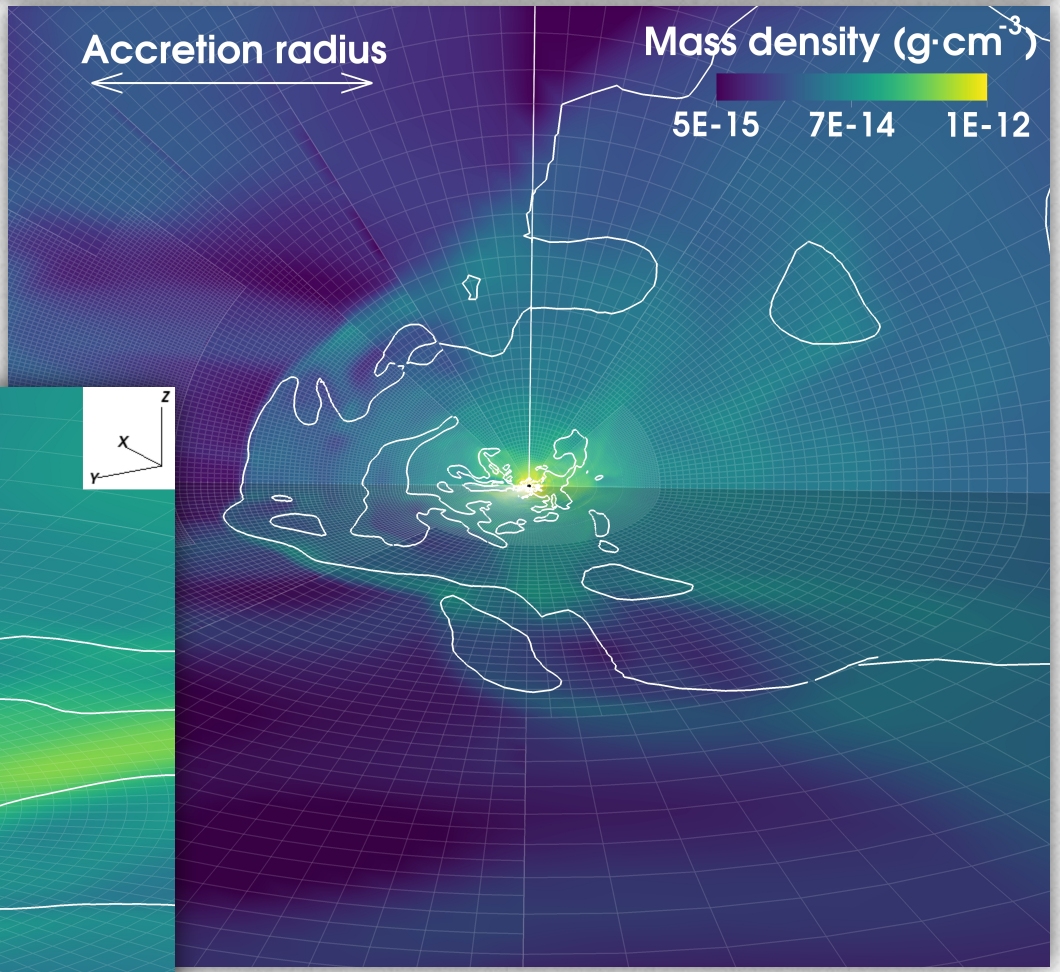


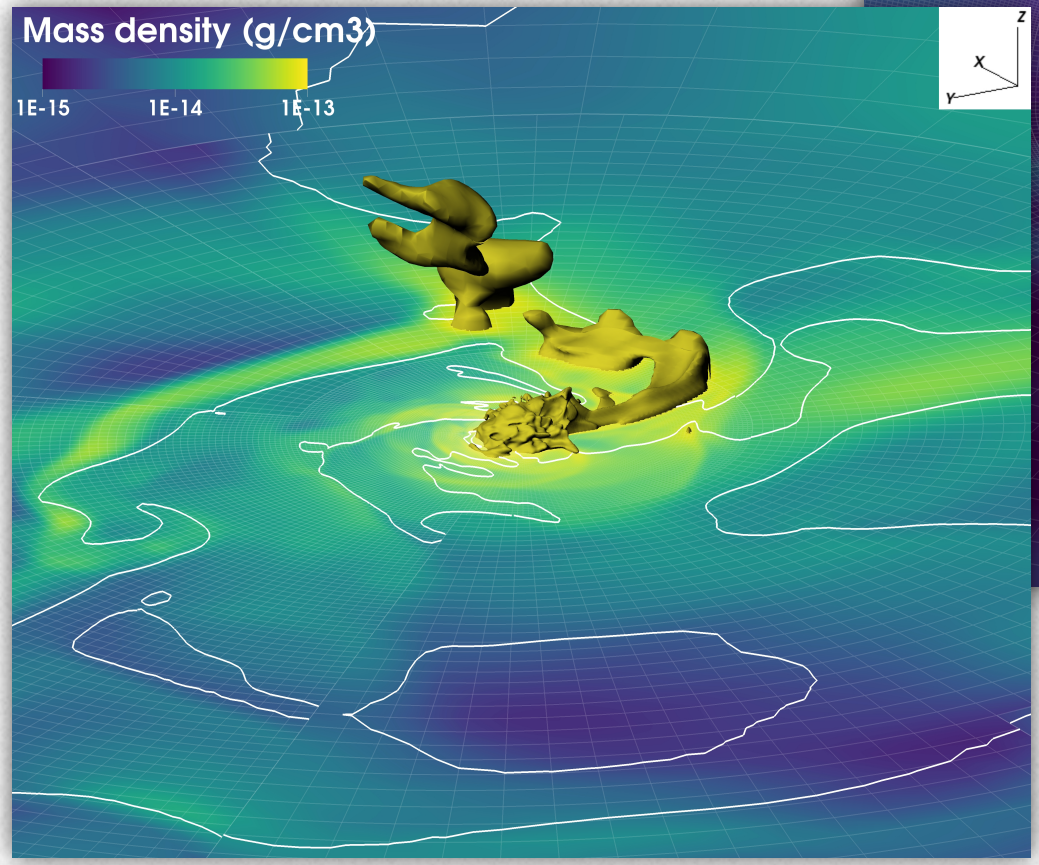
Structure of the flow and time variability of the mass accretion rate

Bow shock @ accretion radius

↳ **prevents direct accretion** of clumps

↳ evacuation of angular momentum





Structure of the flow and time variability of the mass accretion rate

Bow shock @ accretion radius
- ↳ **prevents direct accretion** of clumps
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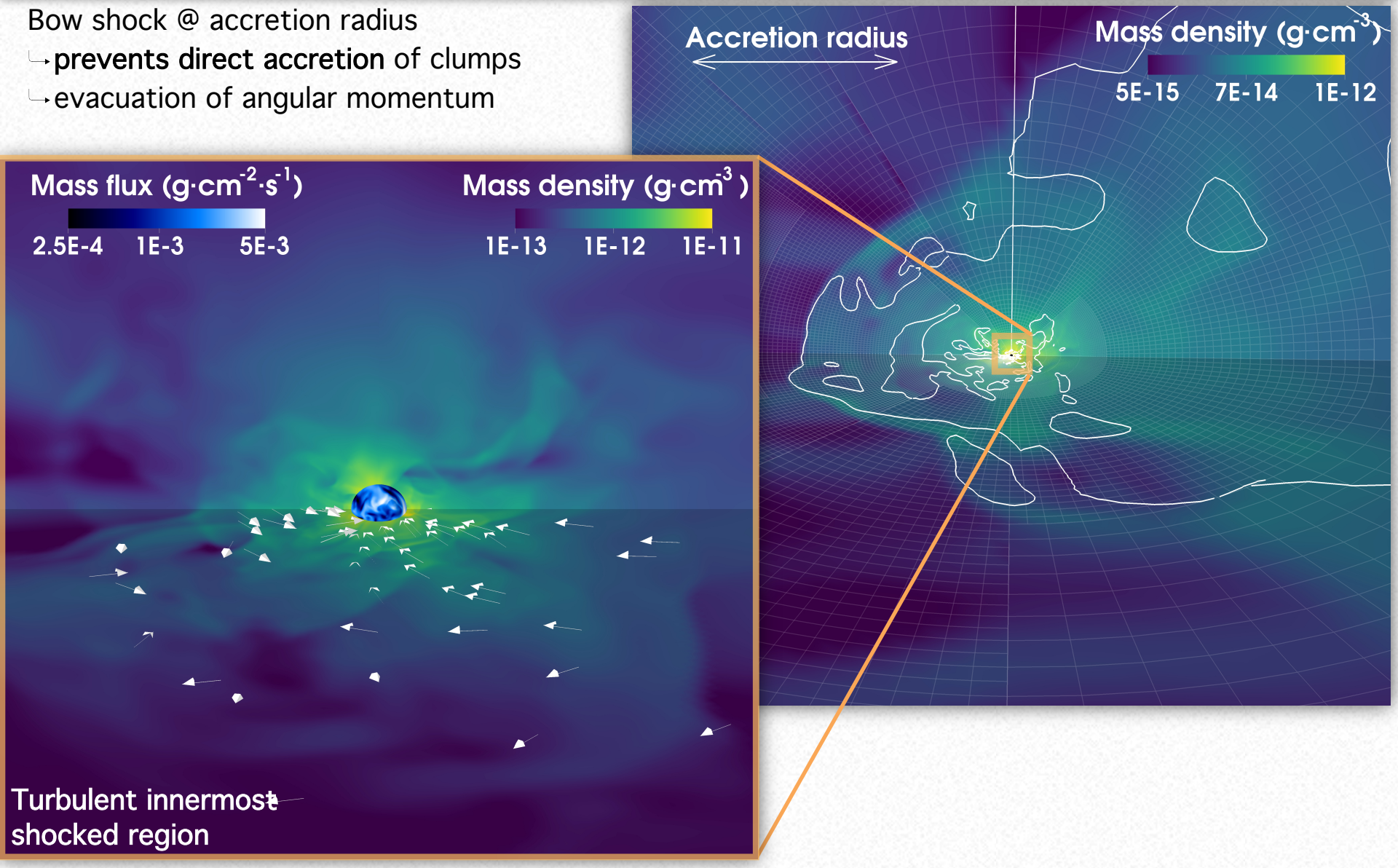
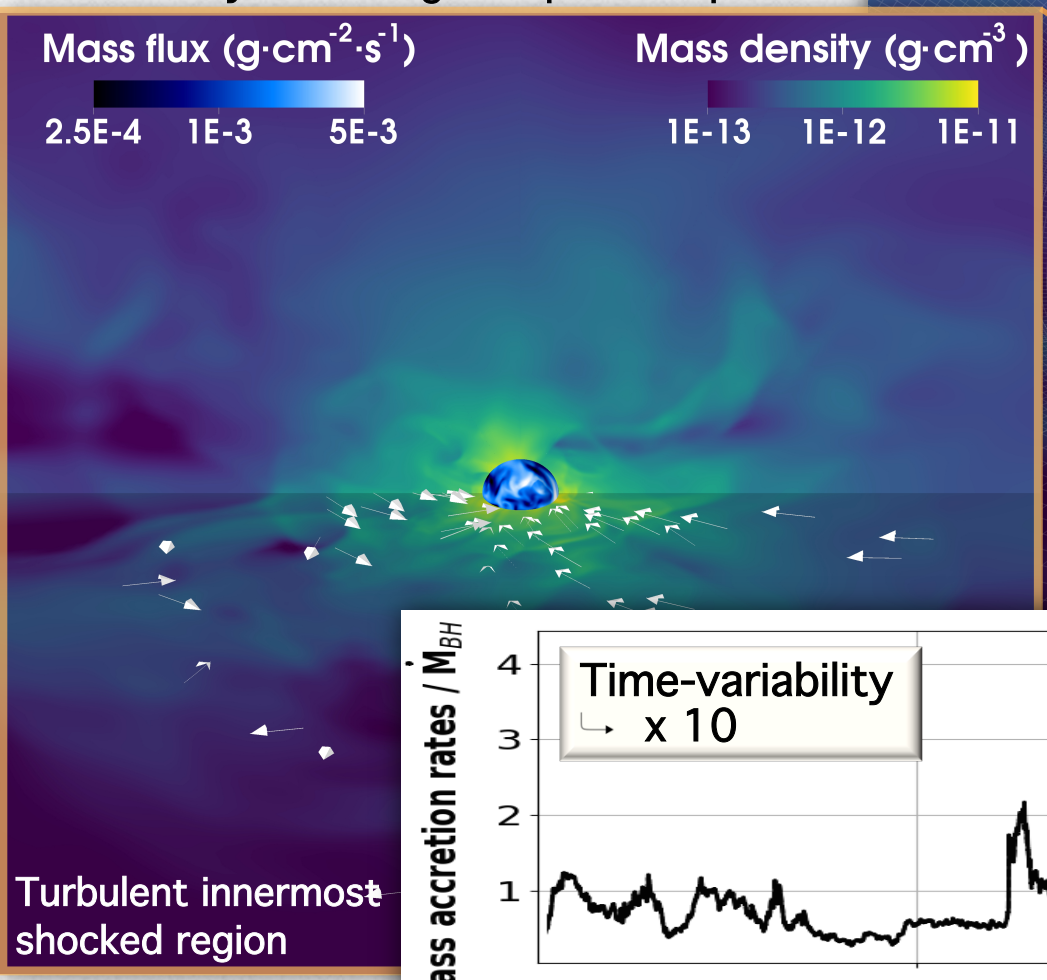
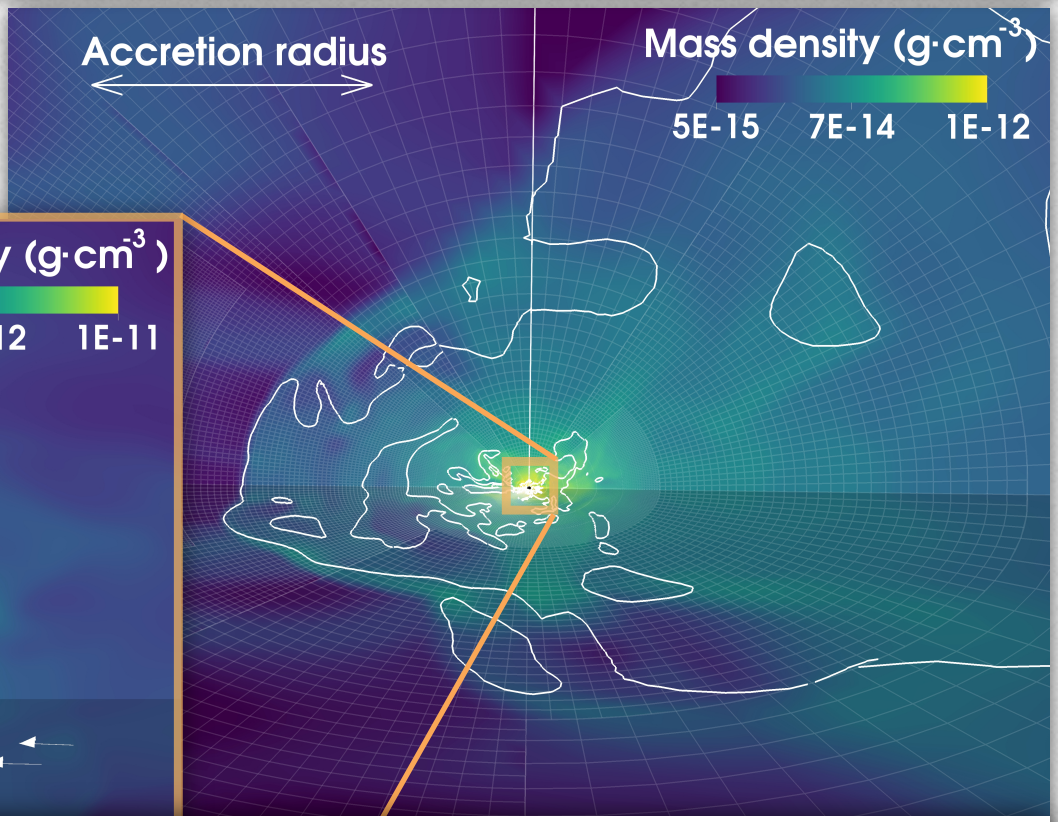
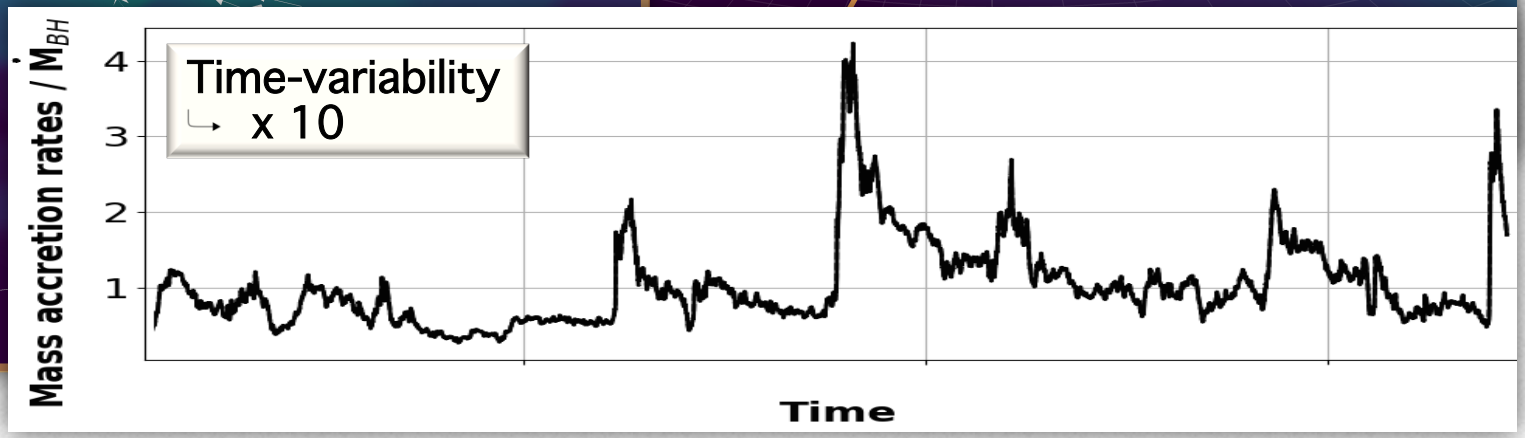


Structure of the flow and time variability of the mass accretion rate

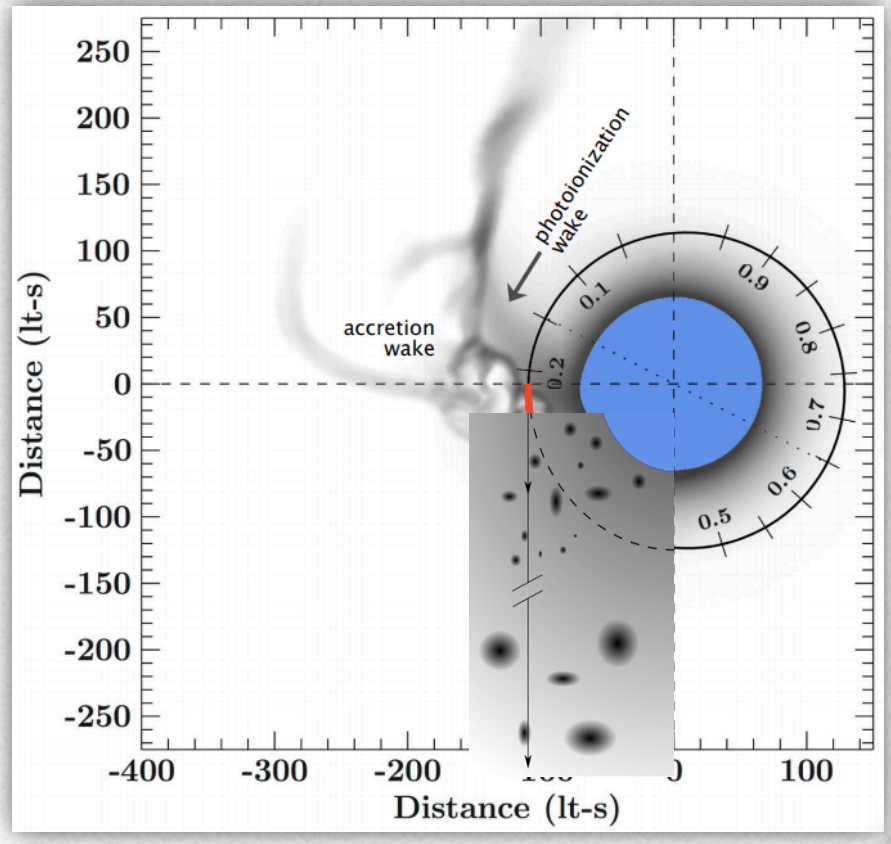
Bow shock @ accretion radius
- ↳ **prevents direct accretion** of clumps
- ↳ evacuation of angular momentum
- ↳ **instability @ NS magnetosphere required**







Observations of Vela X-1



Phase ~ 0.25

↳ no tail in the L.O.S

Hardness enhanced

↳ not from source

↳ increase in N_H (x7)

↳ 1h long

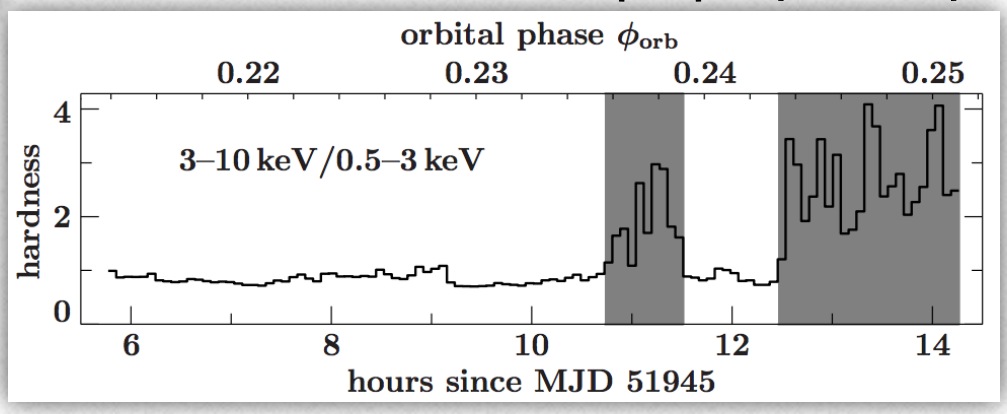
Grinberg et al. 2017

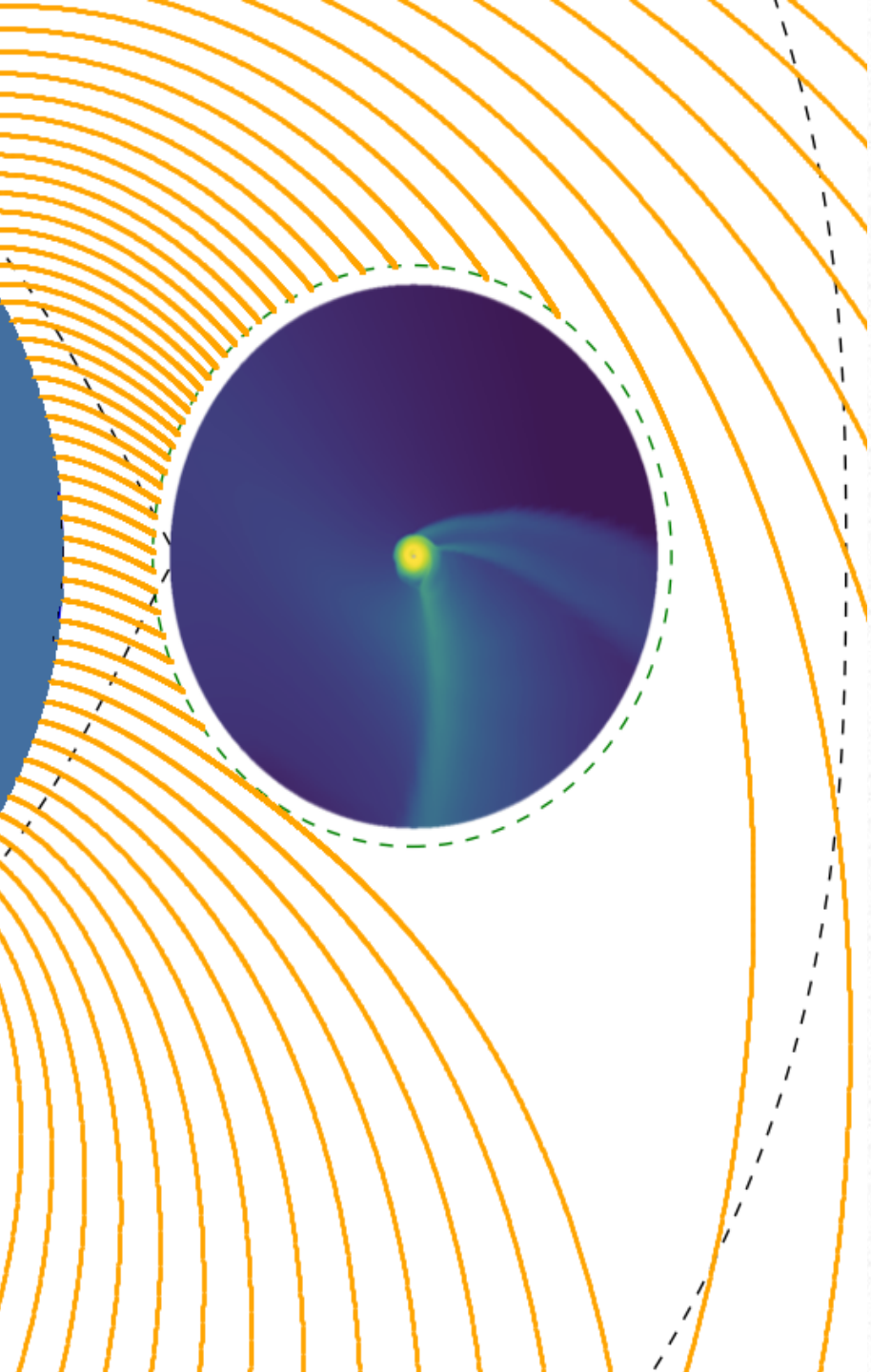
Due to clump event?

↳ too small (1% of R_{star})

↳ too packed

↳ too fast (~1,000km/s)



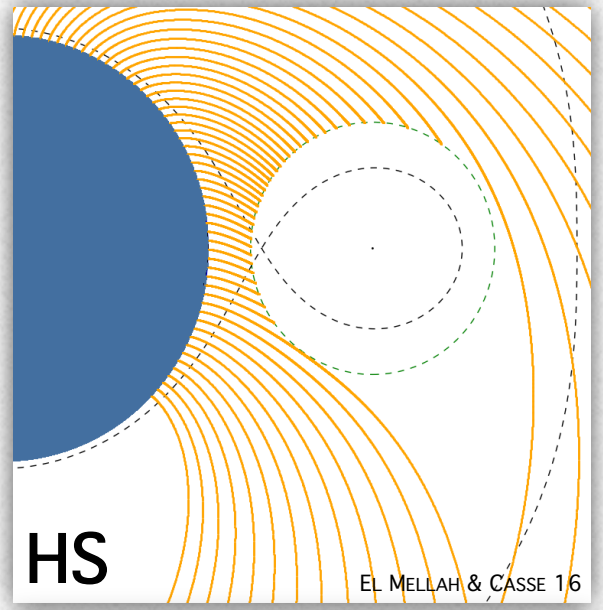


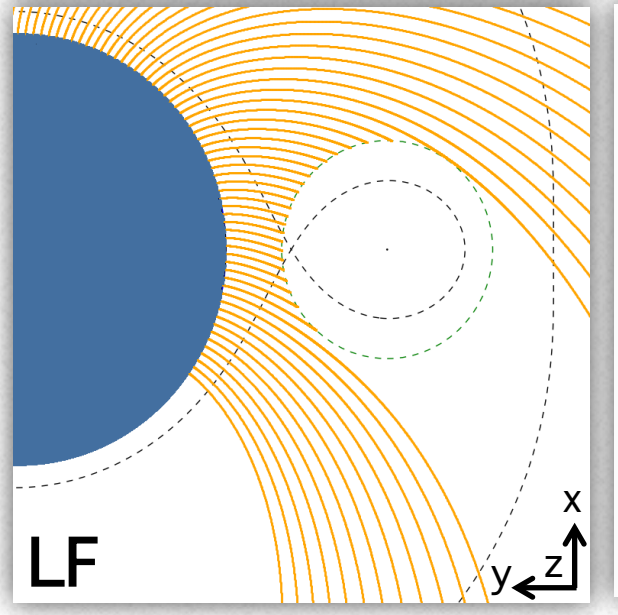
Orbital bending

Wind-capture discs in SgXB,
A&A 2019

IEM, Andreas Sander,
Jon Sundqvist, Rony Keppens

Slow VS fast winds : where should we draw the line?



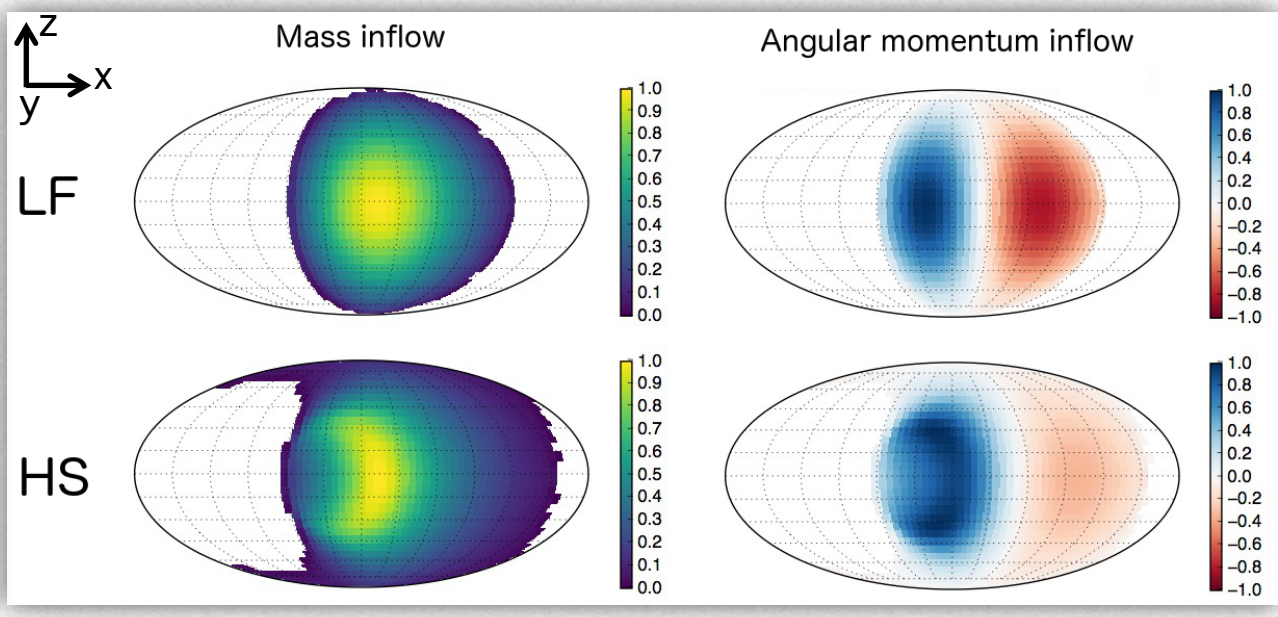


3D ballistic wind (RK4)
Stellar parameters fixed

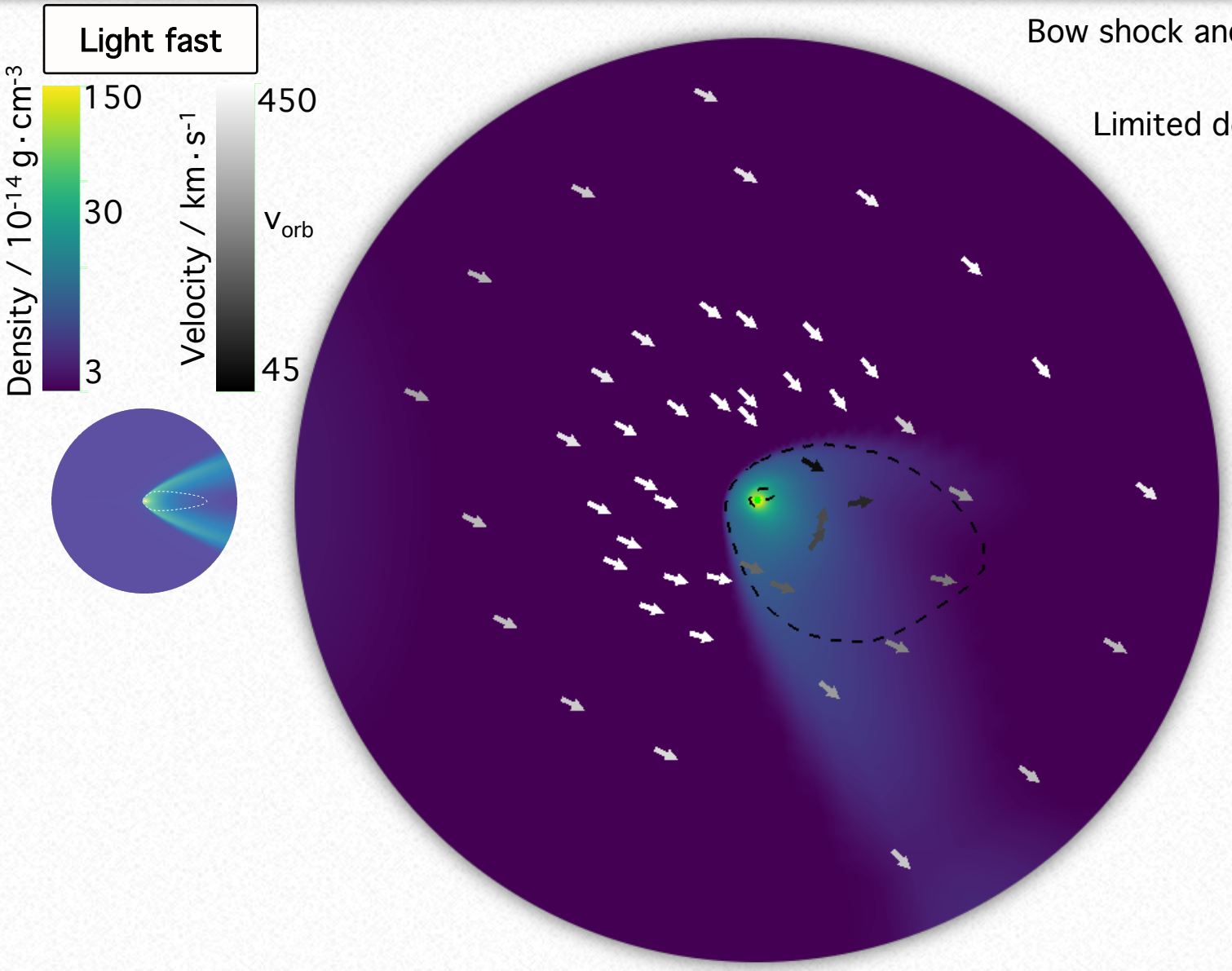
Roche potential +
radiative acceleration (w/ X-rays)

Heavy Slow (HS)	Light Fast (LF)
NS mass : $2.5M_\odot$	NS mass : $1.5M_\odot$
Normal acceleration	Enhanced acceleration (50%)
=> wind speed < orbital speed	=> wind speed > orbital speed

Similar mass inflow distribution
BUT
Net inflow of angular momentum non-zero for HS



Wind-RLOF configuration



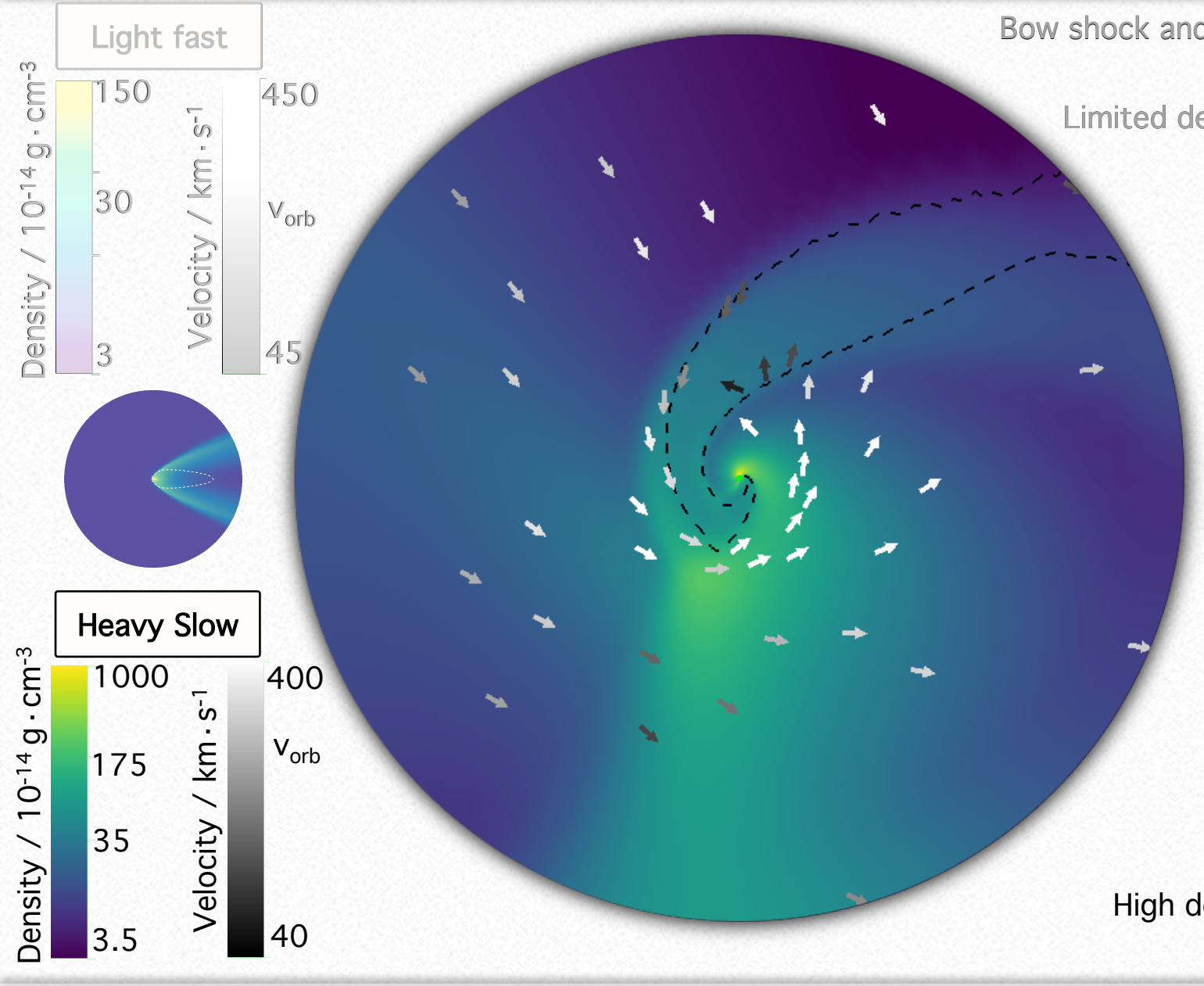
Bow shock and Mach-1 misaligned

Sonic surface

Limited density enhancement

No disc

Wind-RLOF configuration



Bow shock and Mach-1 misaligned

Sonic surface

Limited density enhancement

No disc

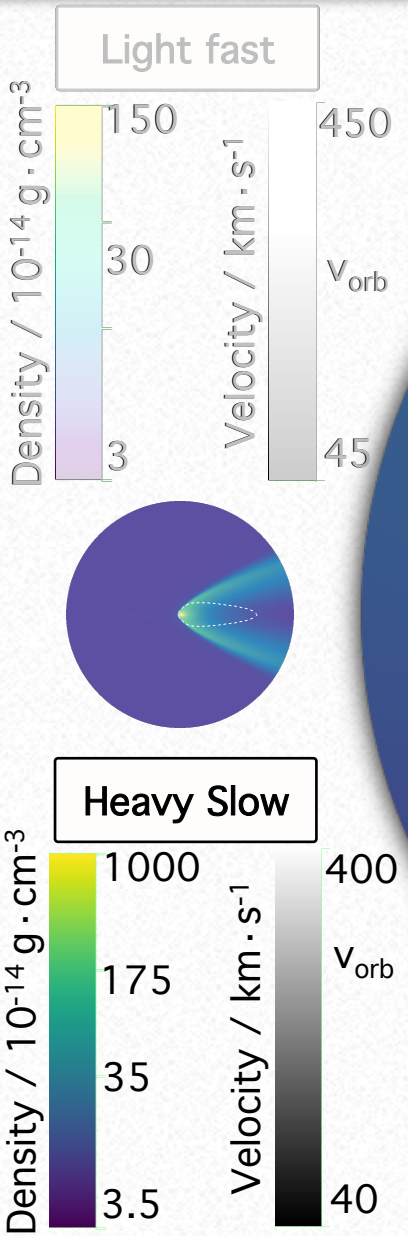
Asymmetric shock

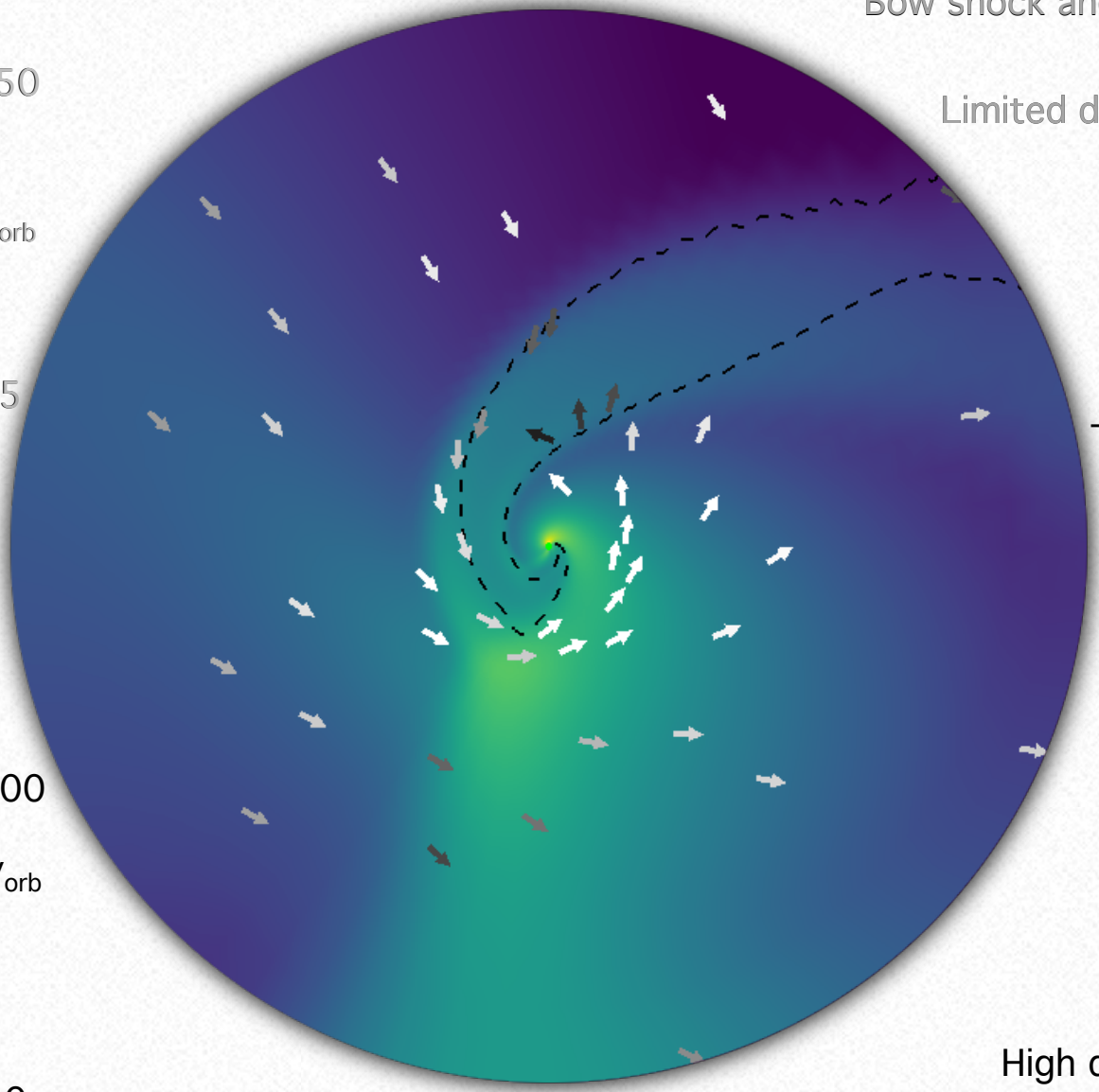
Orbital compression

High density enhancement

Spiral structure

Wind-RLOF configuration





Bow shock and Mach-1 misaligned
Sonic surface
Limited density enhancement
No disc

Temperature increase
by factor x5,000
||
V
cooling required

Asymmetric shock
Orbital compression
High density enhancement
Spiral structure

Cooling prescriptions and wind-capture disc

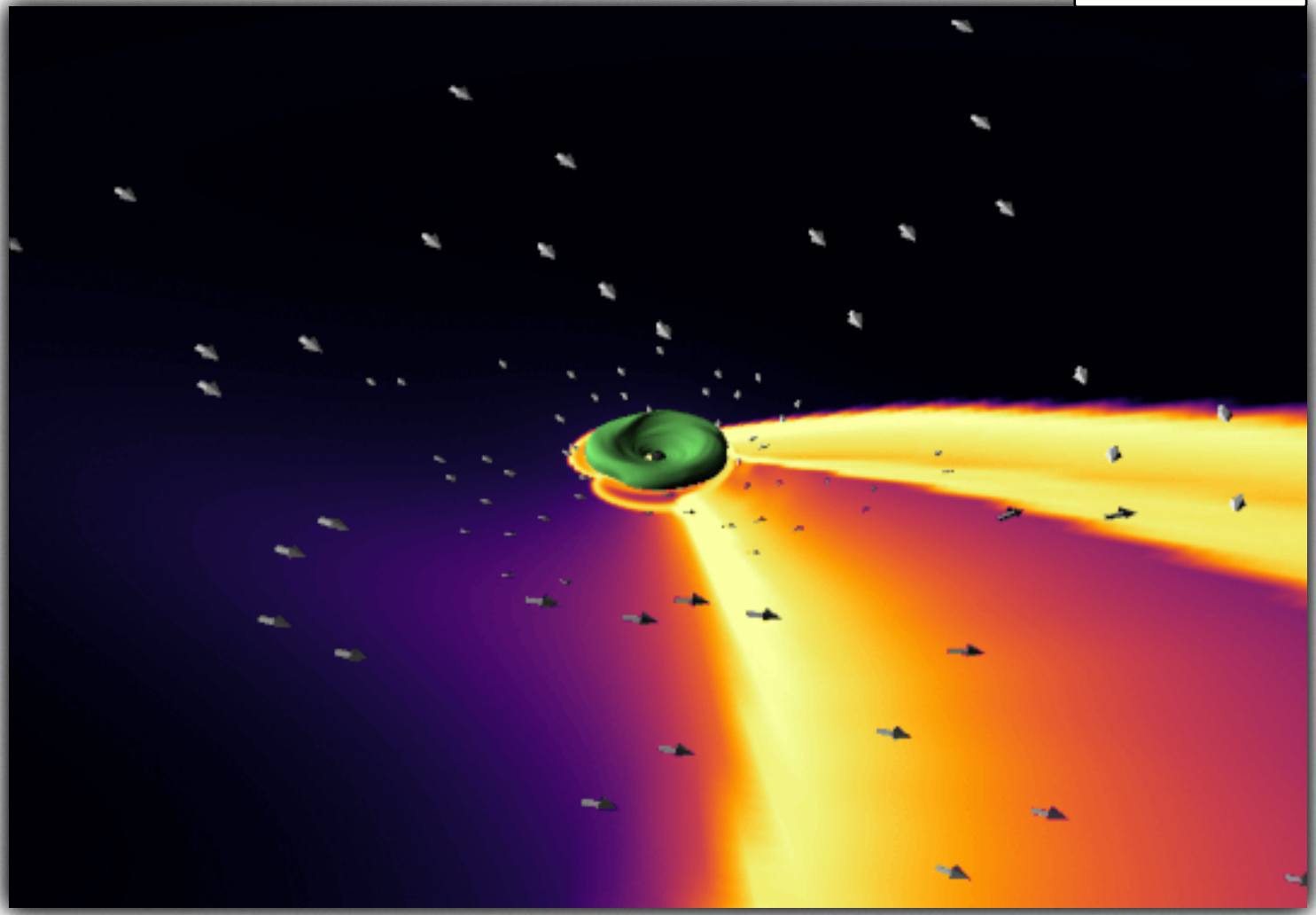
Polytropic prescription to reproduce cooling

Heavy Slow

Constant entropy

Constant high temperature

Constant low temperature



Light fast

↳ no disc

Conclusion

Overview

Impact of clumps on time-variability

- ↳ **lower** than ballistic prediction
- ↳ cushioning **shock**
- ↳ limited absorption variability along LOS
- ↳ **instabilities within a few 100 R_{SCHW}**
- ↳ dependence on orbital separation (SFXT)

Orbital shearing and disc formation

- ↳ provided $v_{wind} < v_{orb}$ ...
- ↳ ... and efficient cooling
- ↳ beyond NS magnetosphere

Perspectives

- ↳ the case of Cygnus X-1
- ↳ disc-like structure => disc wind? transient?
- ↳ NS (or BH) spinning-up
- ↳ **Enhanced mass transfer => ULX (IEM, Sundqvist, Keppens, A&A 2019)**

Merci!