Environnements circumstellaires d'étoiles géantes rouges

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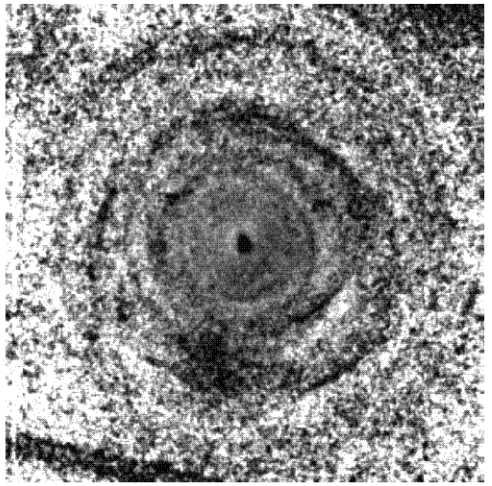
Toutes les étoiles perdent de la masse...

→ **vents des étoiles géantes rouges**

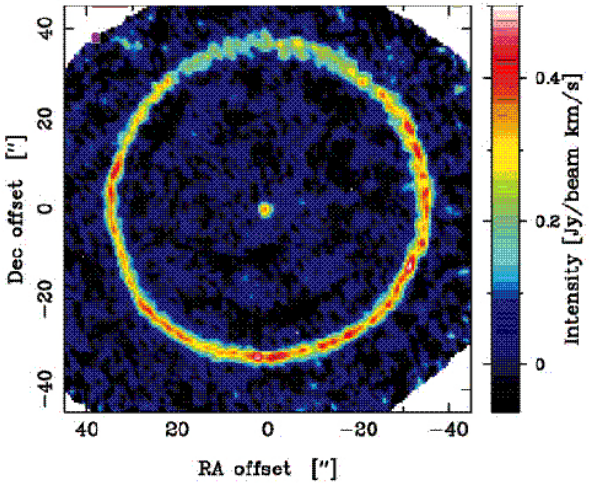
lents : V_{exp} ~ quelques km s^{-1}

parfois massifs : dM/dt ~ 10^{-8} →10^{-4} M_{sol} an^{-1}

variabilité : 100 →10^{6} ans



IRC +10216, CFH, poussières



TT Cyg, IRAM, CO

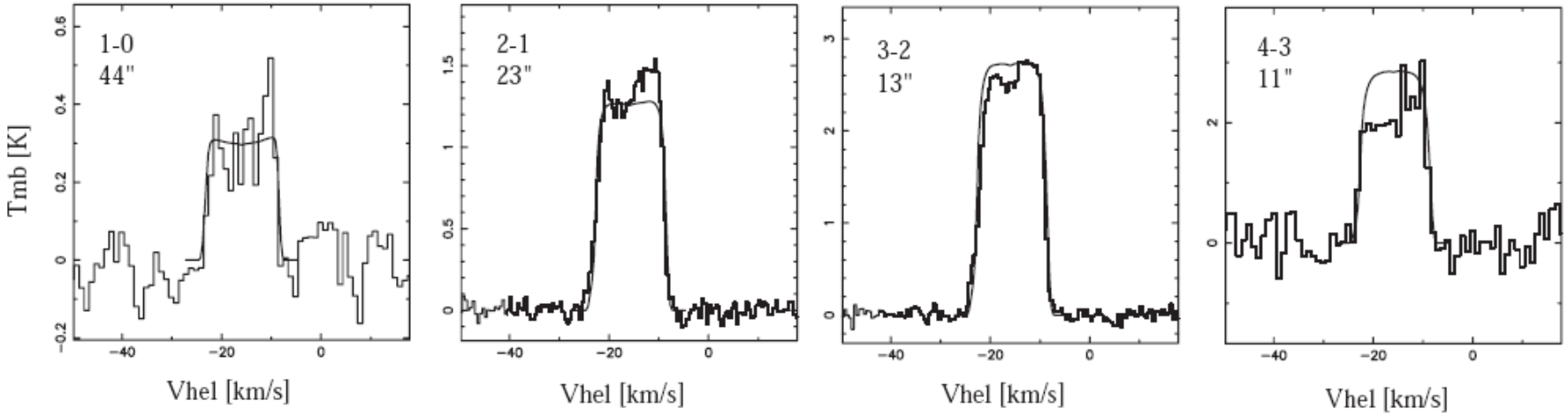
- **<u>contribution au renouvellement du MIS</u>**

- **relations entre propriétés stellaires et perte de masse**
- **historique de la perte de masse**
- **bilan de la perte de masse et évolution stellaire**

SW Vir, 7.5 km/s, 4 10^{-7} Msol/yr at 120 pc

CO: SEST + JCMT

Olofsson et al. 2002, A&A **391**, 1053



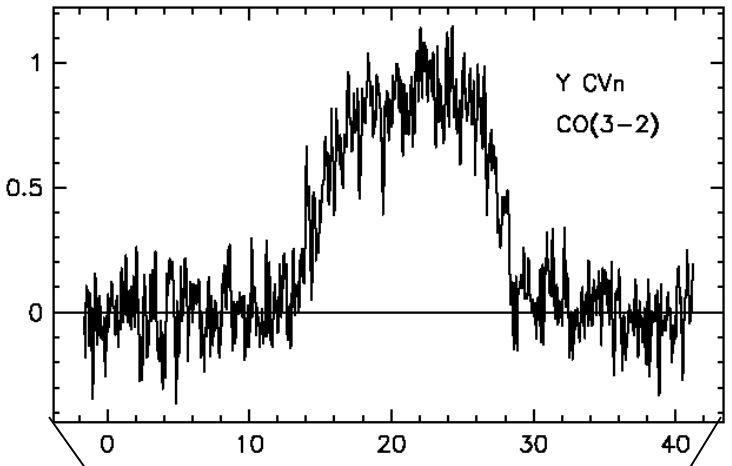
115 GHz	230 GHz	345 GHz	460 GHz
2.6 mm	1.3 mm	870 µm	650 µm

CO → expansion velocity + mass loss rate

But CO is photodissociated at distances ~ 0.01 – 0.2 pc

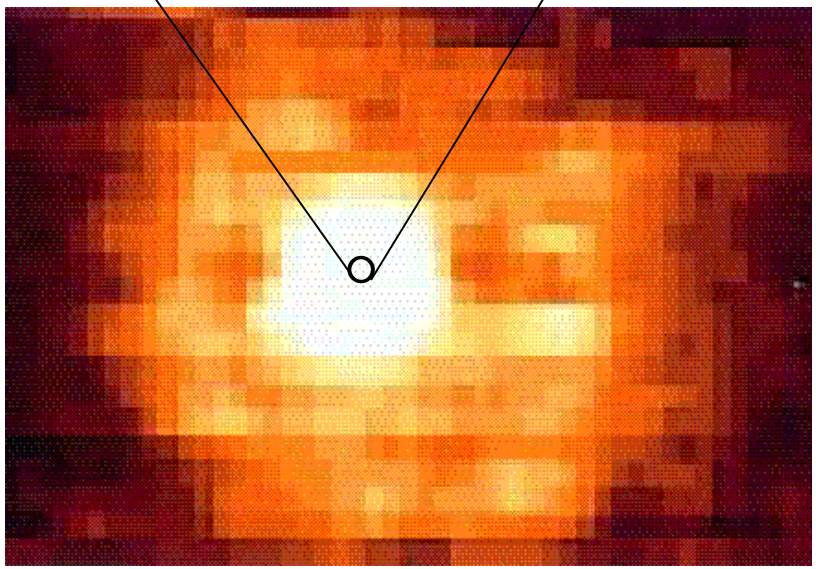
Y CVn

8 km/s; 10^{-7} Msol/yr



Knapp et al. 1998, ApJS 117, 209

Ø~ 10'' ~ 0.01 pc



Izumiura et al. 1996, A&A **315**, L221 →

(ISOPHOT 90 µm : 12 x 8 arcmin²; Ø~8', soit 0.5 pc)

[émission de la poussière en IR lointain]

Why HI at 21 cm ?

→ circumstellar HI should be protected by the surrounding ISM

- hyperfine-structure line of hydrogen in the ground state

  = 21 cm, = 1400 MHz, A_{10} ~3 10^{-15} s^{-1}

- in general optically thin
- ν = 1.4 GHz ==> $h\nu/kT << 1$

  ==> 1. $_{\nu}$ α g_1/g_0 A_{10} $N_0(1 - e^{-h\nu/kT})$ α N_H/T

  2. B_ν α T

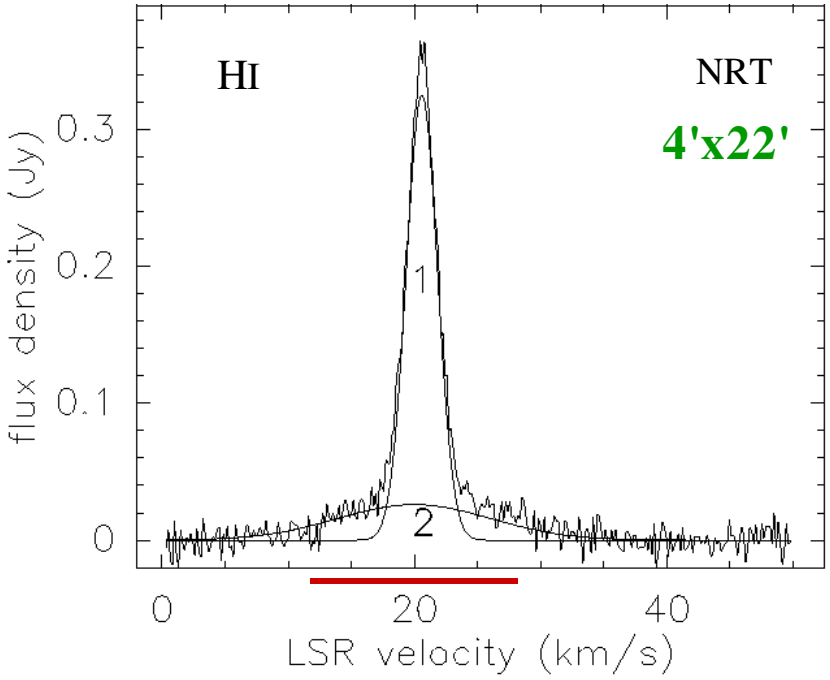
  ==> $_{\nu}xB_\nu$ α N_H (i.e.: **measured flux α N_H**)

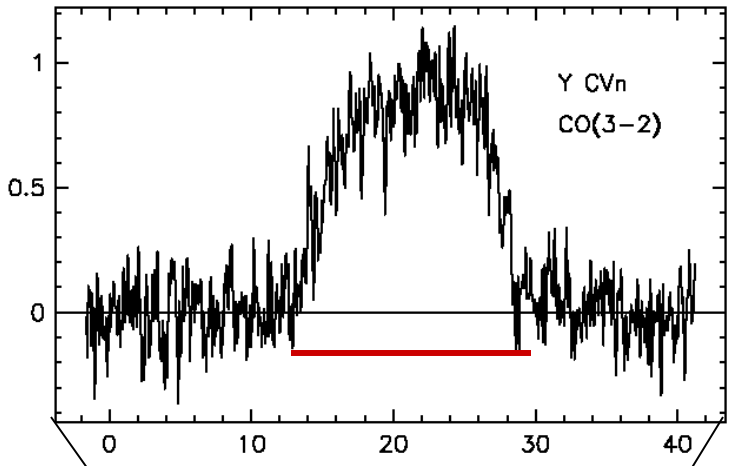
  (HI is a good tracer of morphology)

- **<u>If the distance is known, we get the mass in atomic hydrogen</u>**

  → complementarity with CO

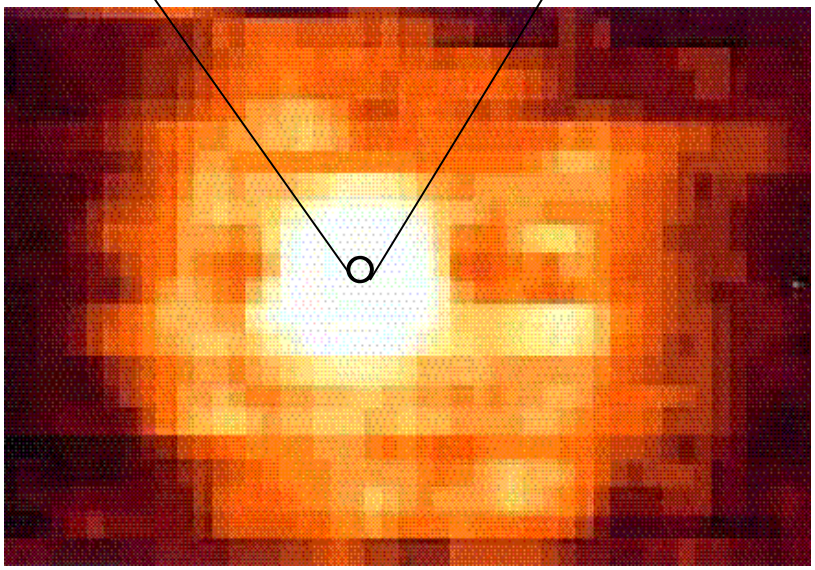
Y CVn (Le Bertre & Gérard 2004, A&A 419, 549)





Knapp et al. 1998, ApJS 117, 209

Ø~ 10'' ~ 0.01 pc



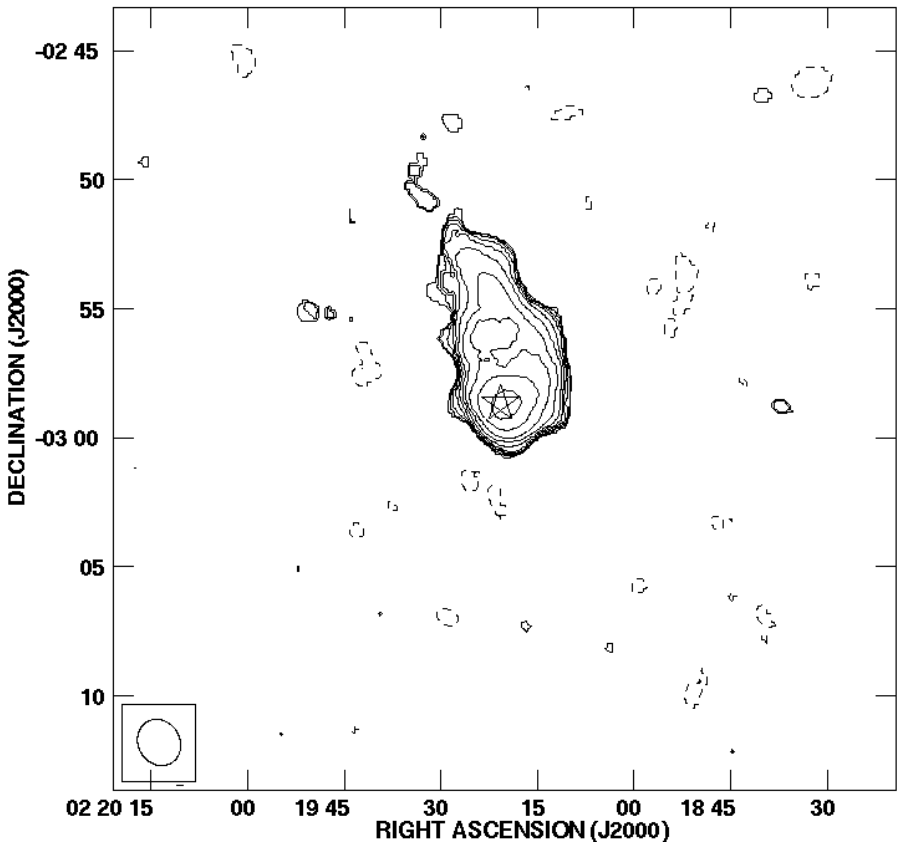
Ralentissement du flot circumstellaire

Izumiura et al. 1996, A&A **315**, L221 →

(ISOPHOT 90 µm : 12 x 8 arcmin²; Ø~8', soit 0.5 pc)

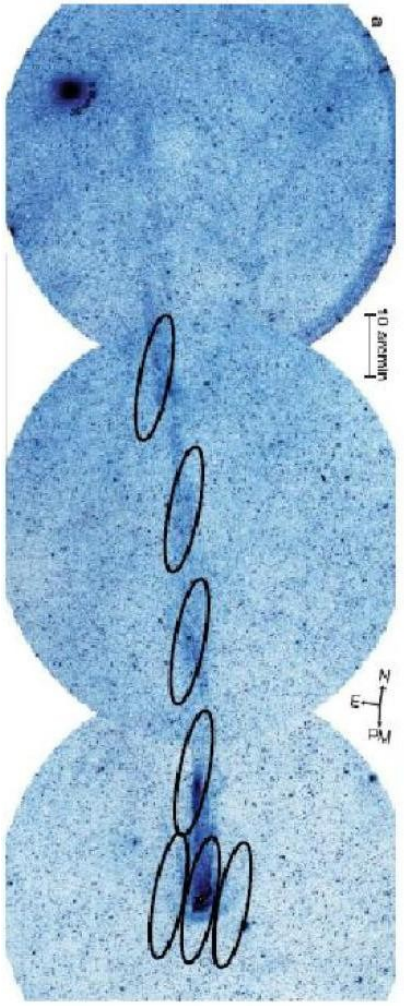
[émission de la poussière en IR lointain]

Mira en HI au VLA (D; avril-mai 2007) et au NRT



Mouvement propre (d=107 pc) :
(-12 , -235 mas an^{-1})

V_{tot} ~ 128 km s^{-1}



GALEX
FUV (~1500 Å)
fluorescence H_2 ?

Martin et al. 2007, Nature, 448, 780

2.7° x 1.1°

Complementarity of CO and HI

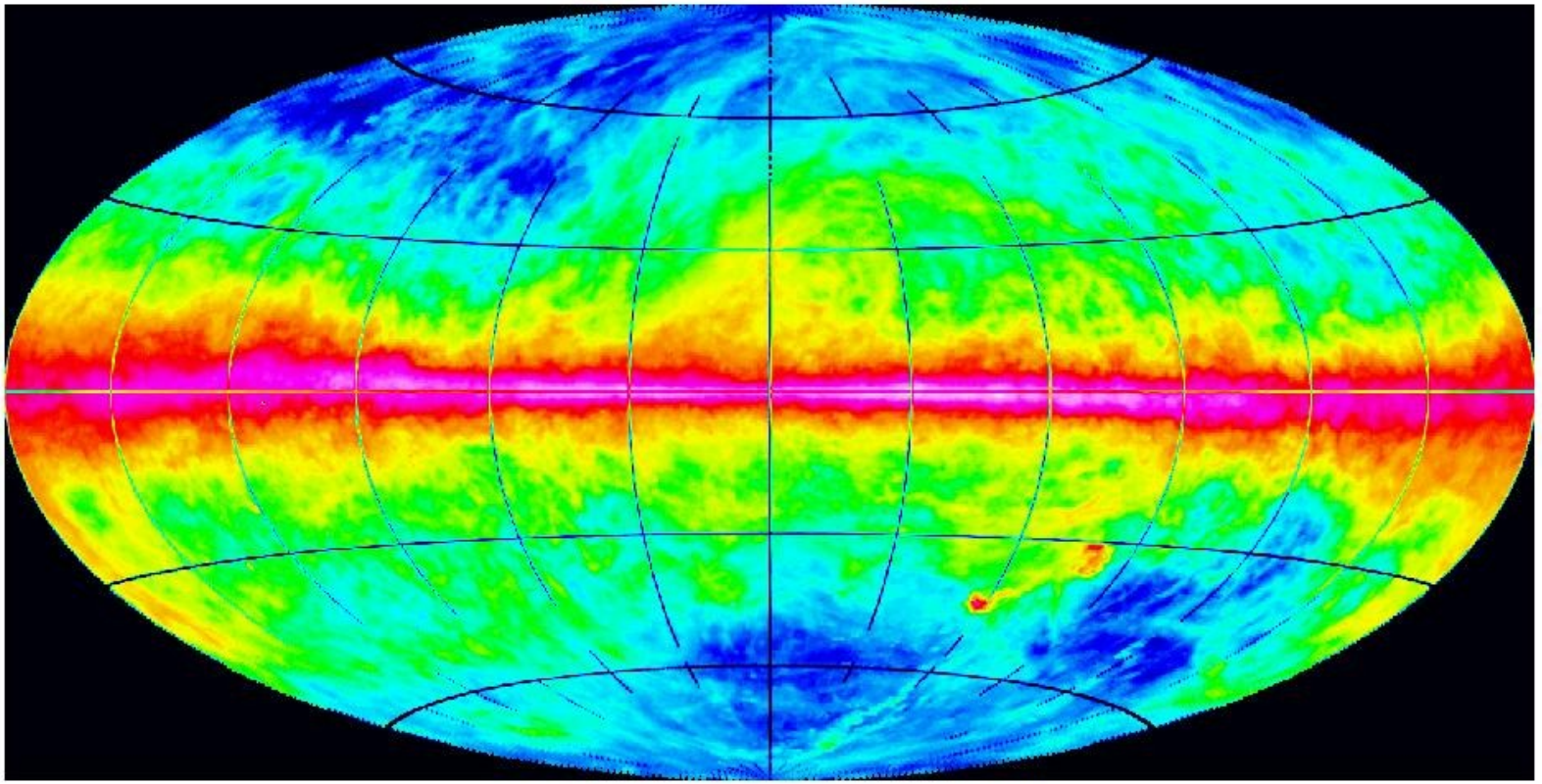
inner shell (few 10^{-2} pc)	outer shell (~1 pc)
10^4 years	10^6 years
Mass loss rate	Mass
Mass loss process	Interaction with ISM
→ ALMA	→ SKA

The combination of the 2 tracers gives access to the history of mass loss.

Sélection de quelques problèmes et objectifs

- H_2/HI → photodissociation de H_2
  (étoiles froides et/ou variables : $T_{eff} < 2500$ K)
- Self-absorption en HI
  (taux de perte de masse élevé > 10^{-6} M_{sol} yr^{-1})
- Hydrogène froid (<10 K)
  (e.g. IRC +10216 ?)
- histoire de la perte de masse; "clumping"; bilan
- évolution stellaire / variabilité
  (M-S-C / Irr-SR-Mira)

difficulté principale: ubiquité de HI



Kalberla et al. 2005, A&A, 440, 775; total galactic HI

-400 km s^{-1} < v < + 400 km s^{-1}

Needs (E-VLA; ATA; ASKAP; MeerKAT)

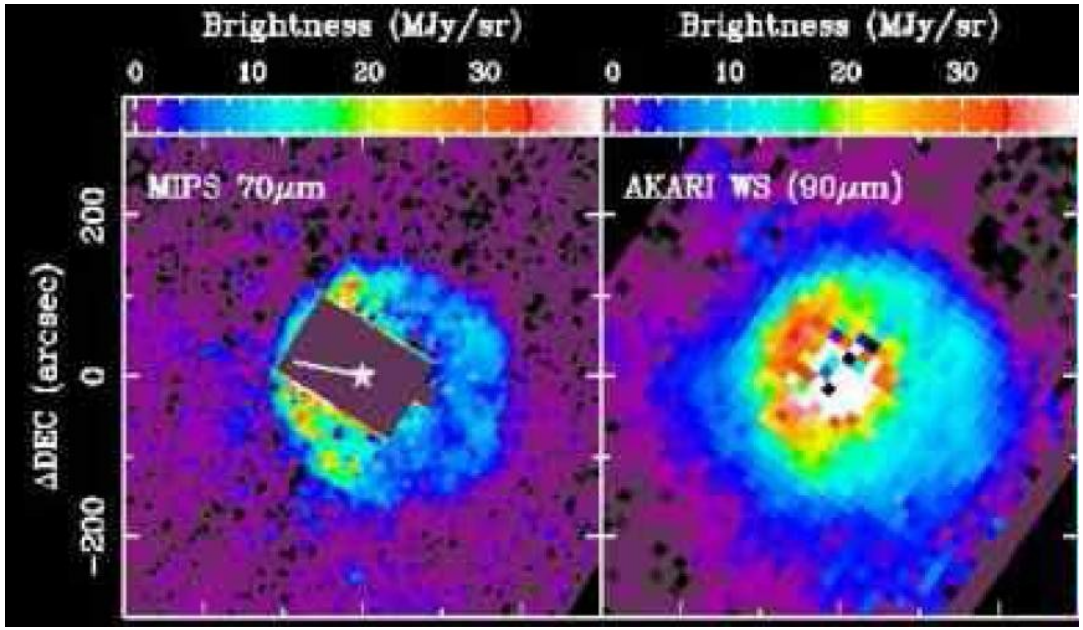
- Improved **angular resolution** : 1 arcminute (better ?)
  morphology of outer CS
  interface with ISM
  [with a goal of 1 arcsec (?) for sub-structures]
  need for **high brightness sensitivity** (5 mJy)

- **Fidelity** (HI provides an image of the column density directly comparable to the images obtained with models)
  → **short spacing ?**

- **Wide field** :
  1. we need to correct for galactic emission
  2. the sources that we prefer are close
  and large on the sky (10'x10', up to 2 degrees)

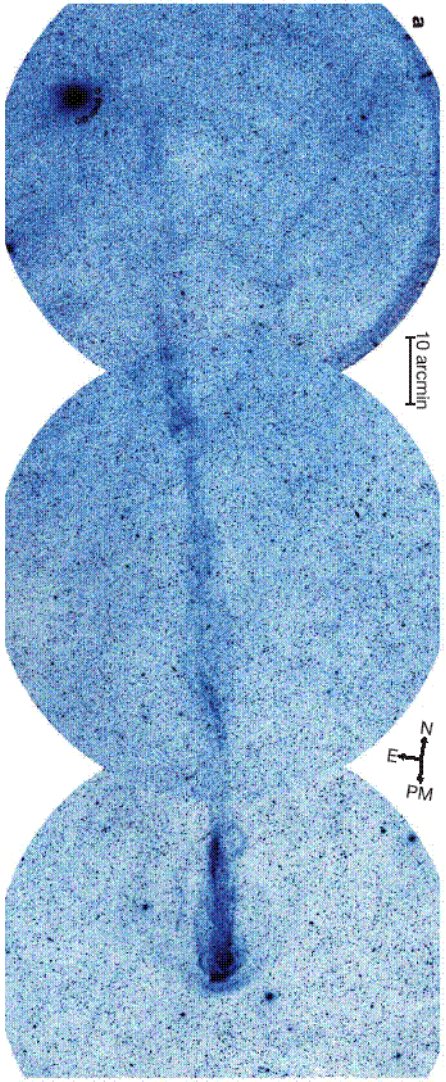
- High **spectral resolution** (~ 0.3 km/s; goal ~ 0.1 km/s)

Merci !



ralentissement

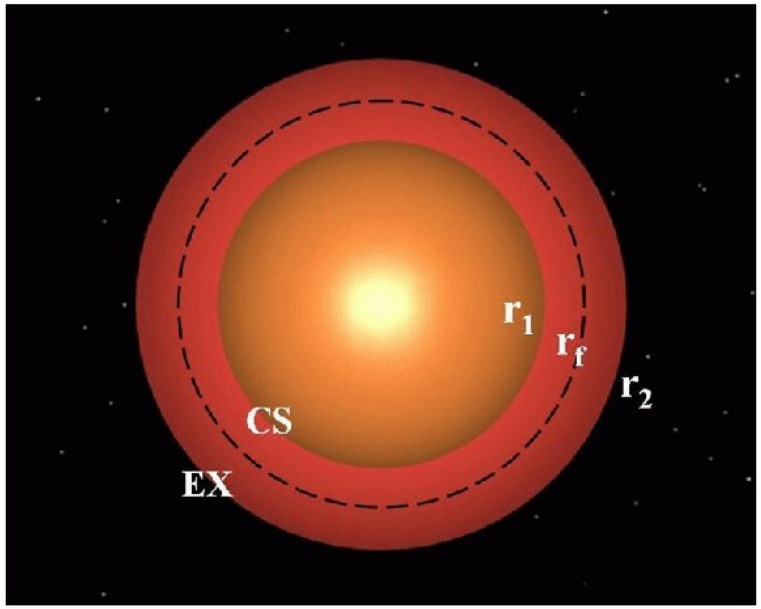
R Cas, avec Spitzer et Akari



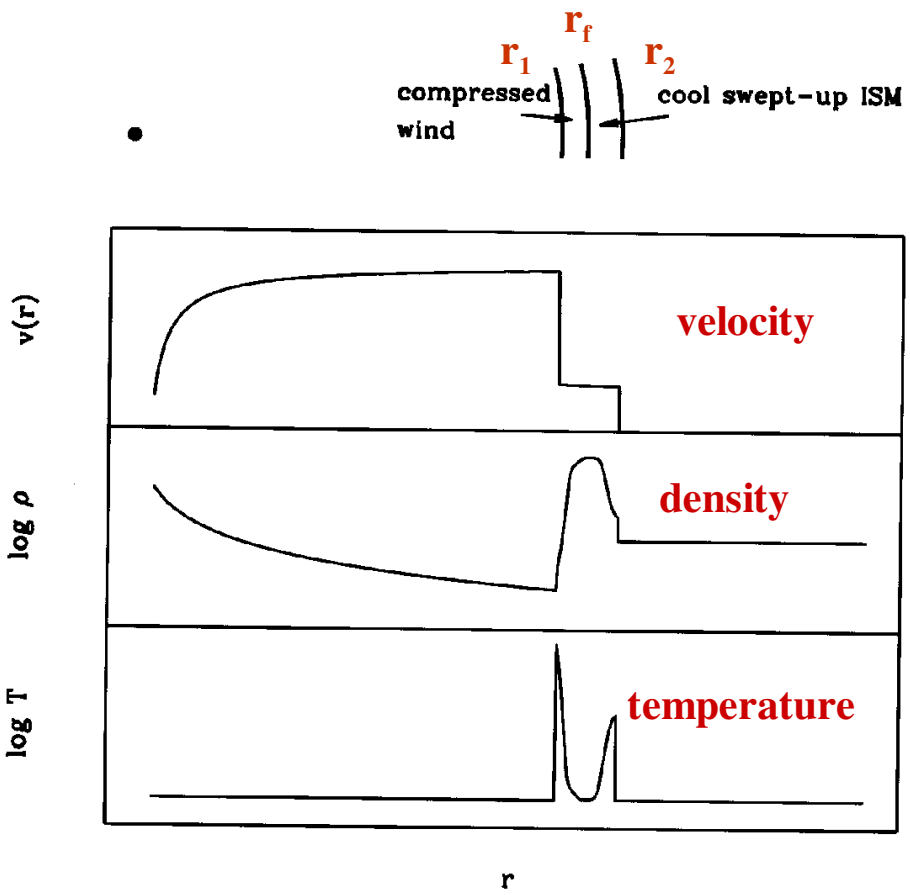
érosion

Mira, avec GALEX

The matter in the shell is the sum of slowed down circumstellar material and accelerated external (ISM ?) material



from Libert (2009)

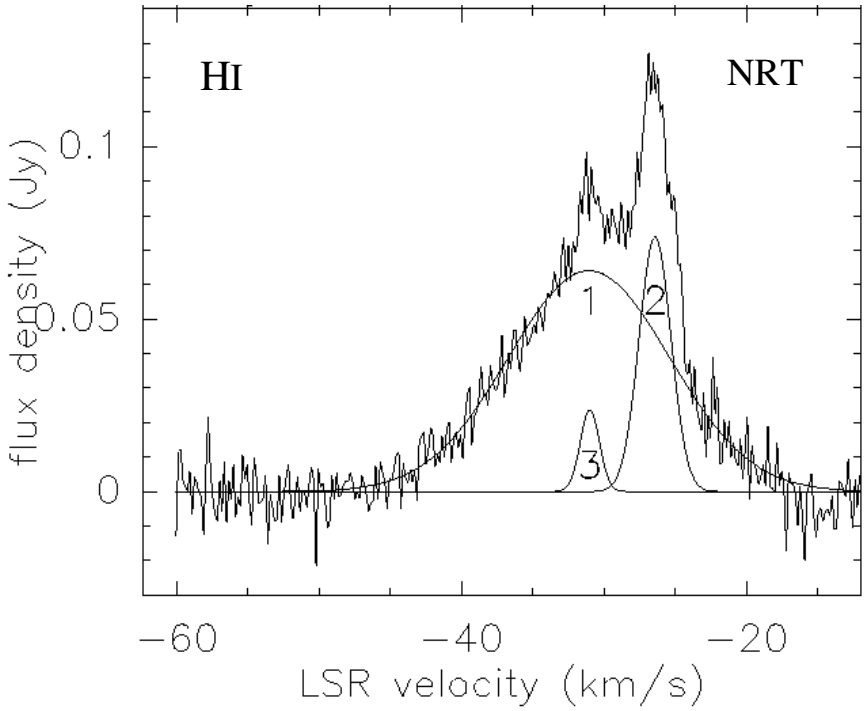


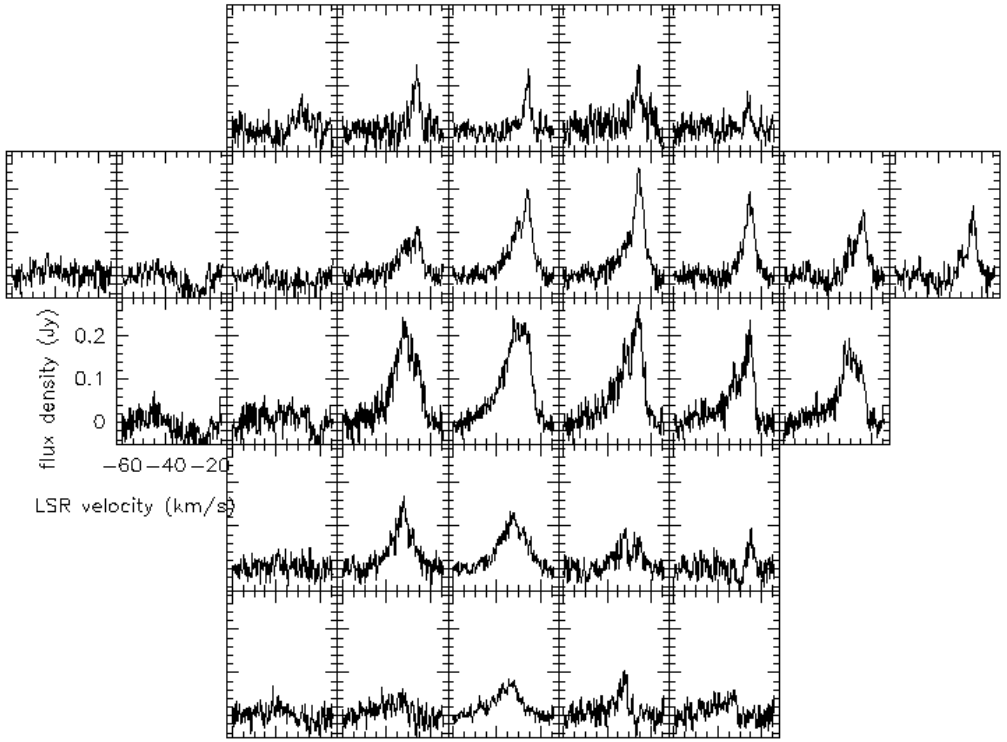
Lamers & Cassinelli (2004)
"Introduction to Stellar Winds"

EP Aqr

(Le Bertre & Gérard 2004)

4’ x 22’ or 0.16pc x 0.86pc (at 135 pc)



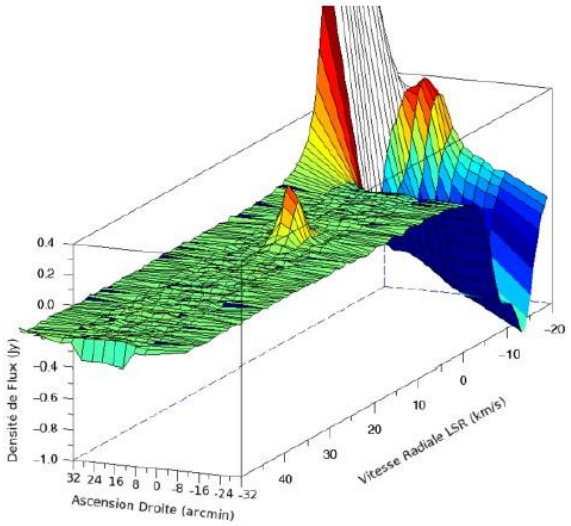


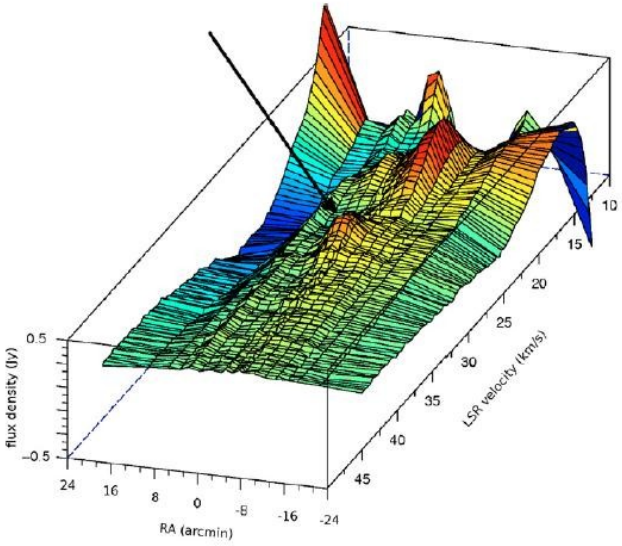
Complex spatial and dynamic structures

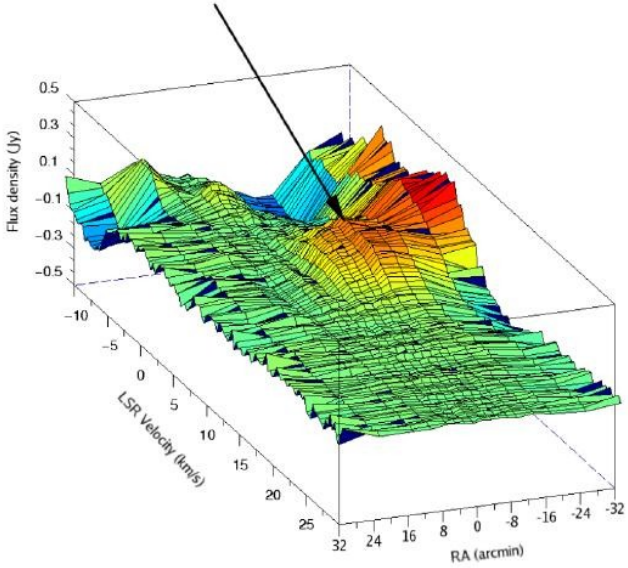
The HI emission is very extended (~ 1 pc)

M_{tot} ~ 0.06 M_{sol}

Need to understand the competing galactic emission (confusion)



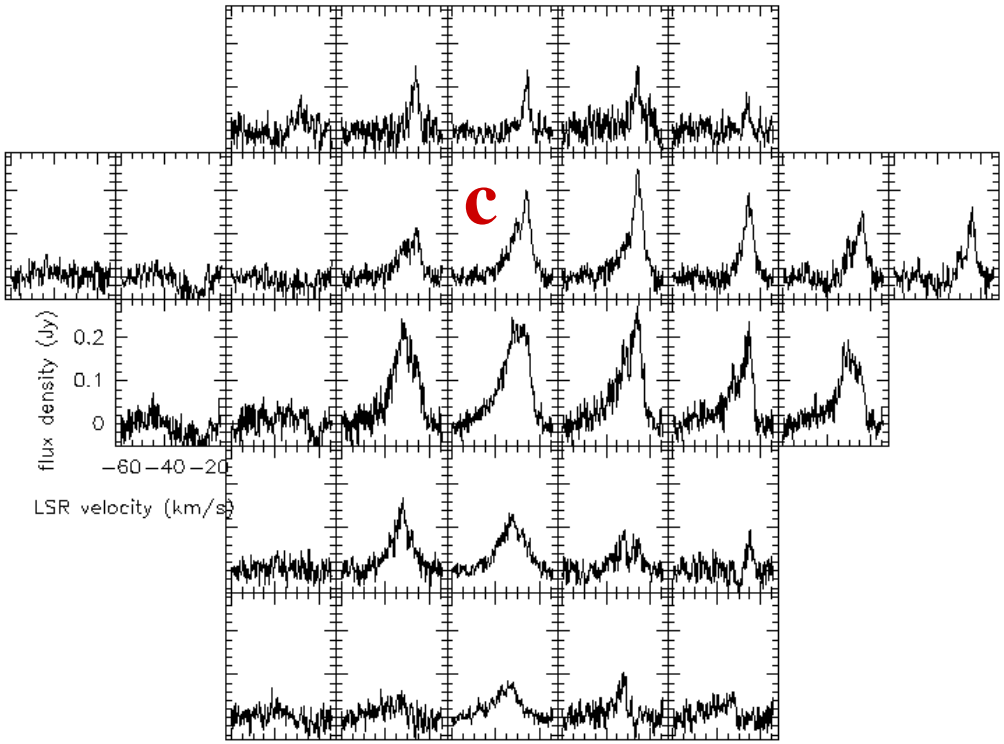


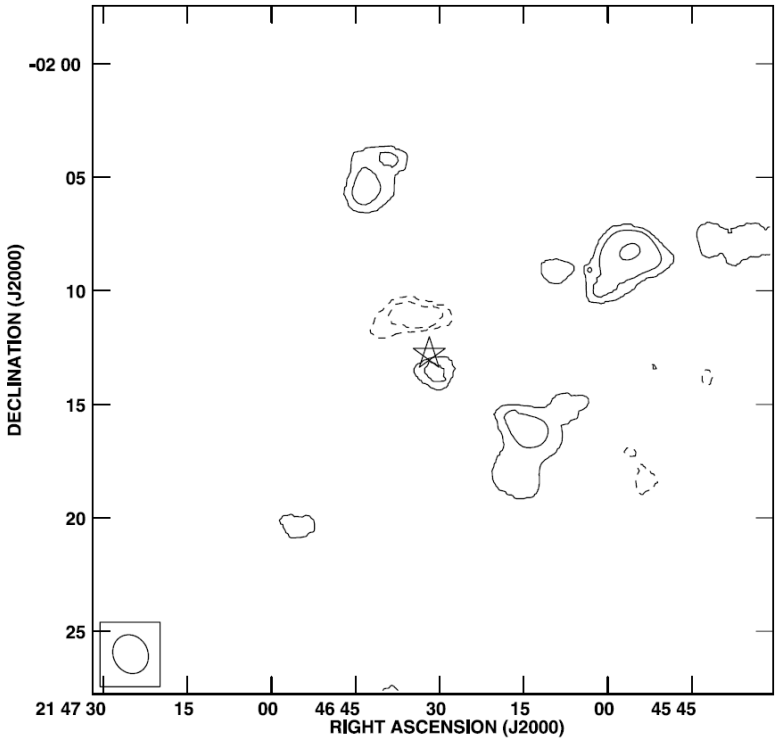


(b ~ +72°) (b ~ -28°) (b ~ +42°)

Libert, 2009, PhD, University of Paris 6

EP Aqr at the NRT and at the VLA



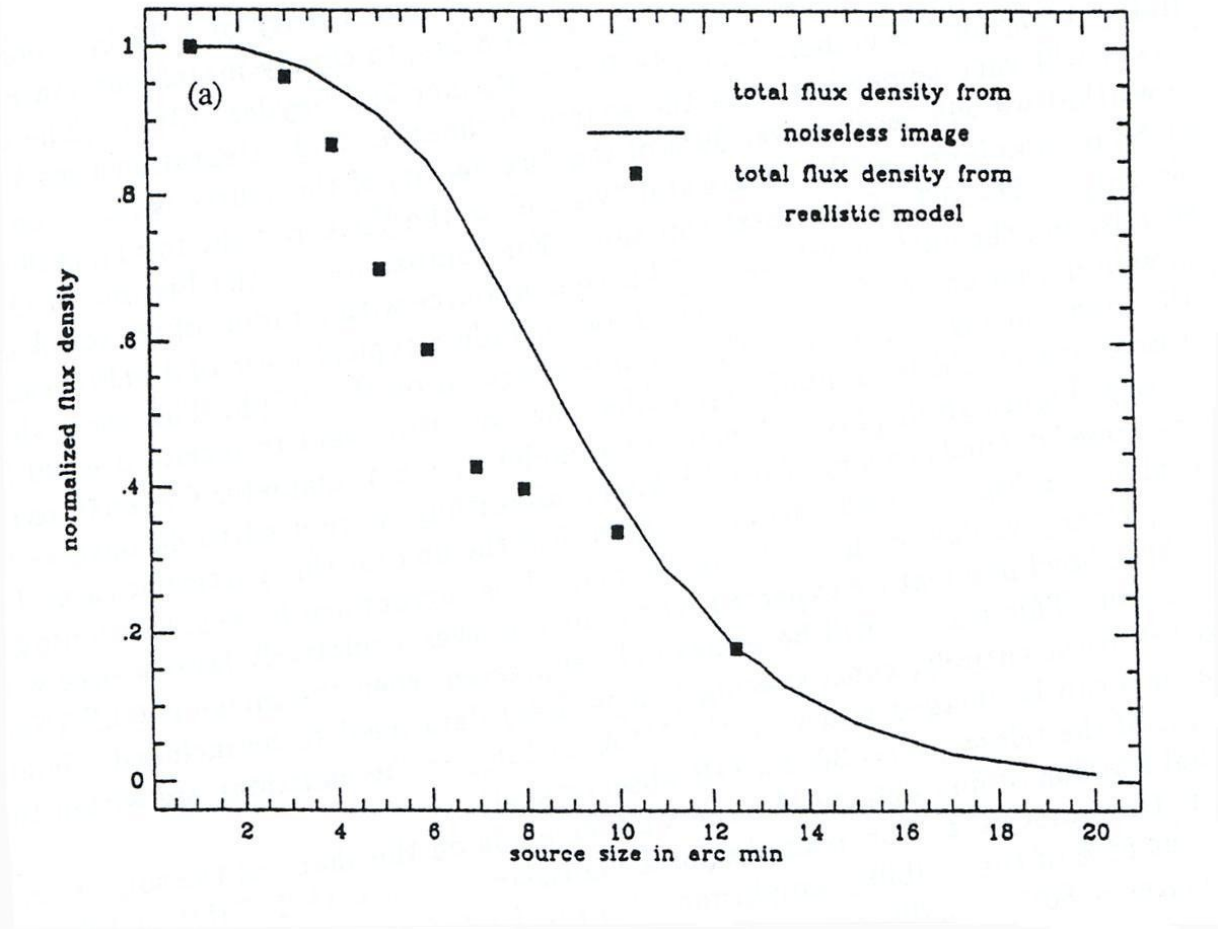


Le Bertre & Gérard, 2004

Matthews & Reid, 2007

fov (VLA antenna @ 21 cm) ~ 30 arcmin.

interferometer in the D configuration



de Pater, Palmer, Snyder, 1991, Ap&SS Lib. 167, 175