# Gas infall and bow shocks

## in the vicinity of the young 8-10 $M_\odot$ star AFGL 490


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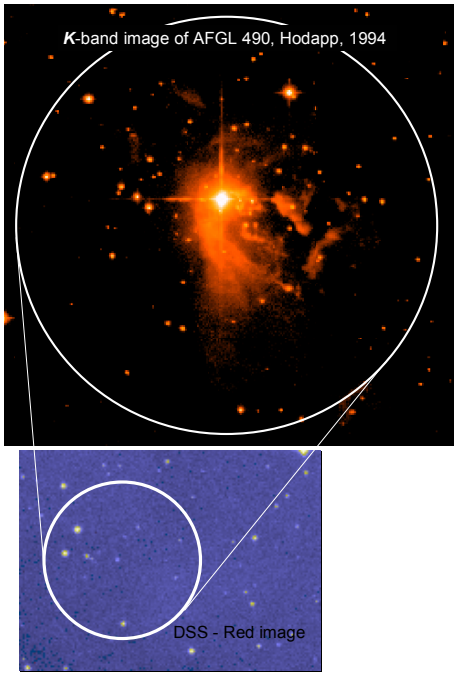
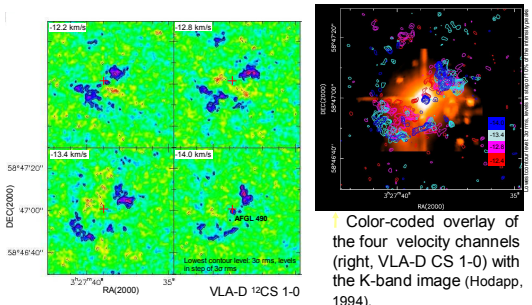




## Summary

We observed the region of the young B2-3 star AFGL 490 in $C^{34}S$ 2-1 and $CH_3OH$ 2-1 using the Plateau de Bure Interferometer as well as in CS 1-0 with the VLA C & D array. These observations show that the 20 000 AU large bar-like structure (originally interpretated as edge-on disk; Mundy & Adelmann 1988) is created by the wide-angle high-velocity outflow.


## Observational results

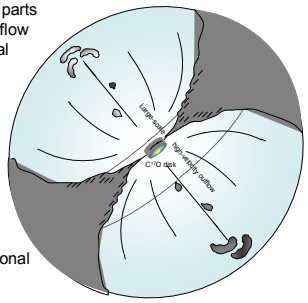



VLA-D $^{12}$CS 1-0

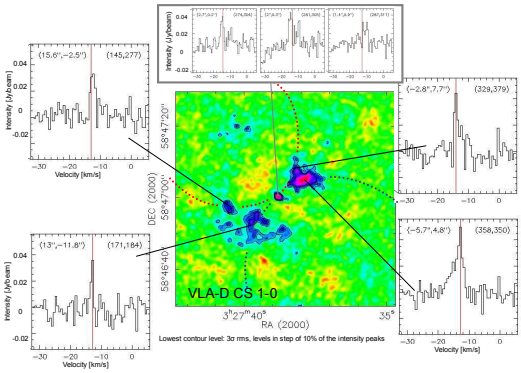
↑ Four channel maps of the VLA-D CS 1-0 measurements. Only parts of the dense shells of the outflow cones are visible. The general morphology and the velocity distribution agree with the PdBI $C^{34}S$ 2-1 and PdBI $CH_3OH$ data.



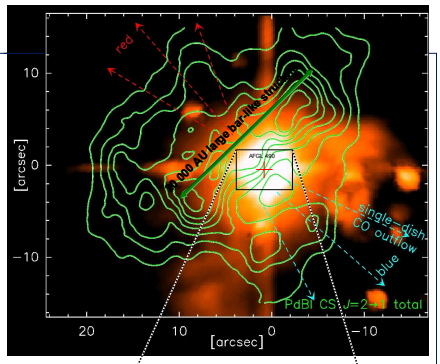
↑ Color-coded overlay of the four velocity channels (right, VLA-D CS 1-0) with the K-band image (Hodapp, 1994).



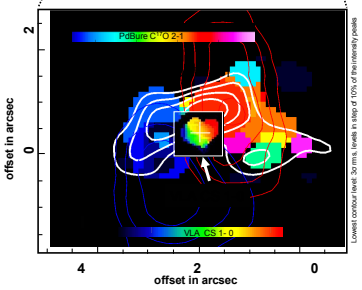

→ Sketch of the assumed morphology of the cloud core based on observational data.




↑ Four VLA-D CS 1-0 spectra (right and left) indicate the presence of shocked dense gas in a thin layer around the outflow cones. The CS double profiles towards AFGL 490 (top) vary over the inner circumstellar disk found in PdBI $C^{17}O$ 2-1 (Schreyer et al. 2006).

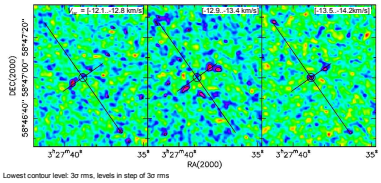



↑ Previous PdBI CS 2-1 (Schreyer et al. 2002):
- a bar-like dense gas structure was found
- disk-like system around the central star AFGL490
- mass inside $R$ = 4000 AU: $M_{disk} \approx M_{star} \approx 8\,M_\odot$



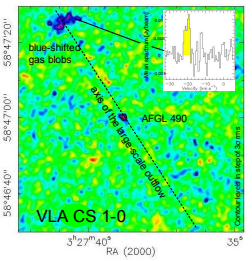

↑ Velocity-coded images of the PdBI $C^{17}O$ 2-1 data (Schreyer et al. 2006; white contours) and the VLA-C CS 1-0 line (white inner box). The red and blue contours represent the previously measured red- and blue-shifted PdBI CS 2-1 line emission (Schreyer et al.2002). The circumstellar disk with $R \approx 1500$ AU is traced with different line transitions. Only the densest parts ($M_{gas} \approx 1\,M_\odot$) are visible in $C^{17}O$ (with two dense spiral arms? Fromang et al. 2004). Advanced modelling of the line profiles points to an inclination & position angle of 30°. The innermost gas is seen with the VLA-C array.

↓ Channel maps of the PdBI $C^{34}S$ 2-1data.

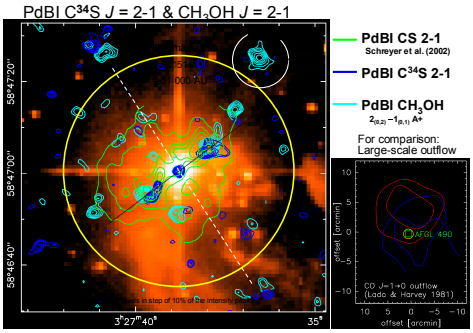



## Bow shocks

The VLA-D CS 1-0, the PdBI $CH_3OH$ and the $C^{34}S$ data show dense gas clumps along the main axis of the large-scale high-velocity outflow.



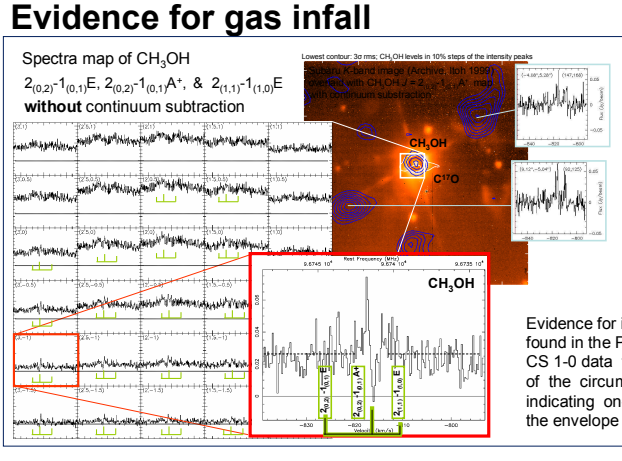

PdBI $C^{34}S$ $J$ = 2-1 & $CH_3OH$ $J$ = 2-1

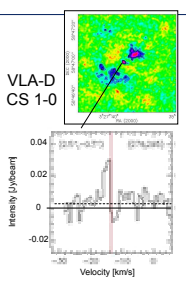



Total integrated line emissions of $C^{34}S$ 2-1, $CH_3OH$ $2_{(0,2)}$-$1_{(0,1)}A^+$ and CS 2-1. Whereas $C^{34}S$ traces mainly the rim of the blue-shifted outflow conus, $CH_3OH$ is detected predominantly on the red-shifted outflow conus.

## Evidence for gas infall

Spectra map of $CH_3OH$ $2_{(0,2)}$-$1_{(0,1)}E$, $2_{(0,2)}$-$1_{(0,1)}A^+$, & $2_{(1,1)}$-$1_{(1,0)}E$ **without** continuum subtraction




Evidence for inverse P Cygni profiles are found in the PdBI $CH_3OH$ 2-1 and VLA-D CS 1-0 data towards the southern region of the circumstellar disk of AFGL 490 indicating on-going gas accretion from the envelope to the disk.

## Results & Conclusions

- In $C^{34}S$ and $CH_3OH$, parts of the dense rims / shells of the outflow cones are detected. These dense cloud parts build likely the 20 000 AU-large bar-like structure in the cloud center in which the young star AFGL 490 is embedded.
- We assume that the large-scale high-velocity CO outflow is created by a surface disk wind. The opening angle close to disk is >140°.
- Inverse P Cygni profiles in $C^{34}S$ and CS detected towards the immediate envelope of the inner circumstellar disk ($R$ = 1500 ±100 AU, Schreyer et al. 2006) indicate on-going gas infall *from* the envelope disk *to* the disk.
- The presence of individually small gas clumps along the main axis of the bipolar outflow point to non-steady state gas accretion *from* the *to* the central star.
- Interestingly, there is no dense gas (detectable in $C^{34}S$ and $CH_3OH$ and VLA CS) between the circumstellar disk ($R_{out}$ = 1500 AU with a rather sharp outer edge) and the ``outflow shells´´ (which start out at a distance of $R \geq 2500$ AU from the star).