Where is the water in low-mass young stars?

Lars E. Kristensen

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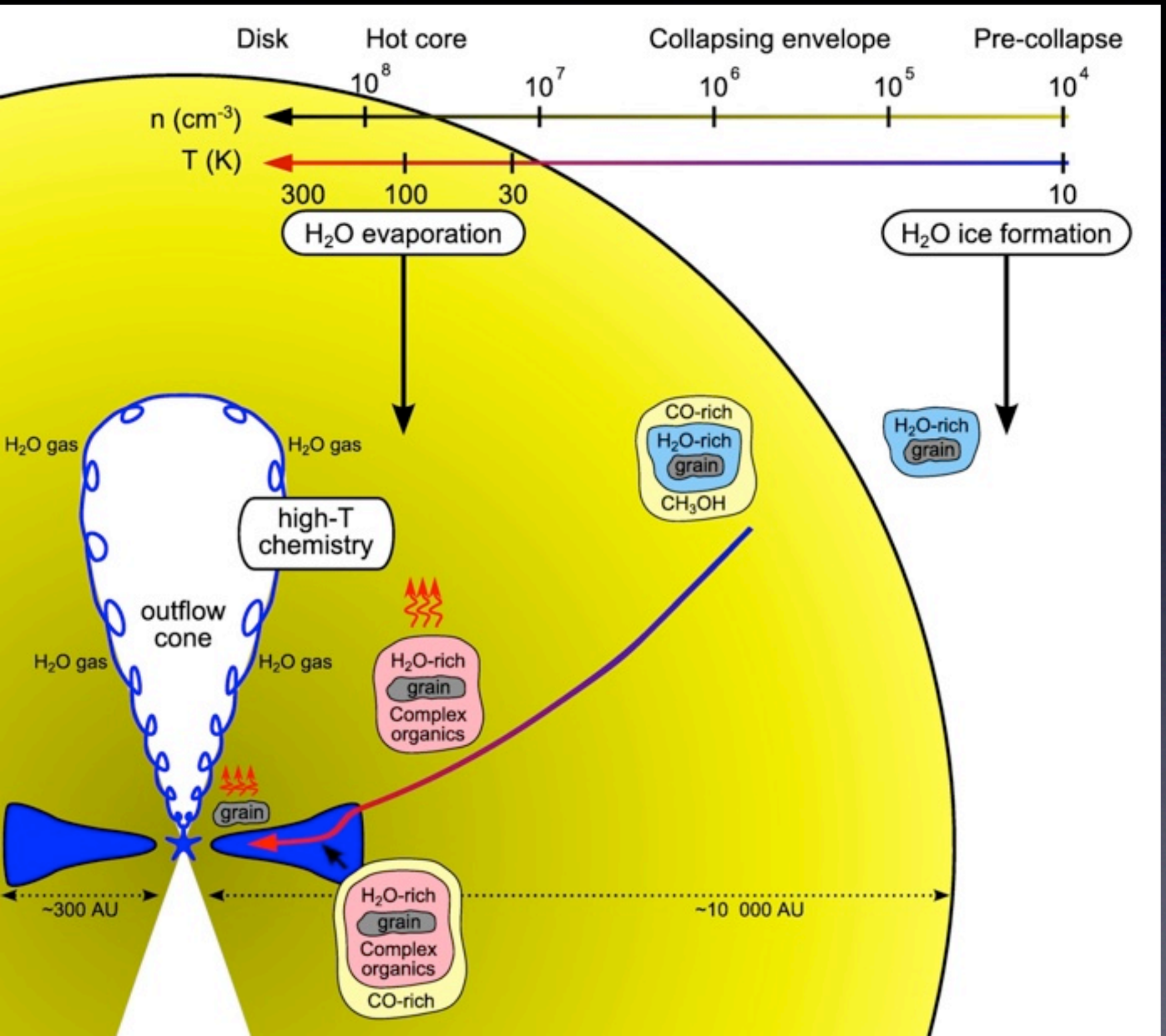
Star formation & water

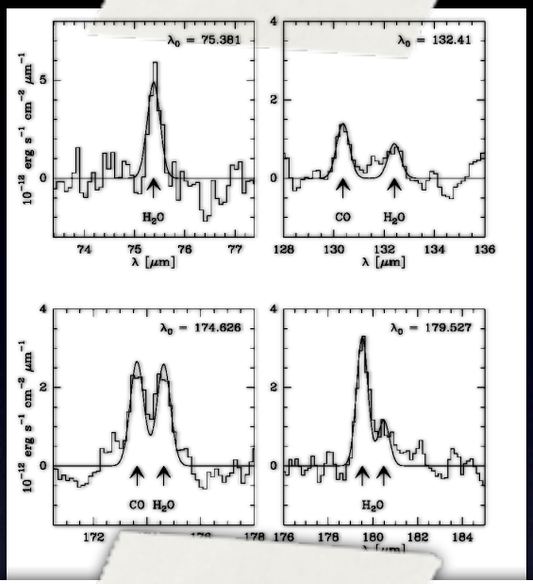


- Pre-Herschel expectations:
- Bulk of envelope: H_2O in ice, $x_{gas} \sim 10^{-9}$
- $T > 100$ K: x_{gas} jumps to 10^{-4}
- *WISH*: test expectations

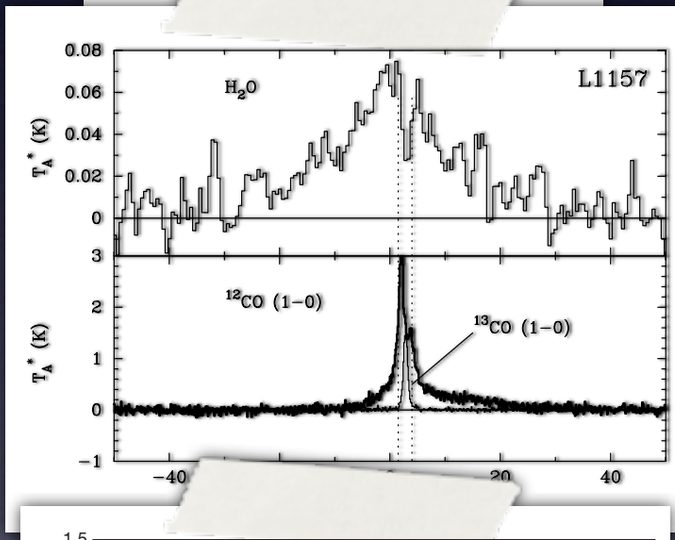
Visser et al. 2009
van Dishoeck et al. (2011)

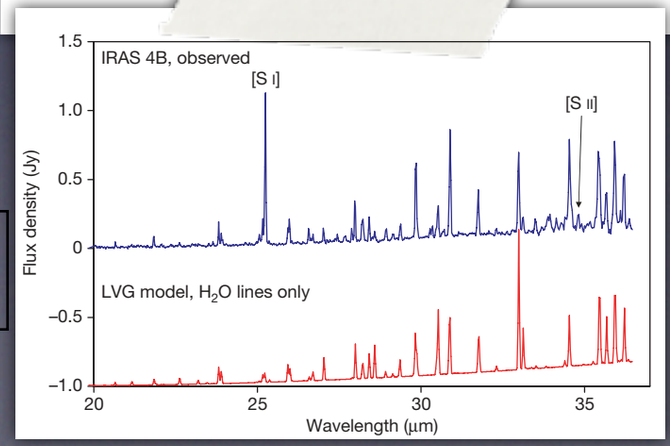
Pre-Herschel observations

- Water observed extensively over 20 years from space *(ISO-LWS, SWAS, Odin, Spitzer)*
  (e.g., Ceccarelli et al. 1999, 2000; Nisini et al. 2000, 2002; Bergin et al. 2003; Hjalmarson et al. 2003; Watson et al. 2007; Melnick et al. 2008)



- Inner hot core or shocked outflowing gas?
- *Herschel-HIFI*: Gain in sensitivity and resolution
- *WISH*: observe ~ 80 sources to determine $x(H_2O)$ in envelope and outflow: H_2O trail

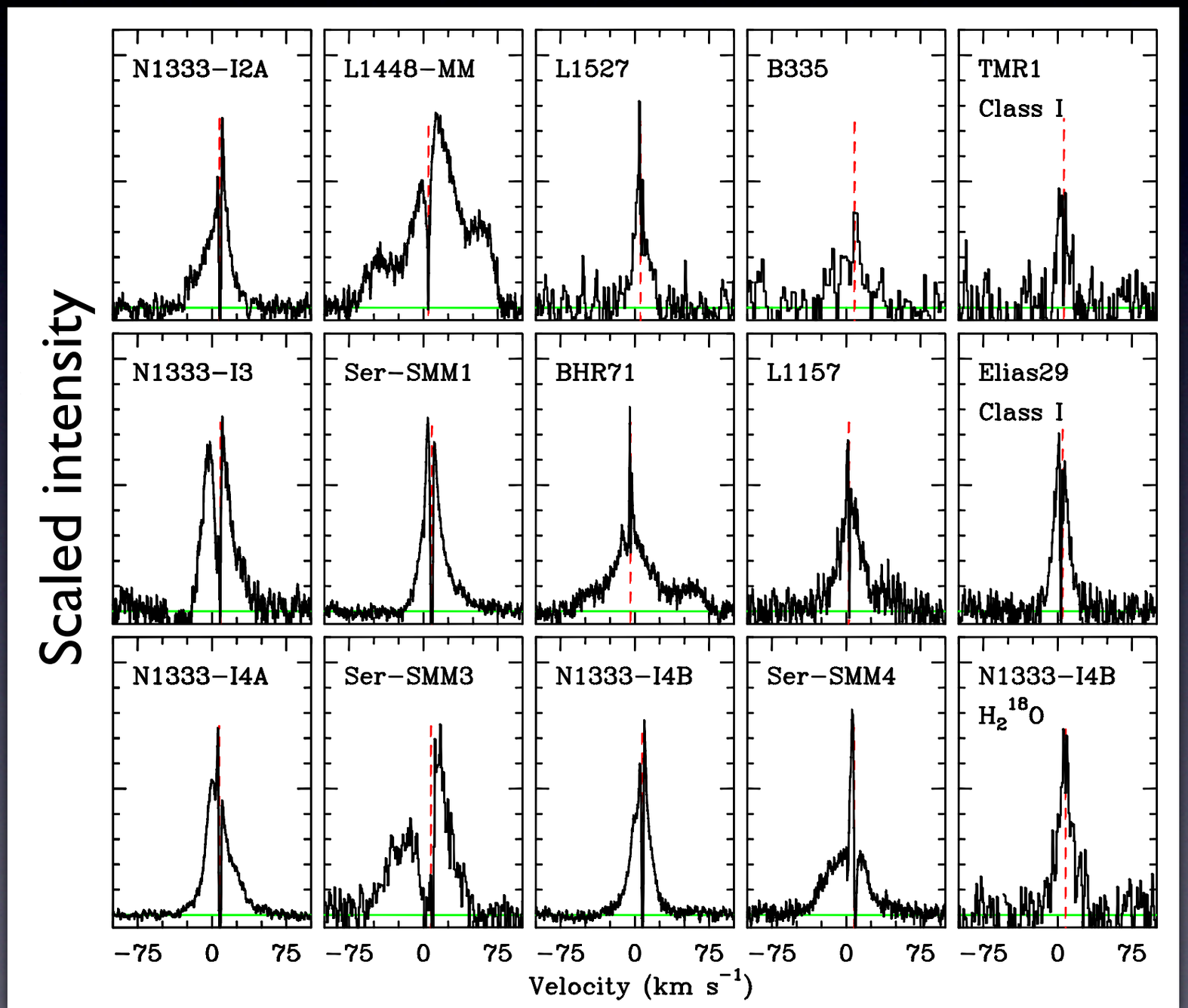




Posters: 1.36, 1.42, 1.74, 1.77, 1.102

Early Herschel results

H_2O 1_{10}-1_{01} @ 557 GHz

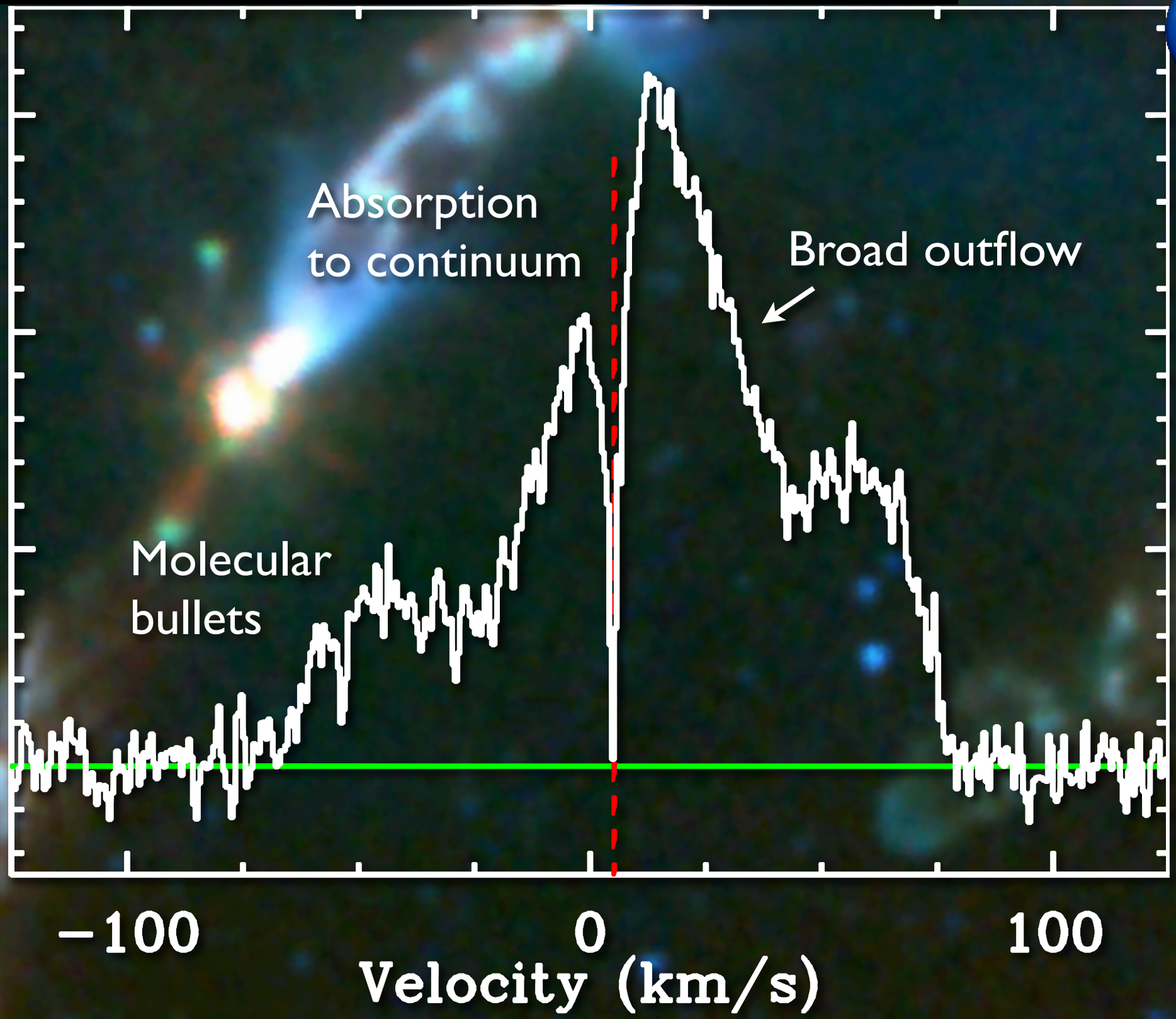


Velocity scale: -100 to 100 km/s

- Envelope emission expected to be < 5 km/s...
- Emission outflow dominated, even in small beam (2000 AU)
- Ground-state $H_2{}^{18}O$ broad (Lefloch et al. 2010; Kristensen et al. 2010; Kristensen et al. in prep.)

Water bullets in a low-mass protostar

L1448:
D ~ 250 pc
L ~ 11 $L_\odot$

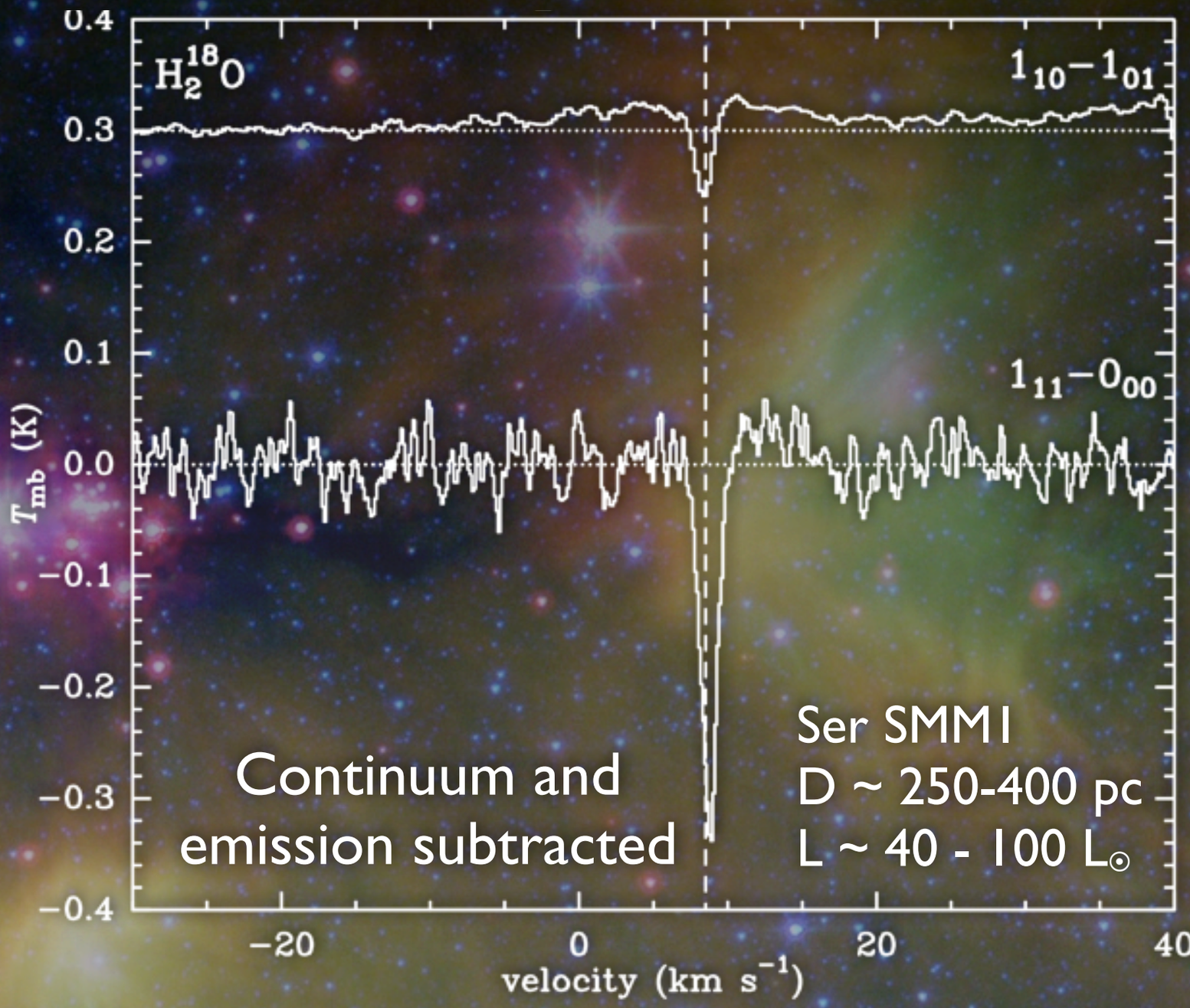


Bullets H_2O rich indicating fast and efficient formation from atomic gas

Kristensen et al. (2011; astro-ph)

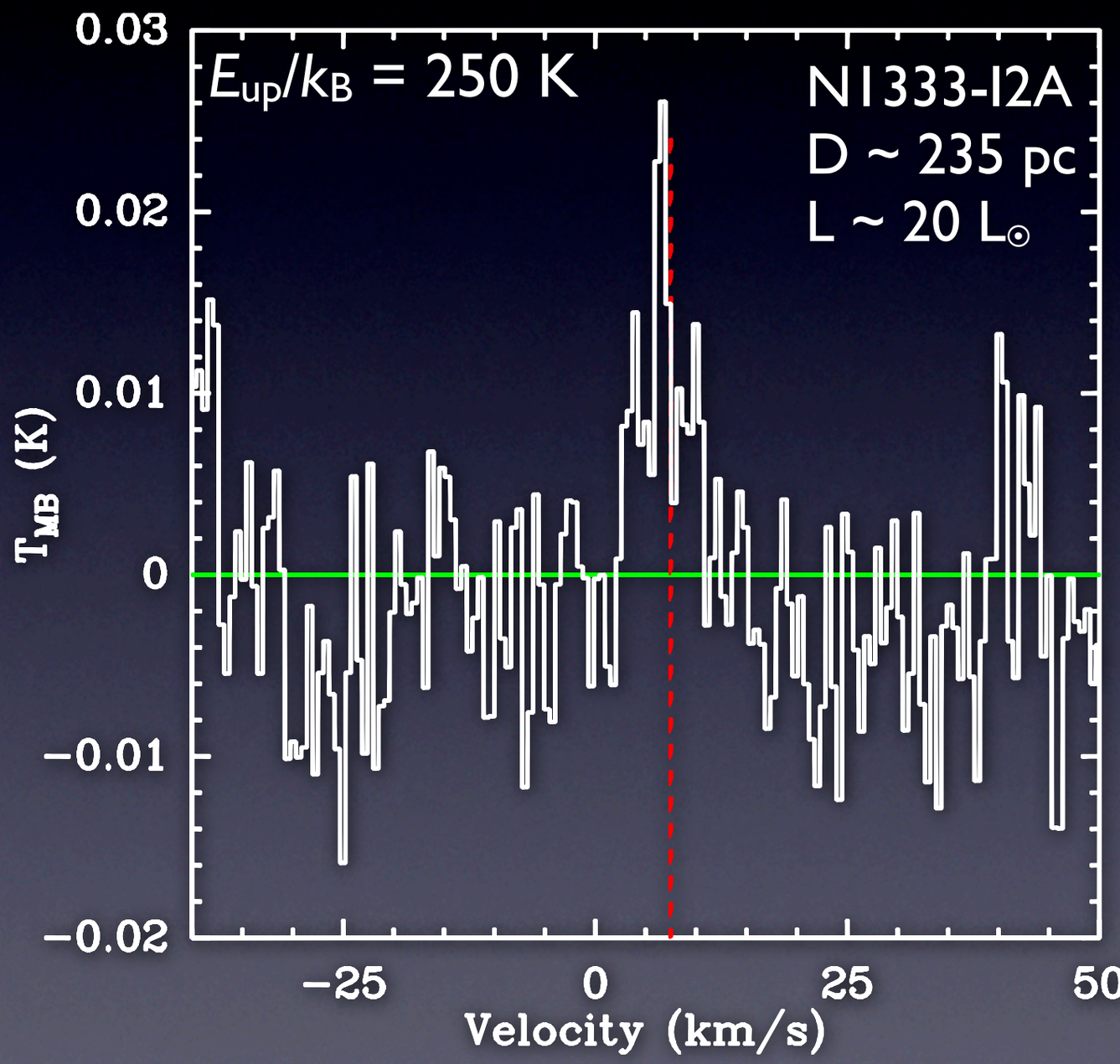
Absorbing envelopes

- Clearest sign of envelope: absorption also seen in $H_2{}^{18}O$ (Visser et al. in prep.)
- Traces *x*(out) directly: 10^{-8}



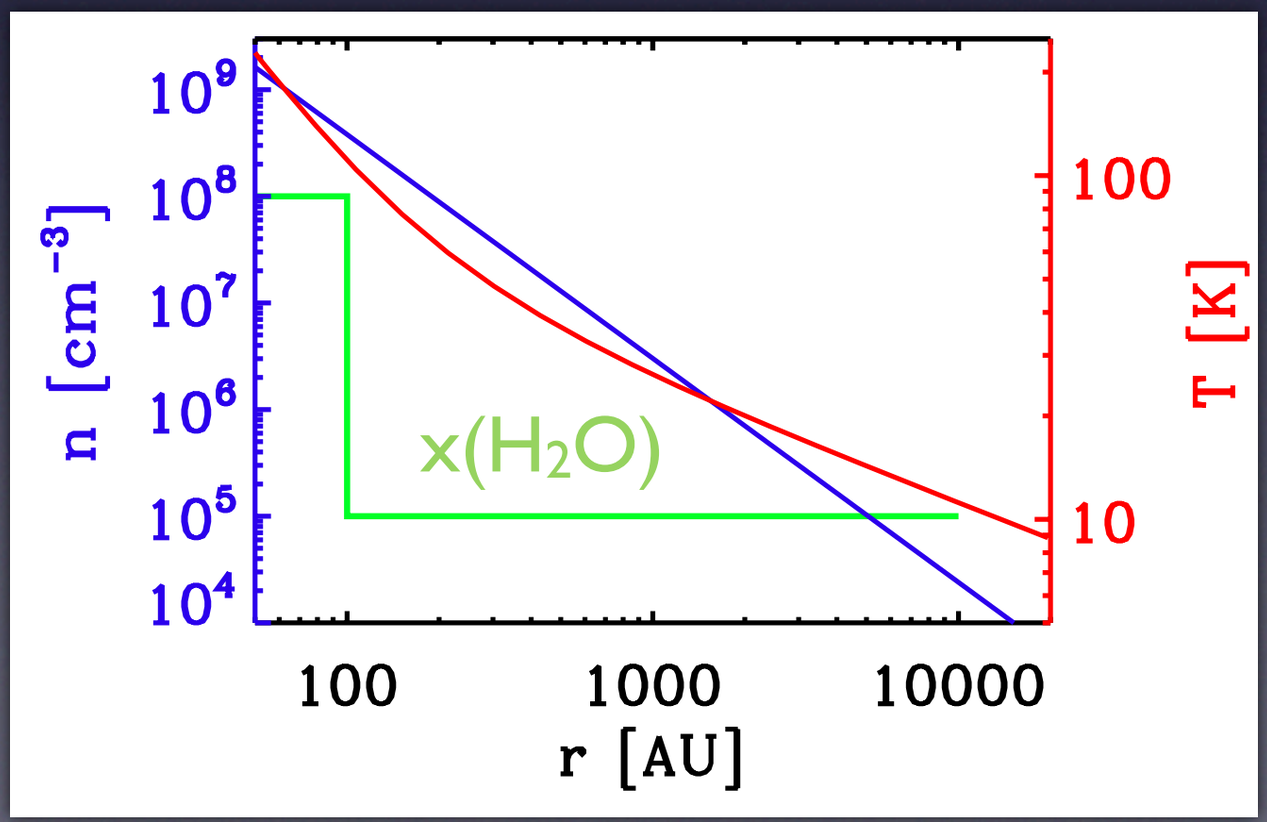
Inner region

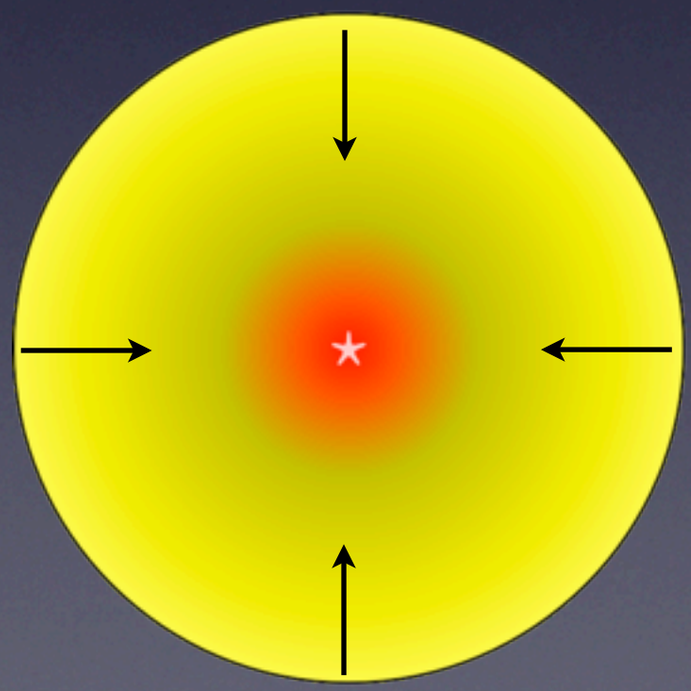
- 5h integration on excited $H_2{}^{18}O$ line
  ($H_2{}^{18}O$ 3_{12}-3_{03} @ 1094 GHz)
- *FWHM* ~ 5 km/s
- **Direct** detection of inner region with single-dish telescope
  (Visser et al. in prep.)



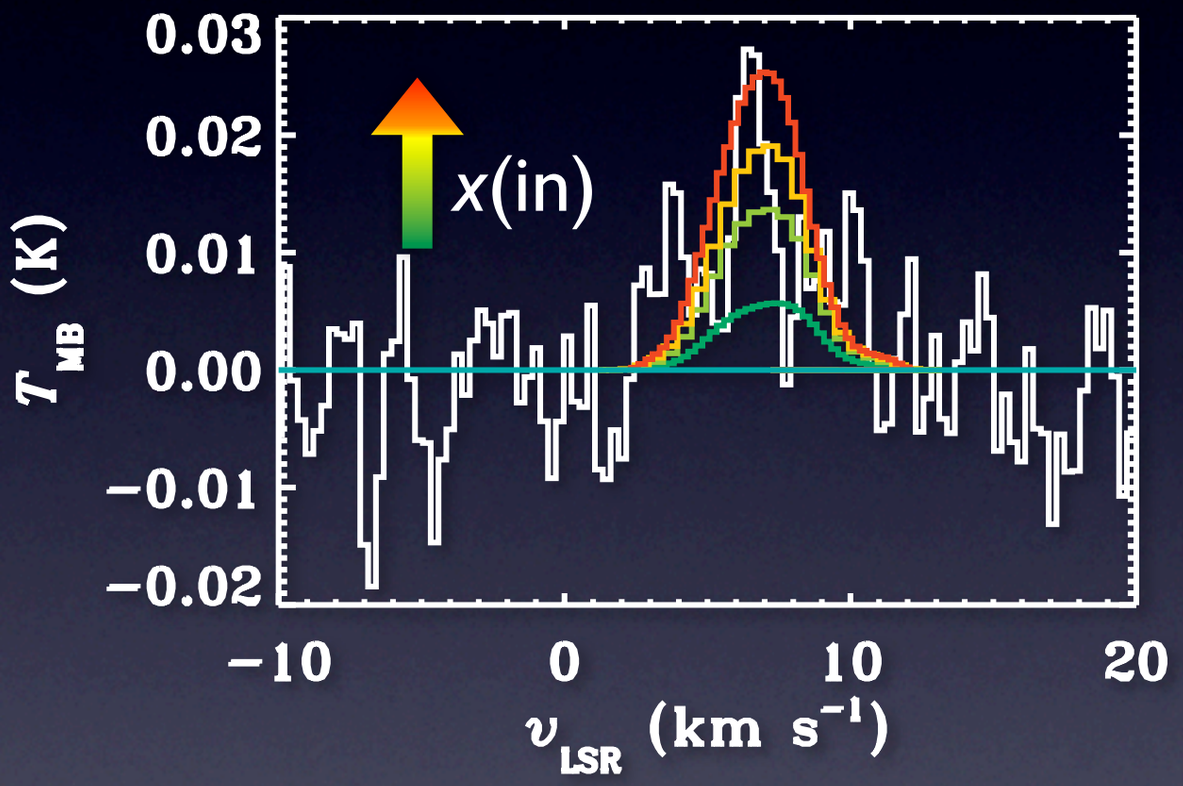
Envelope modelling

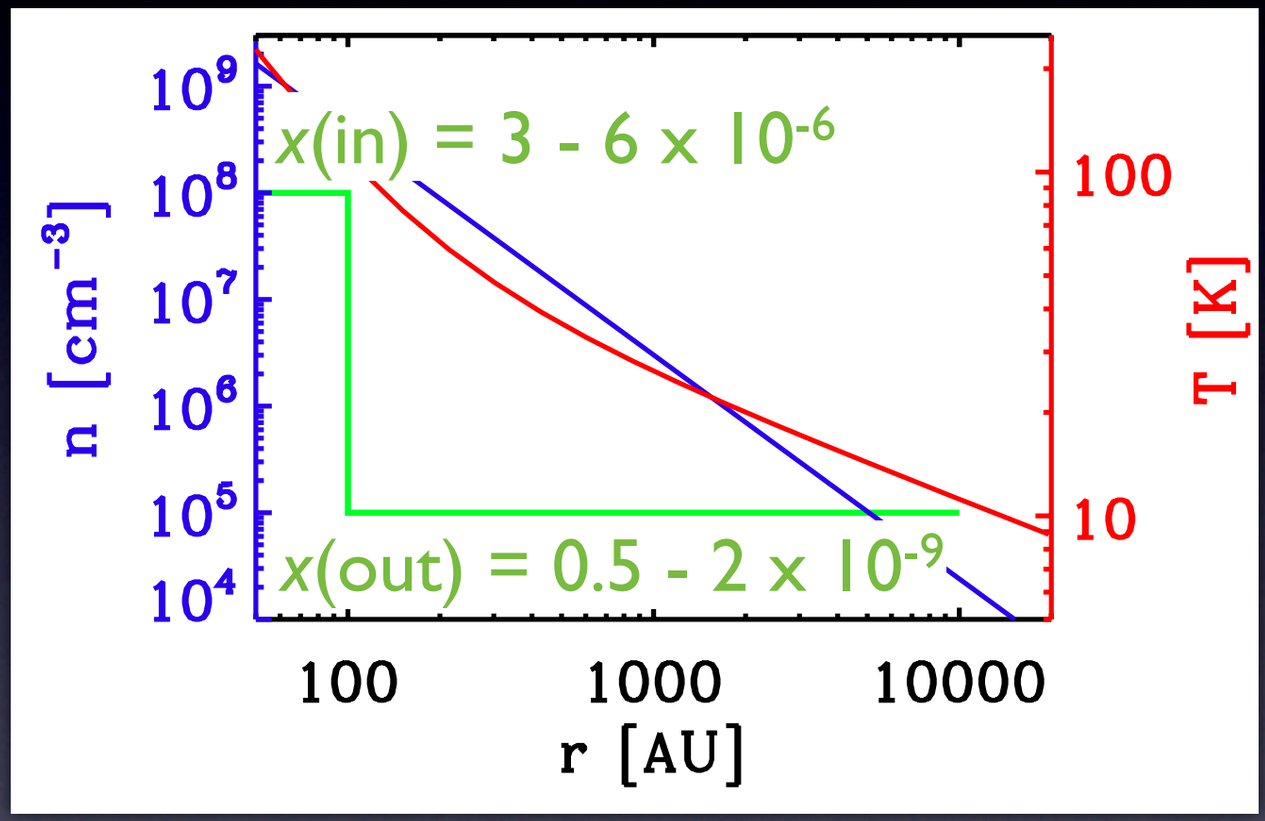
- Model infalling envelope using radiative transfer code (LIME; Brinch & Hogerheijde 2010)
- $H_2{}^{16}O$ traces *x*(out) and limits *x*(in)
- Excited $H_2{}^{18}O$ traces *x*(in)





Abundances





- *x*(in) determined to 3-6 x 10^{-6}, i.e., << 10^{-4} !

Conclusions

- Inner H_2O abundance of a low-mass envelope determined
- Low-mass hot cores are dry; *x*(in) ~ 100 times lower than expected
- Inner envelope only probed by excited $H_2{}^{18}O$

http://www.strw.leidenuniv.nl/WISH