The multi-scale environment of RS Cnc from CO and HI observations

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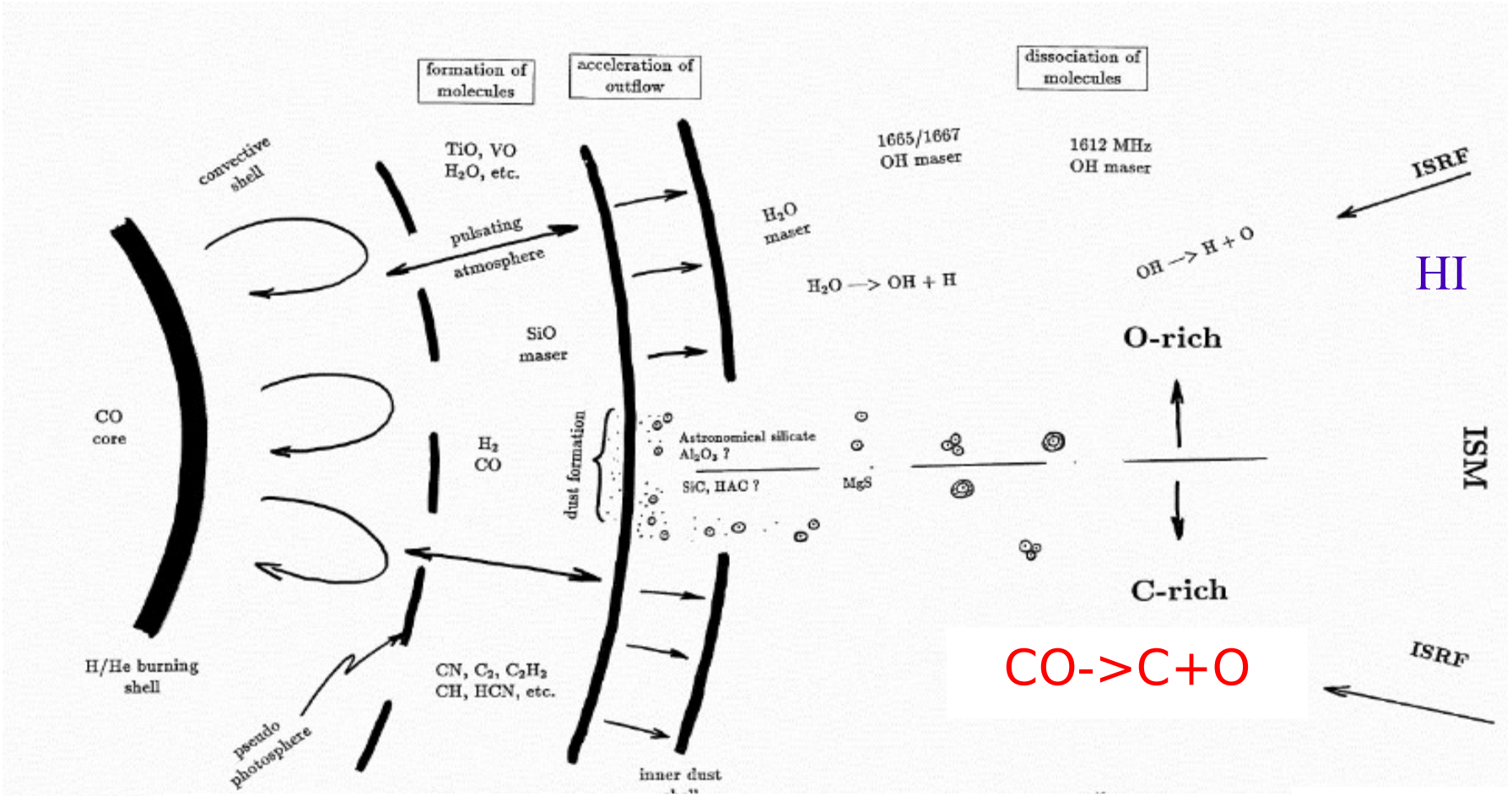
Schematic view of an AGB star



The Earth radius
$T = 10^8$K

1AU
T= 3000K

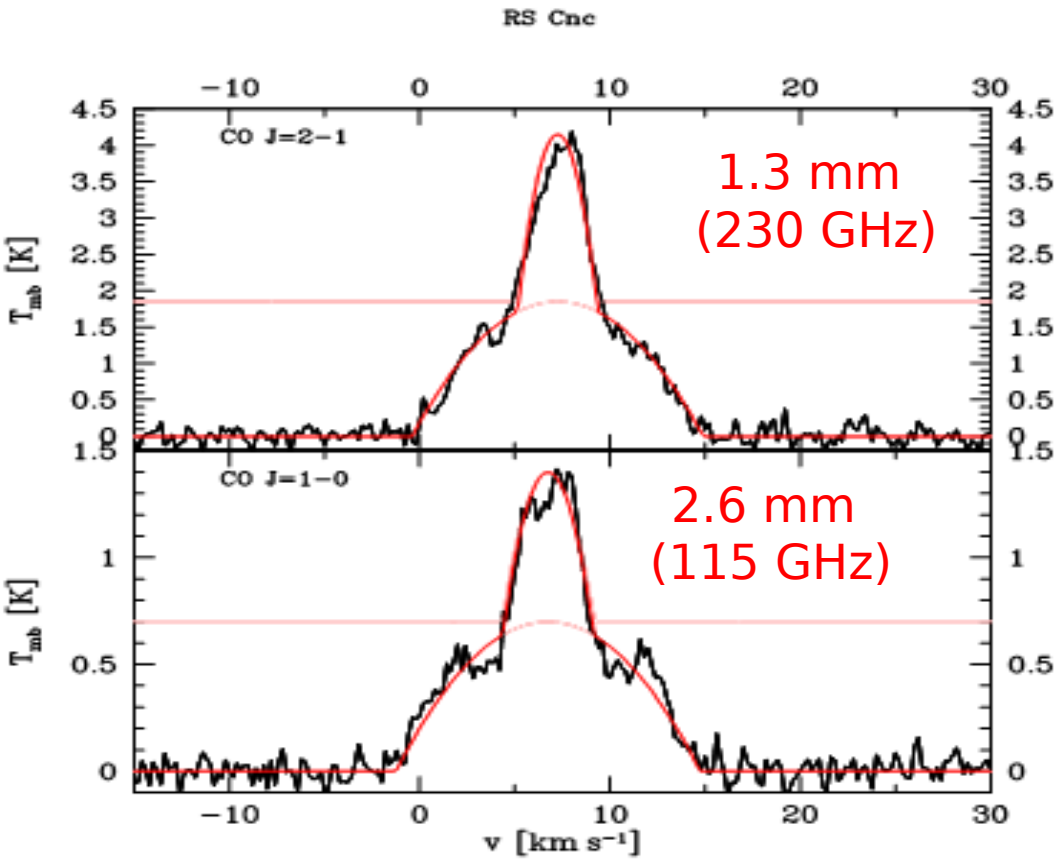
10AU
T= 1000K

1000 AU
T= 100K

100 000 AU
T= 20K

Previous CO observations of RS Cnc

Show clearly presence of two components, with ~8(2) km/s winds and 4(0.8) 10^{-7} M_{sun}/yr mass loss.



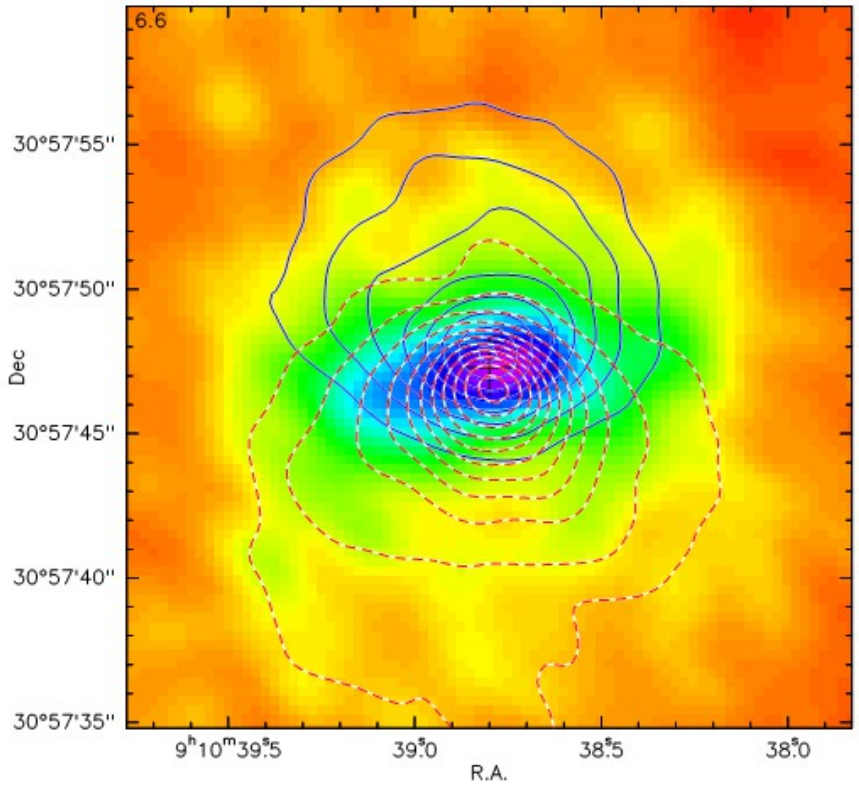
30m spectra, Libert et al. 2010

Mapping across the source gives evidence for a strong bipolar flow corresponding to the broad component.

Detailed inspection shows that this flow is along an axis making ~45° with the plane of the sky (AI) and away from North (PA) by only ~10°.

Moreover, it is accompanied by a disk-like flow associated with the narrow component and normal to the axis of the bipolar flow.

25”
(0.2 pc)



CO(1-0)

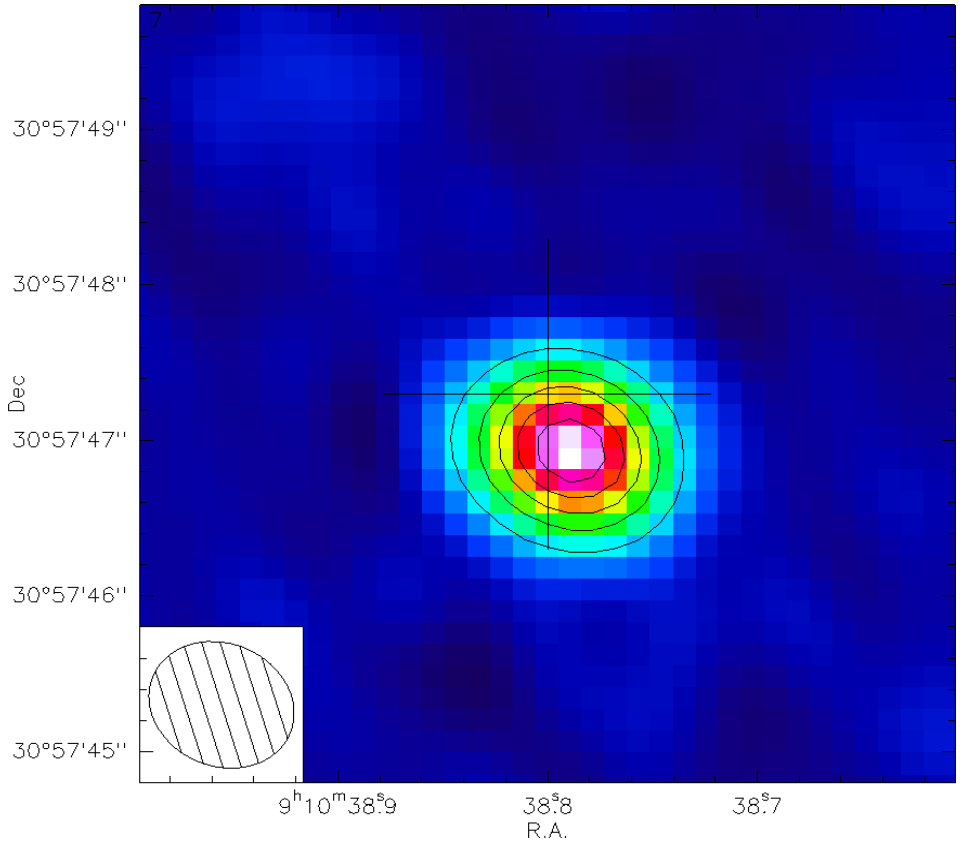
Libert et al. 2010, PdBI observation

The new CO(1-0) observation with PdBI

A+B configurations extending to 760m. The resolution is ~ 1”.

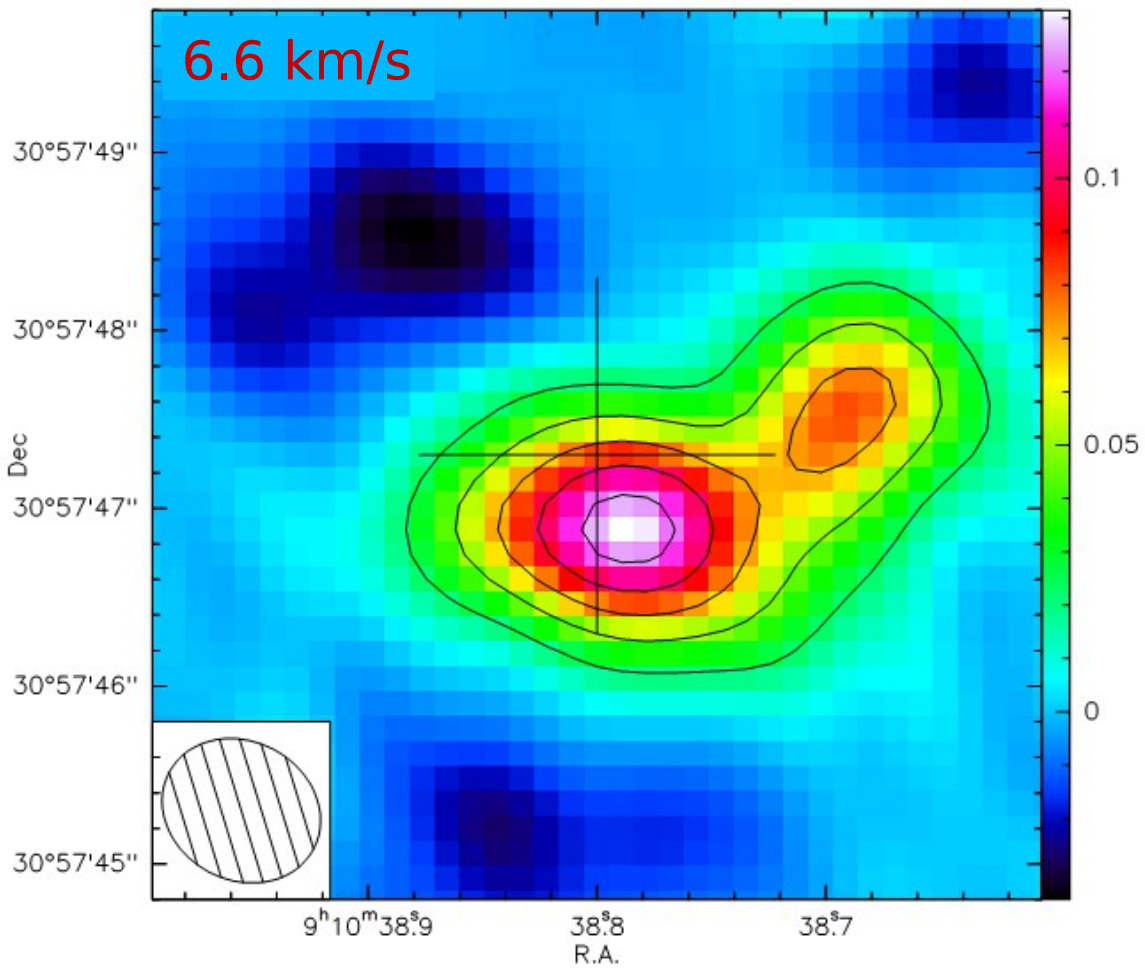
A single point source is clearly detected in continuum at 115 GHz.

The flux is corresponding to what is expected from the central star.



The continuum map

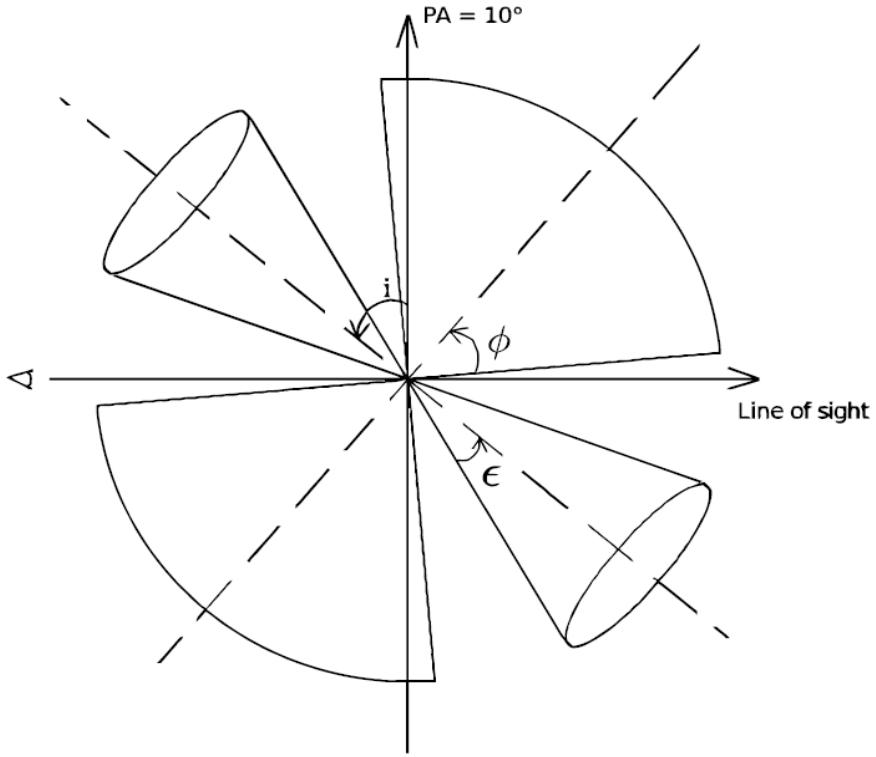
The continuum subtracted channel maps of CO(1-0) (from 5.8 to 6.8 km/s) reveal a companion source at ~ 1″ west-north-west (PA~ 300^{o})



CO model

In order to constrain the spatio-kinematic structure of RS Cnc, we have constructed a new model of CO emission taking into account the velocity-dependent emission and absorption of each element along the line of sight. This allows the evaluation of the detected flux from a source of arbitrary geometry.

The model is based on the suggestion of Libert et al. 2010, however with density and velocity varying smoothly from equatorial plane to polar axis.



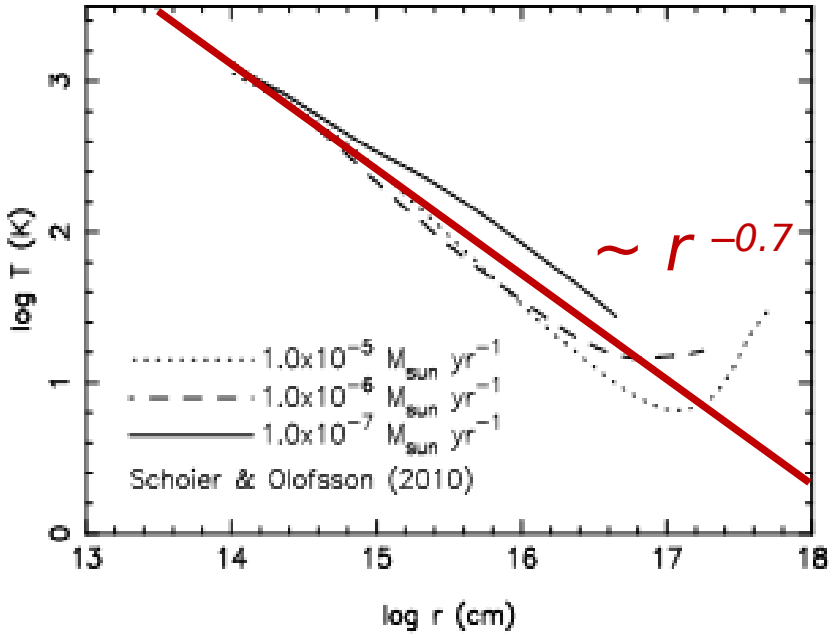
The velocity gradient is introduced

The populations of the rotational levels of the CO molecules are calculated assuming local thermodynamic equilibrium.

Temperature of the gas ~ log(T)~r $^{-0.7}$

CO abundance: 4.10^{-4} then decreased by photo-dissociation

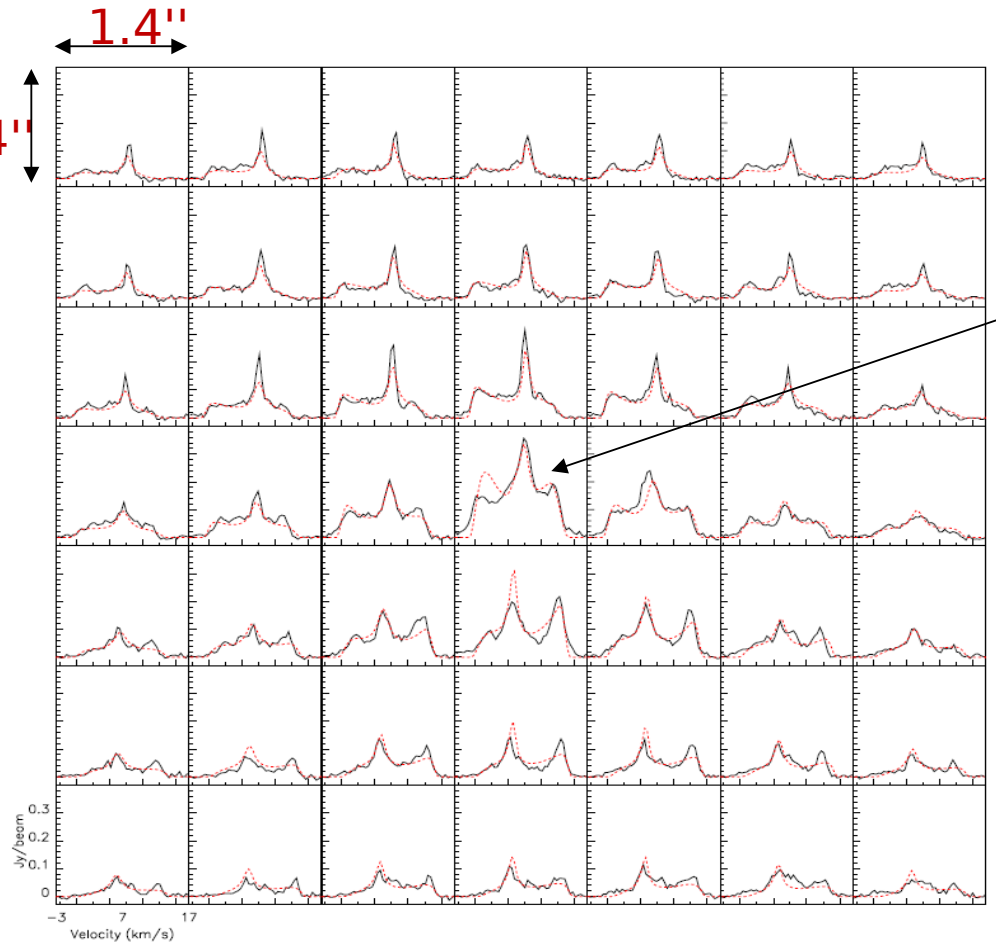
Thermal broadening is included



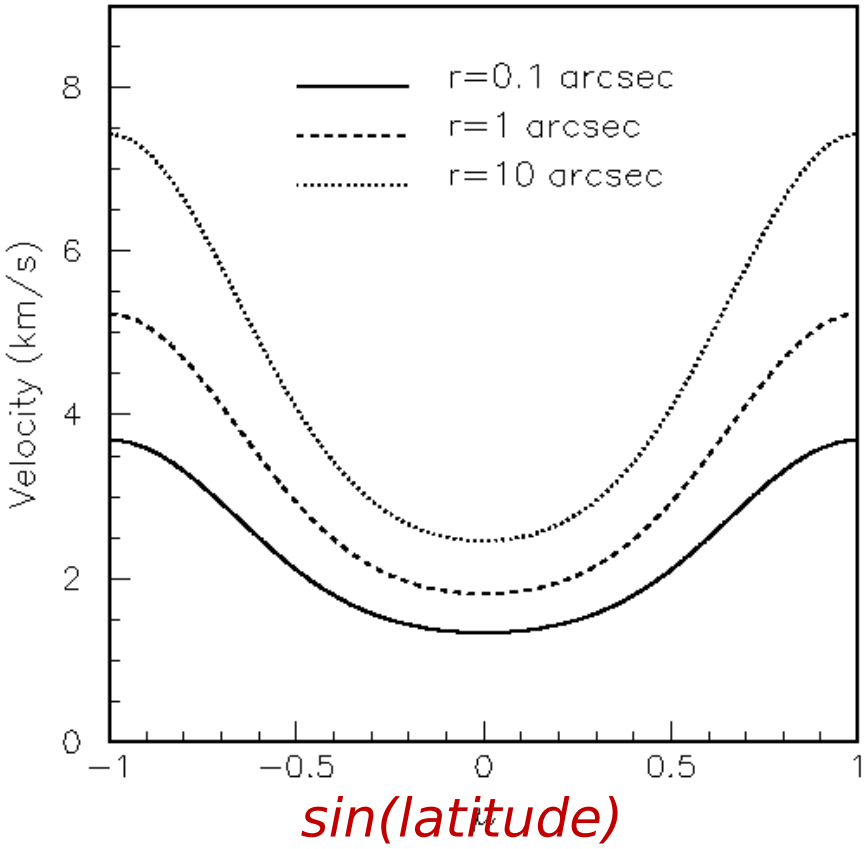
The parameters which define the orientation of polar axis, velocity and mass loss rate are adjusted to minimize the sum of square deviations over 7x7 grid map (9.8''x9.8'')

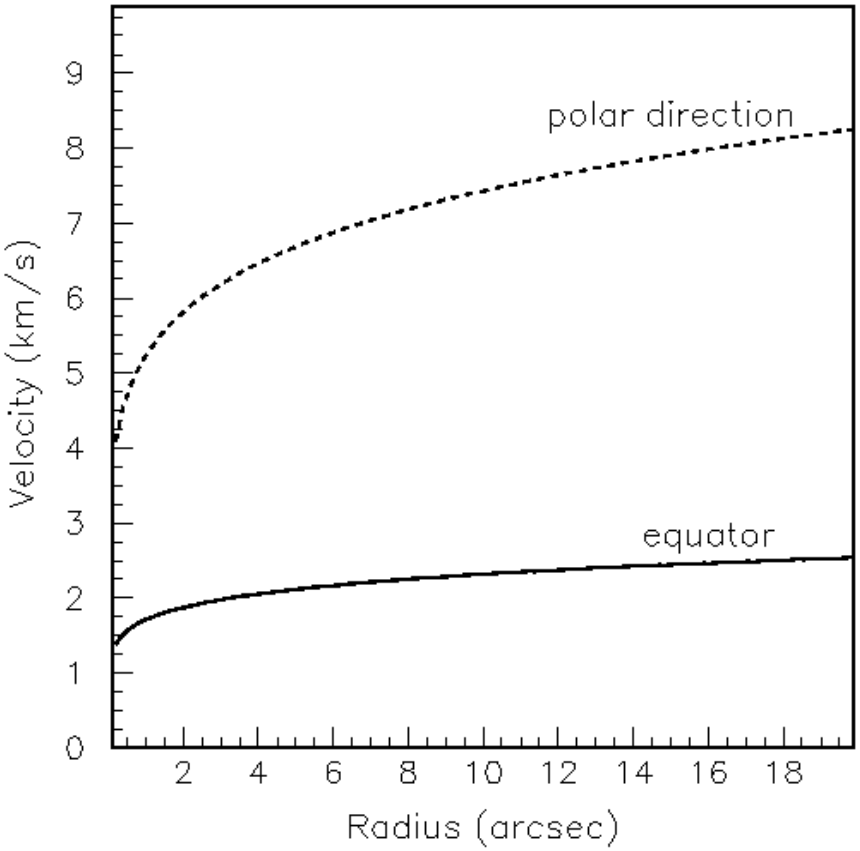
The best fit gives:

AI=52^{o} , PA=10^{o} , total mass loss rate=1.24 10^{-7} M$_{o}$/yr

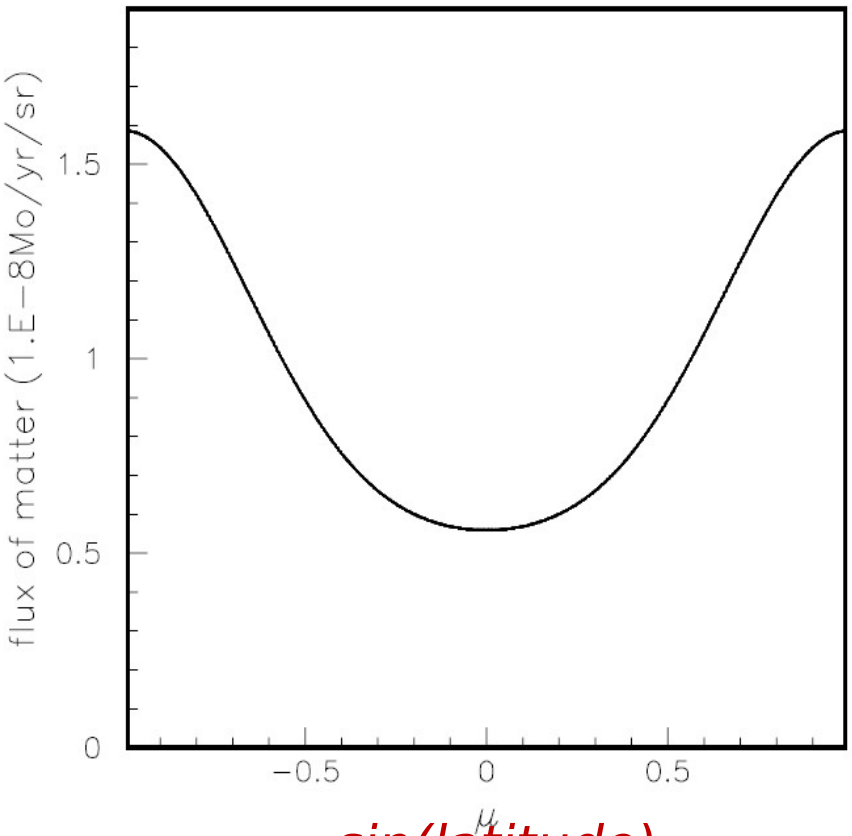


Velocity


r=0.1 arcsec
r=1 arcsec
r=10 arcsec
Velocity (km/s)
0
2
4
6
8
−1
−0.5
0
0.5
1
sin(latitude)

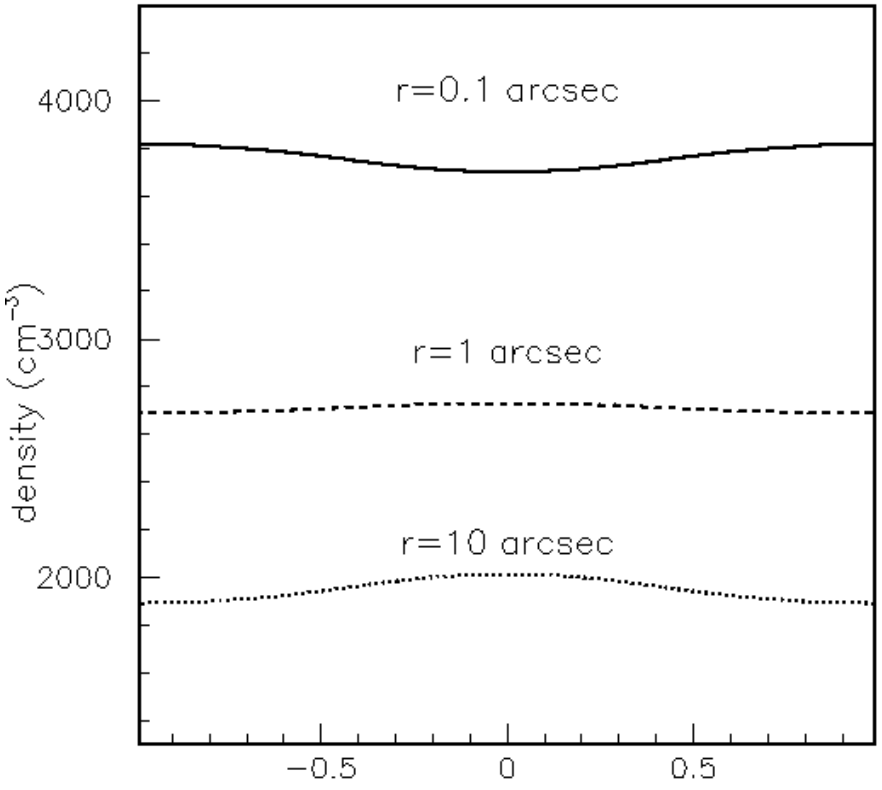

polar direction
equator
Velocity (km/s)
0
1
2
3
4
5
6
7
8
9
2
4
6
8
10
12
14
16
18
Radius (arcsec)

Flux of matter



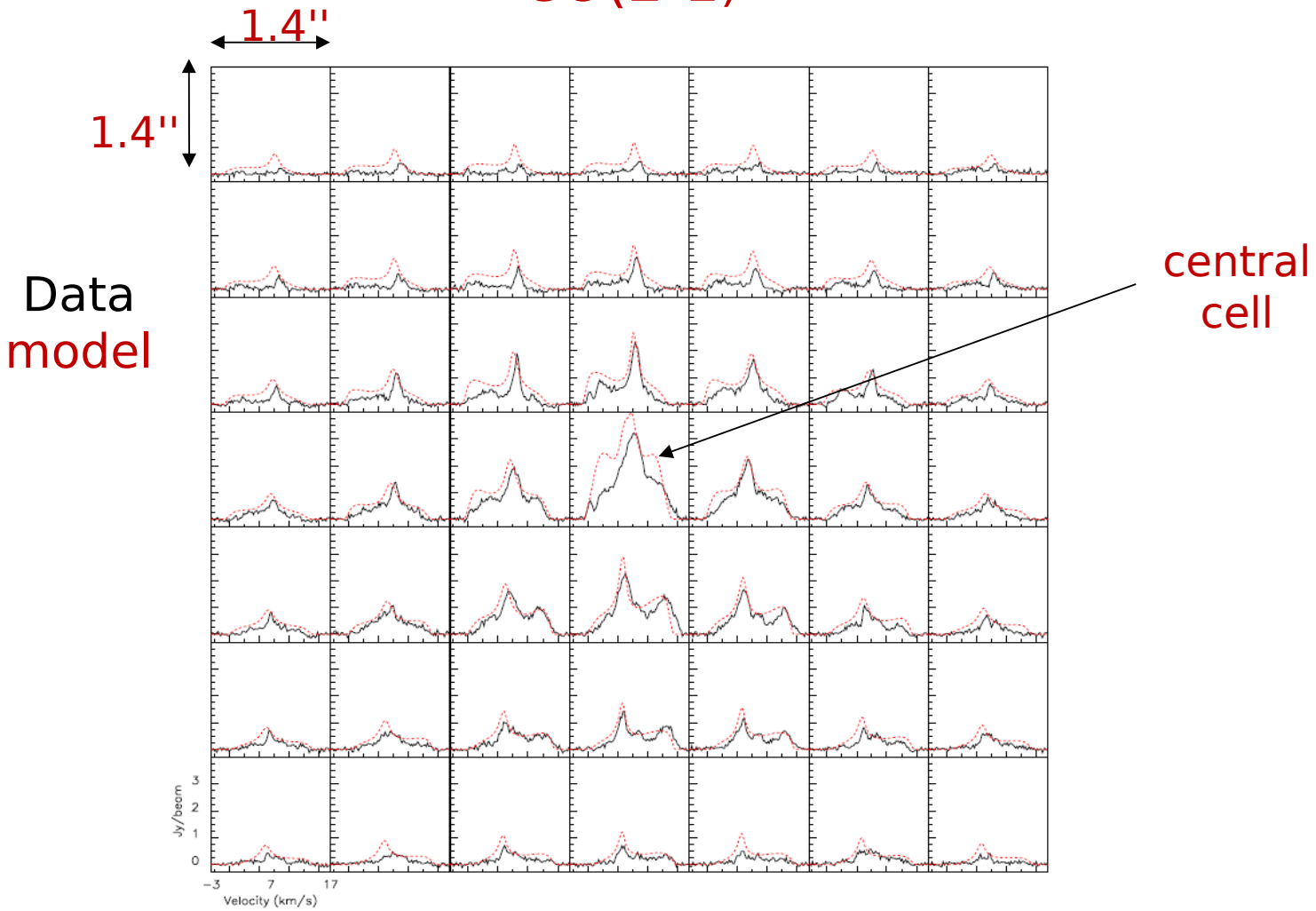
sin(latitude)

Density



sin(latitude)

CO(2-1)



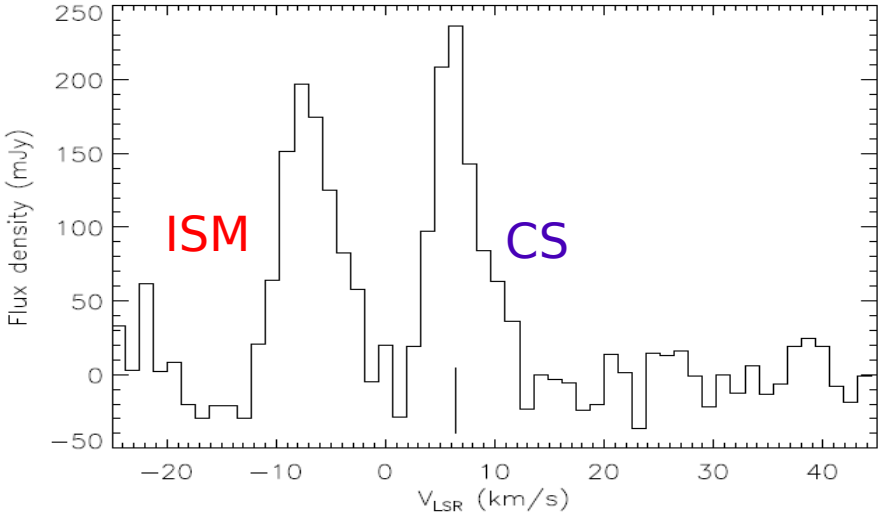
The fit is further improved by adjusting the temperature profile and including an asymmetry in the bipolar flow (Nhung et al. 2014)

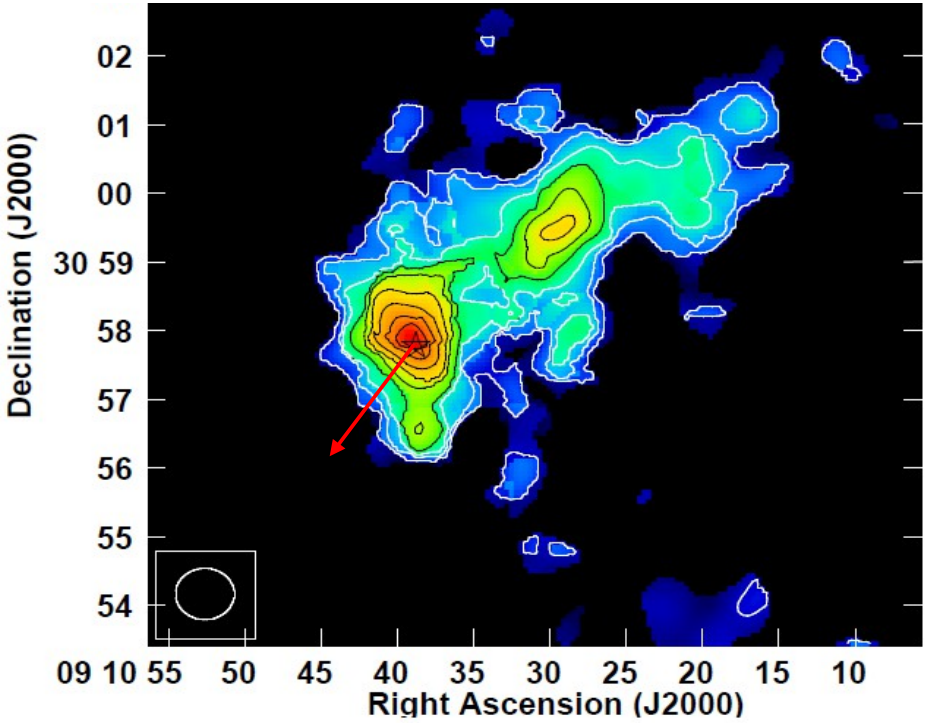
HI observations

The HI traces circumstellar gas beyond the molecular dissociation radius and shows a head-tail morphology.

The head (1') is elongated in a direction consistent with the polar axis observed in CO.

The tail (6') trails in a direction opposite to the space motion of the star (red arrow).





Conclusions

CO and HI are complementary tracers that allow us to study the morpho-kinematics of stellar winds from the central stars to their surrounding ISM.

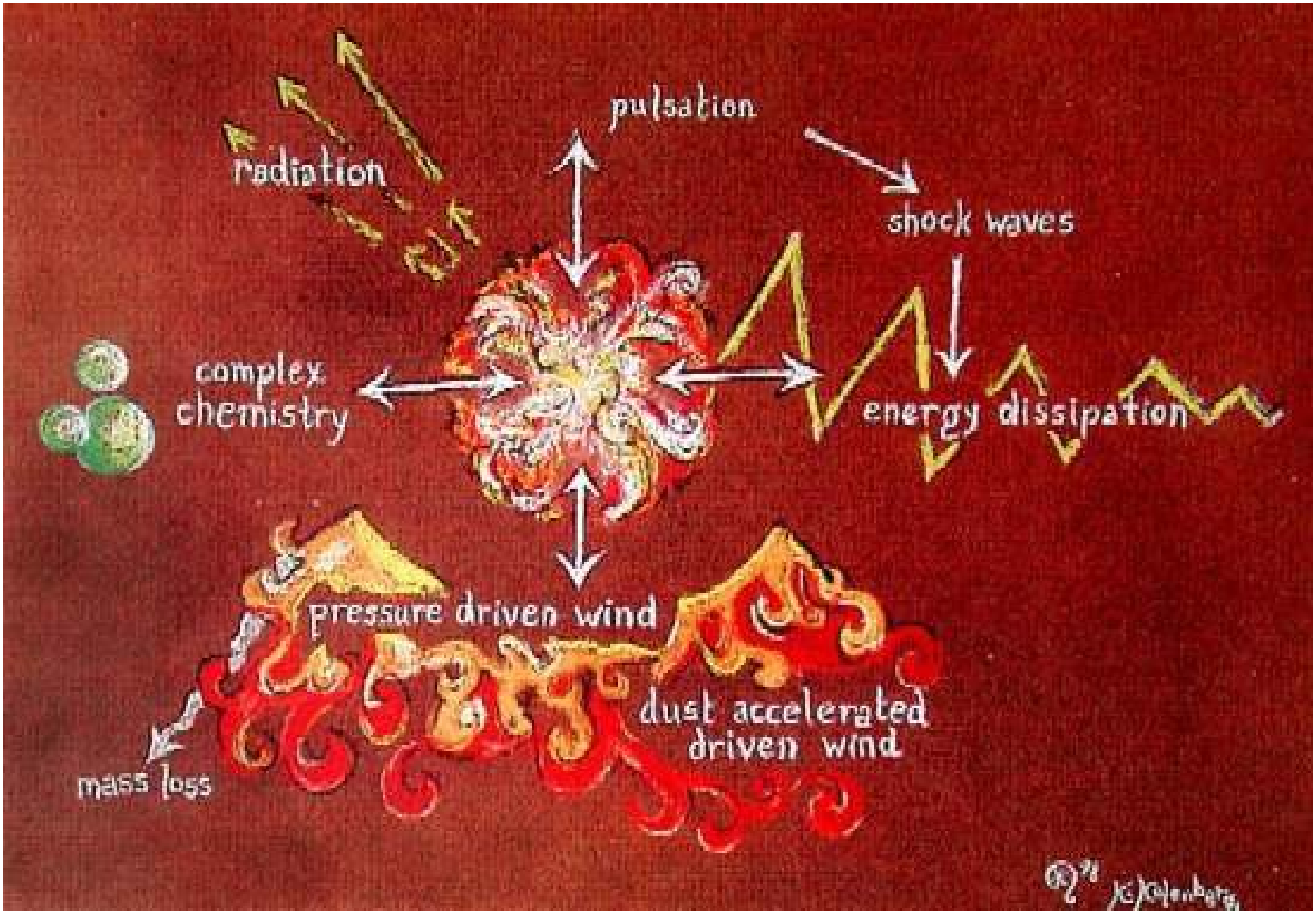
CO emission in the inner environment of RS Cnc is described by a simple model in which the velocity and density vary smoothly from the equatorial plane to the polar axis.

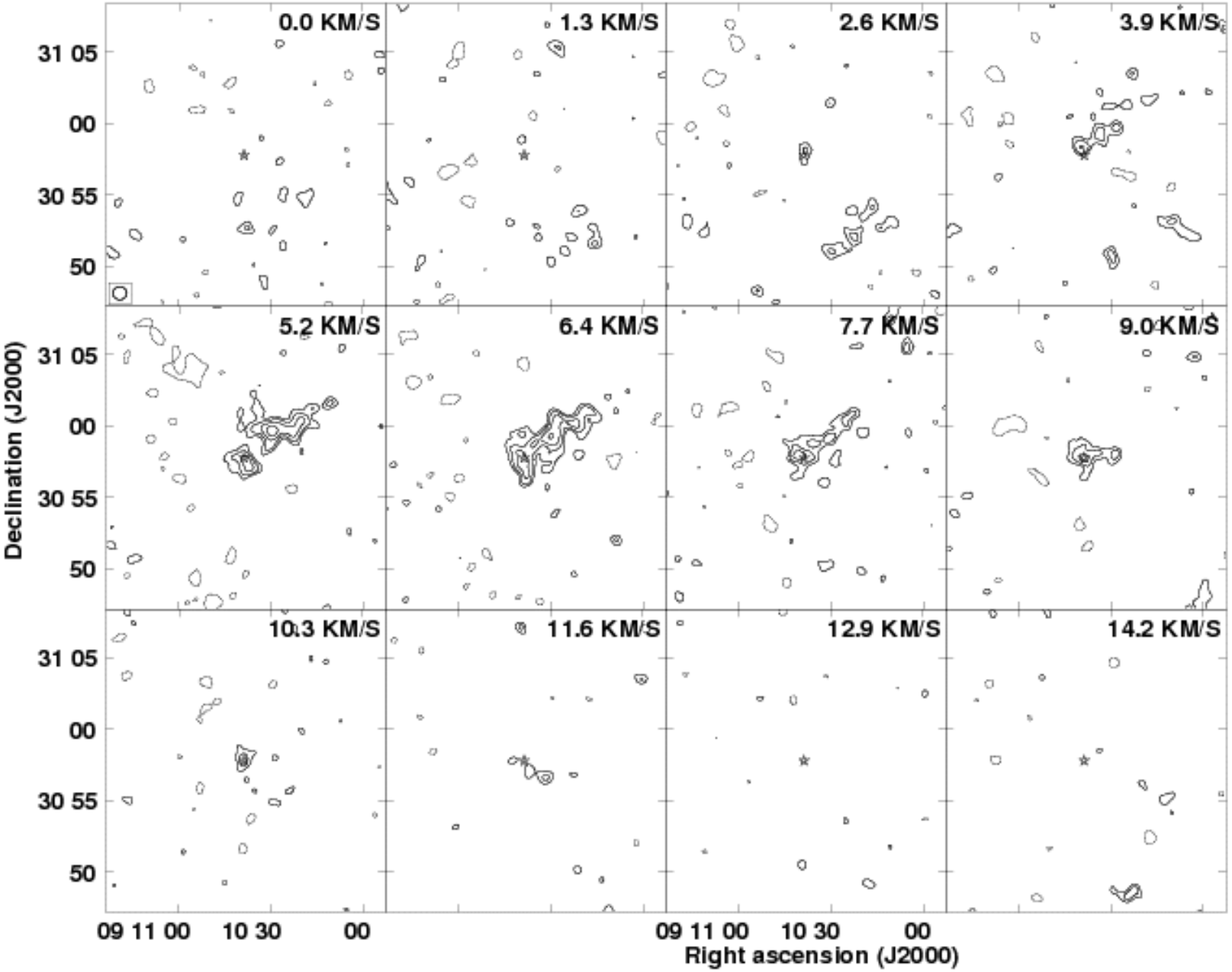
The wind is accelerated up to quite far distance (10^{16} cm) compared to that in the dust driven wind models (10^{14} cm).

The results imply that the origin of axi-symmetry is probably not due to stellar rotation or the presence of a magnetic field.

HI traces the circumstellar gas beyond CO dissociation radius and shows an elongated head consistent with the polar axis observed in CO and a long tail in a direction opposite to the space motion of star.

THANK YOU FOR YOUR ATTENTION!




0.0 KM/S
1.3 KM/S
2.6 KM/S
3.9 KM/S
5.2 KM/S
6.4 KM/S
7.7 KM/S
9.0 KM/S
10.3 KM/S
11.6 KM/S
12.9 KM/S
14.2 KM/S
31 05
00
30 55
50
Declination (J2000)
09 11 00
10 30
00
Right ascension (J2000)