

Nathan Maindon

HH 46/47, NIRCAM – Crédits: NASA, ESA, CSA -Joseph DePasquale, Anton M. Koekemoer

LUX Day

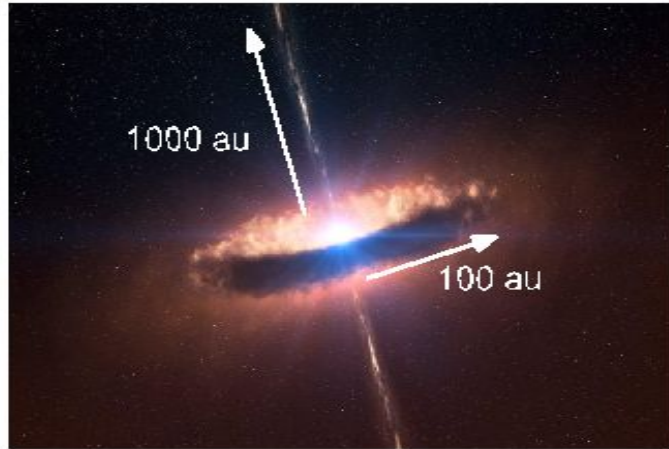
Feedback of protostellar ejections on planetary formation

Supervisors : Sylvie CABRIT, Guillaume PINEAU DES FORÊTS

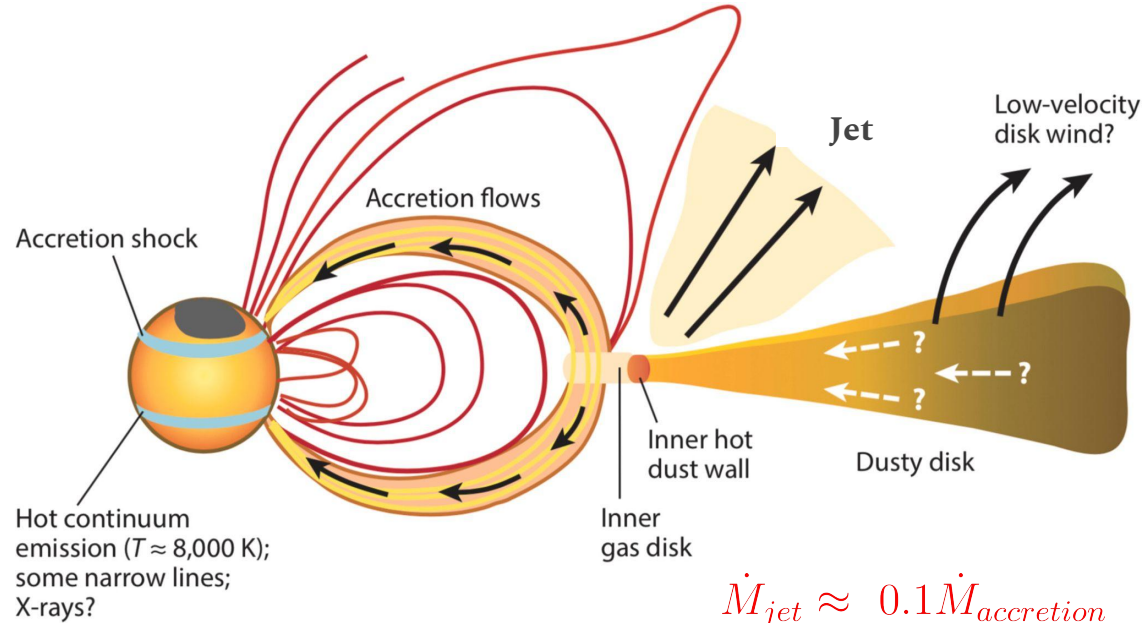
Context of star formation

$$\dot{M}_{\text{accretion}} = 10^{-8} - 10^{-6} M_{\odot} \cdot \text{yr}^{-1}$$

*Vue d'artiste d'un système
stellaire en formation*



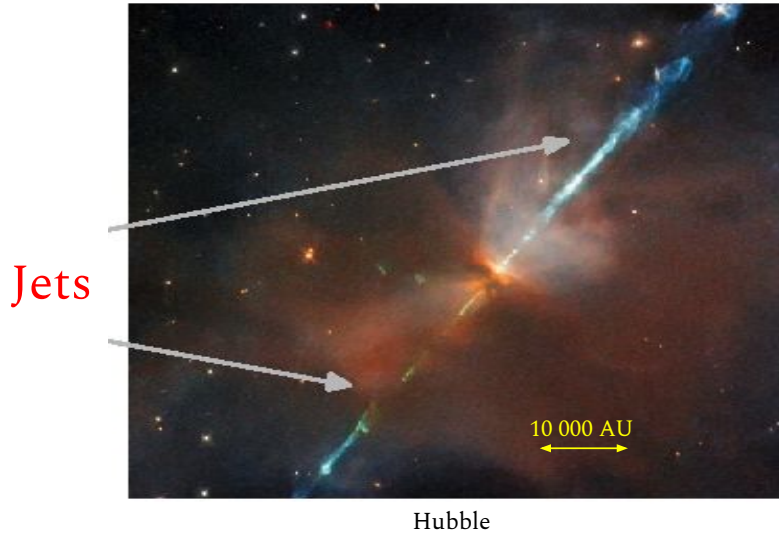
- Collapse of a gas cloud
- Formation of a star and an accretion disk



Ray & Ferreira, 2021

Launching of a jet !

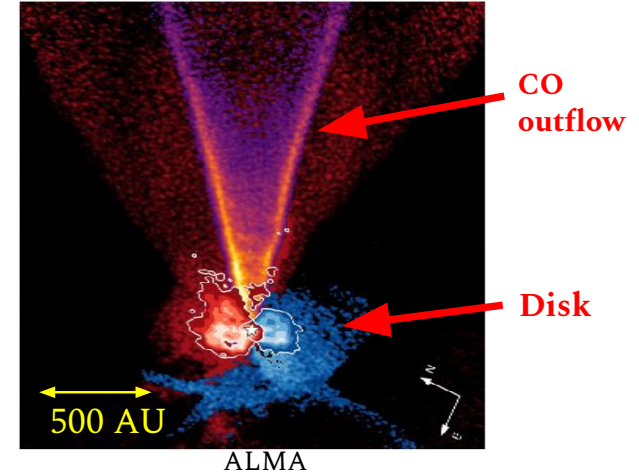
Class I objects show atomic jets



$$\dot{M}_{jet} \approx 0.1 \dot{M}_{accretion}$$

$$V \sim 100 \text{ km/s}$$

$$\text{Origin} < 0.1 \text{ AU}$$



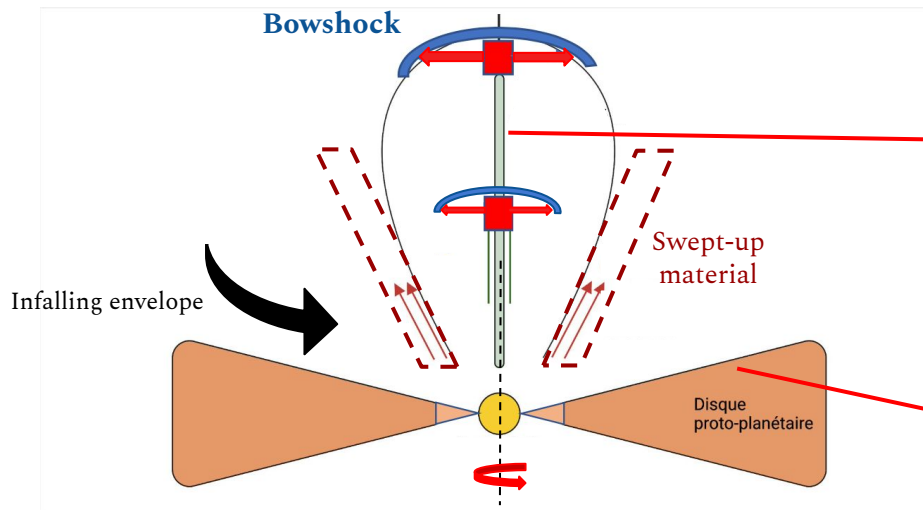
$$\dot{M}_{outflow} \approx \dot{M}_{accretion}$$

$$V \sim 10 \text{ km/s} = 0.1 V_{JET}$$

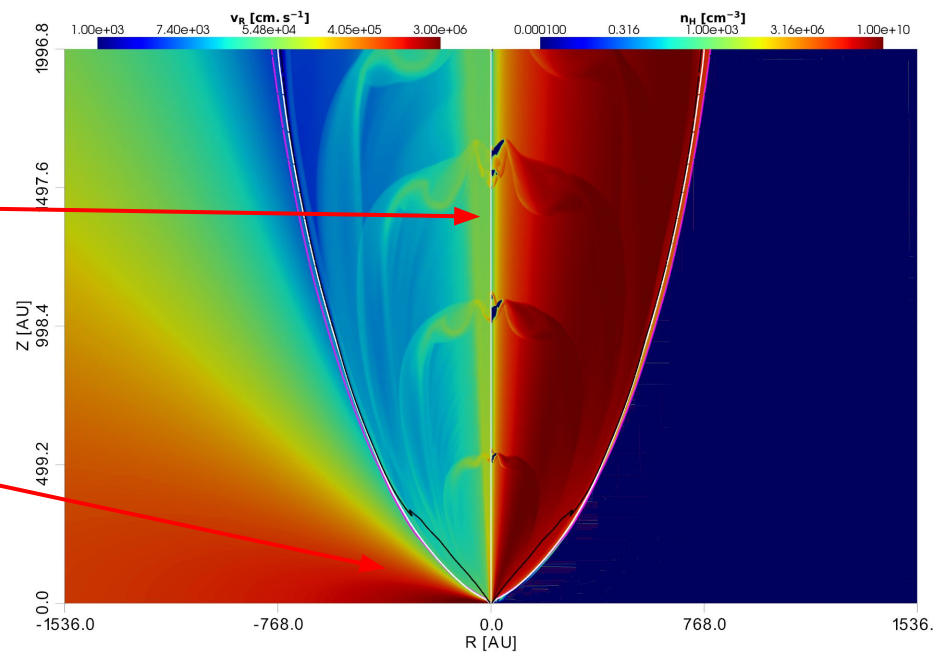
$$\text{Origin in } 1\text{-}30 \text{ AU}$$

Questions : What is the **origin** of the **observed molecular flows**?
What **impact** do these outflows have **on planetary formation**?

Aim of the PhD : simulations of a variable jet in protostellar environments



Model

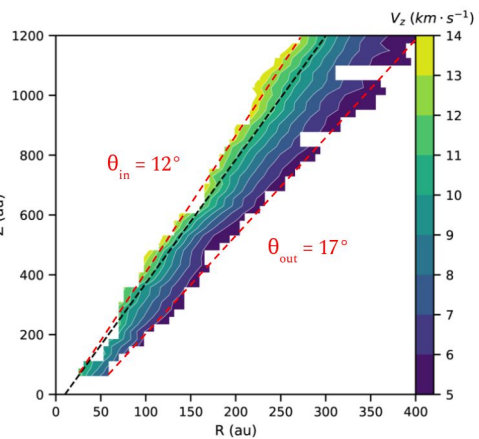


Simulation box

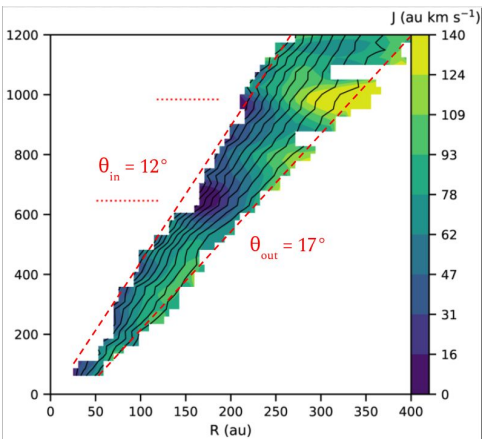
Observables

Observations :

(1) V_z (5 – 15 km/s)



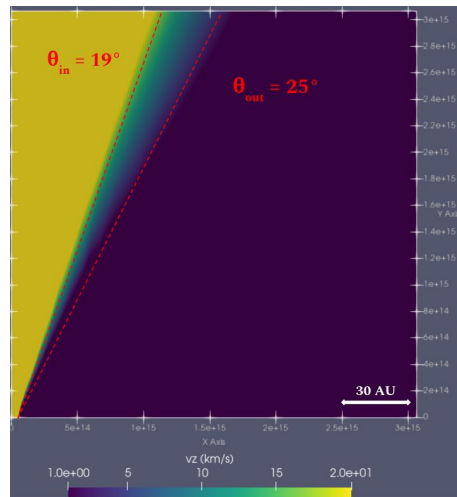
(2) J (30 – 80 AU.km/s)
(angular momentum)



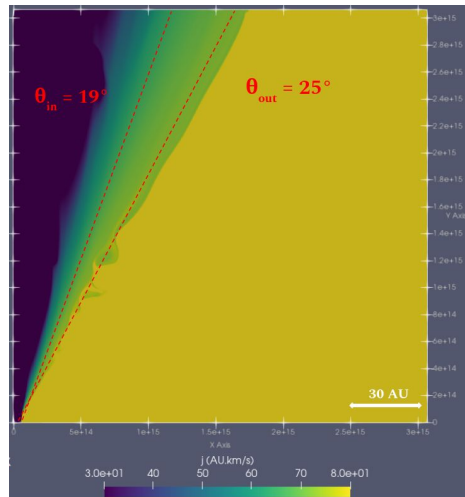
(3) $\dot{M}_{obs}(CO) = 2 \times 10^{-7} M_\odot \cdot yr^{-1}$

Simulations :

(1) V_z (1 – 20 km/s)



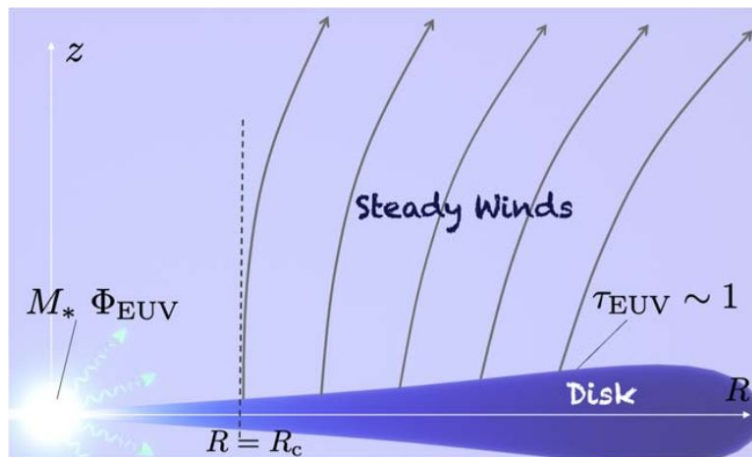
(2) J (30 – 80 AU.km/s)
(angular momentum)



(3) $\dot{M}_{flow} = 3 \times 10^{-10} M_\odot \cdot yr^{-1} \ll \dot{M}_{obs}$

Perspectives

- We reproduce morphology, kinematics, **but not the outflowing mass flux**
(First article in prep.)
- Enhancing the model : coupling with (observed) photo-evaporative winds



$$\dot{M}_{\text{flow}} \nearrow ?$$

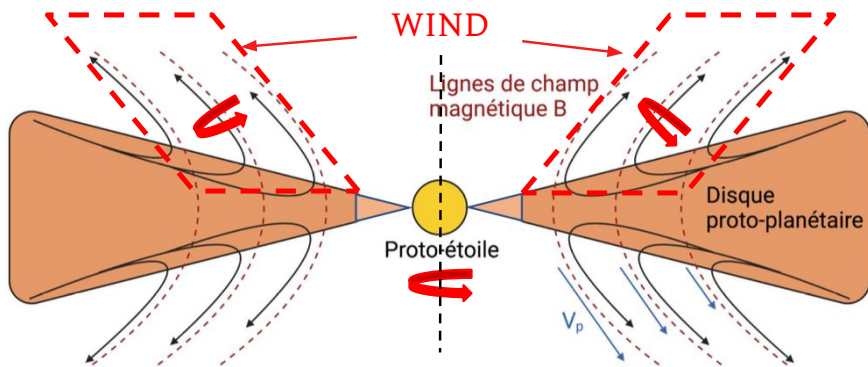
Nakatani et al., 2024

Appendix

Disk winds

1-a. MHD winds

Disk material follows B_z

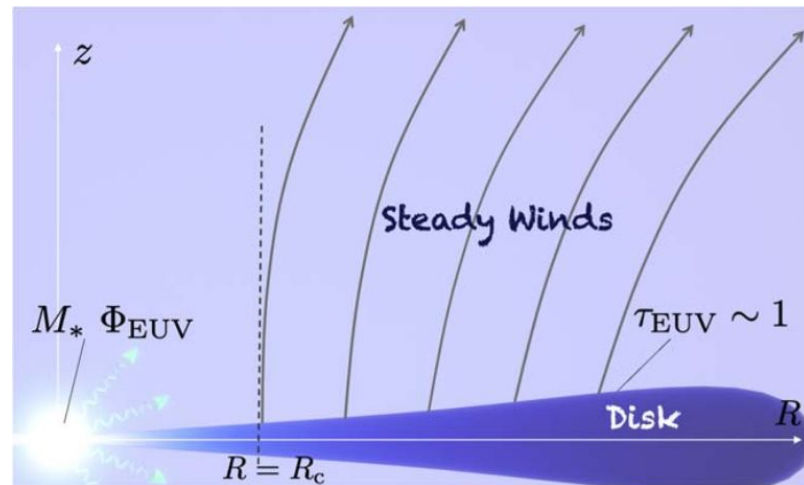


Problem :

Not detected on every accreting disk

1-b. Photo-evaporative winds

Disk material heated by stellar radiation

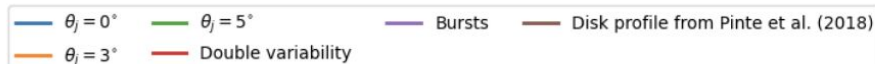
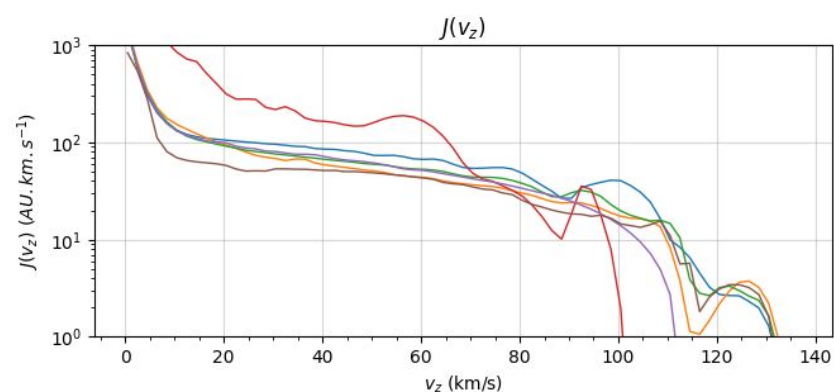
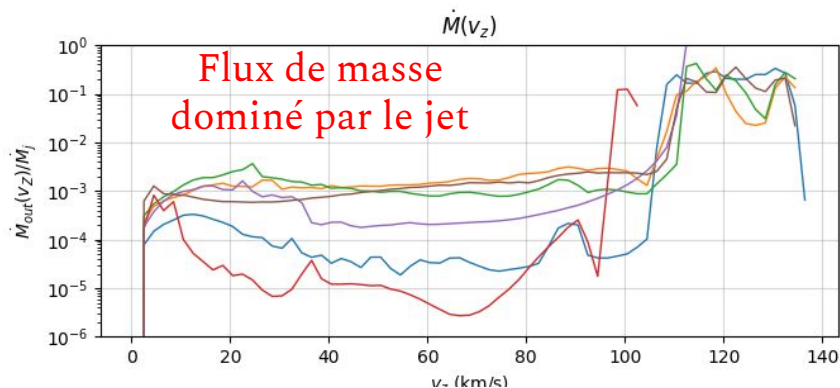
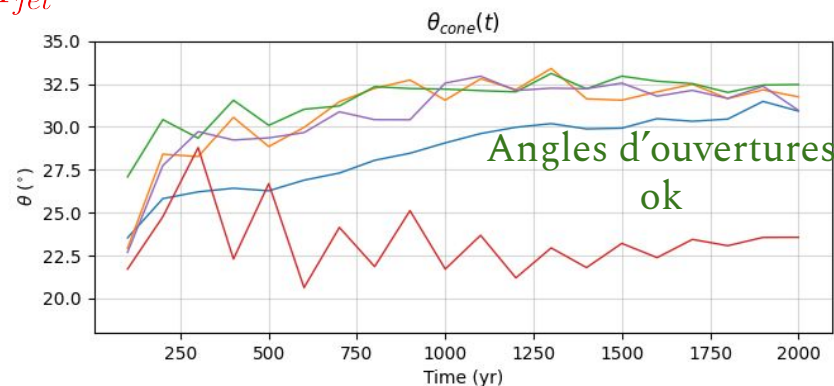
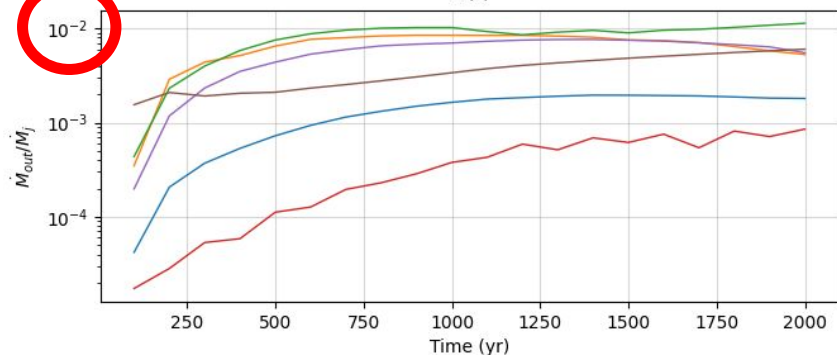


Nakatani et al., 2024

Problem :

Observed for class II but not (yet?) for class I

$\dot{M}_{outflow} = 10^{-2} \dot{M}_{jet}$ au lieu de $\dot{M}_{outflow} = 10^1 \dot{M}_{jet}$



Cinématique & morphologie : ✔ ; Flux de masse sortant: trop faible ✗