High-*J* CO survey of low-mass protostars with *Herschel*-HIFI and LOMASS database

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Introduction

CO line emission is the main tracer of the physical structure and column density of protostellar envelopes in which young stellar objects (YSOs) form.

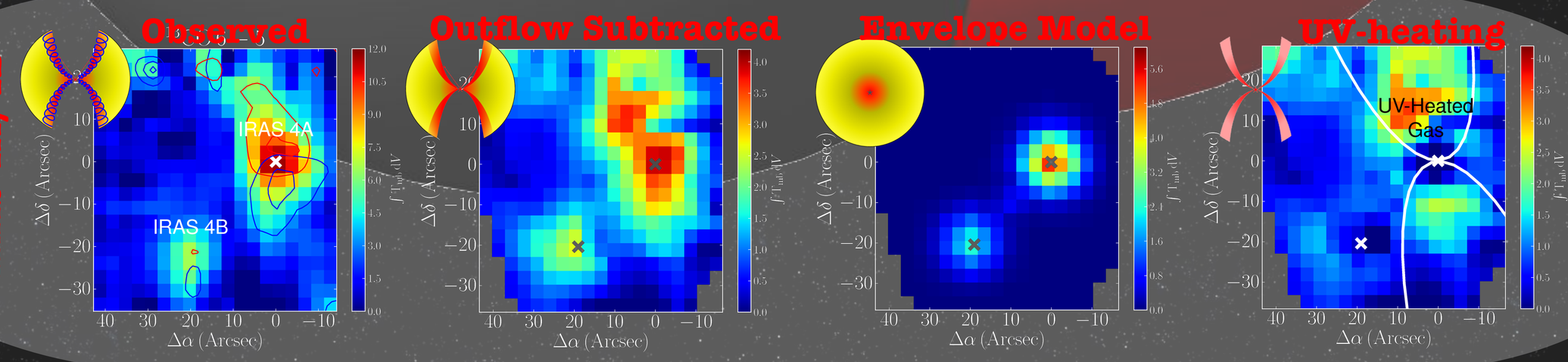
- Goal is to characterize the warmer parts of the protostellar envelopes in their deeply embedded phase.
- A sample of 13 Class 0 and 13 Class I YSOs (d=100-400 pc) is observed in CO with Herschel-HIFI as part of the **Water in star-forming regions with Herschel (WISH)** key program.
- High-J CO lines, including ^{12}CO, ^{13}CO and C^{18}O 10–9 and C^{18}O 5–4, 9-8 lines are observed (E_{up}~250-300 K), which trace the warmer material (T>50 K) in the envelope.
- This work allows us to quantify the feedback of the protostars on their surroundings in terms of UV-photon heating, photodissociation and outflow dispersal.

Results

- Broad **CO** emission line profiles trace entrained outflow gas with typical temperatures of ~100K.
- Mapping **^{13}CO 6-5** emission allowed us to obtain the first bonafide evidence for UV-heated gas around a low-mass protostar.
- The abundance --modeled by the **C^{18}O** lines-- in the outermost part of the envelope, X_0, is the canonical value of 2.7×10^{-4}; however the inner abundance, X_{in}, is a factor of 3–5 lower than X_0.
- Implications for spectrally unresolved **SPIRE** data:
  ^{12}CO: entrained outflow gas;
  ^{13}CO: envelope+UV heating;
  ^{12}CO/^{13}CO: limited meaning

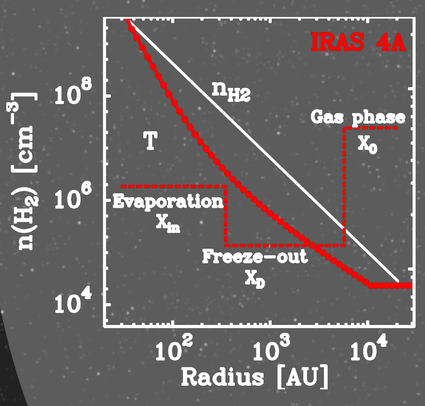
WISH

^{13}CO 6-5

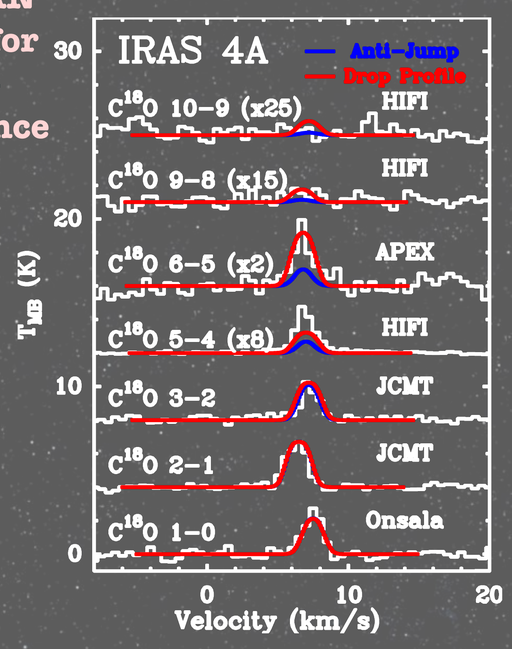


C^{18}O 6-5

Abundance Studies



RATRAN model for drop-abundance

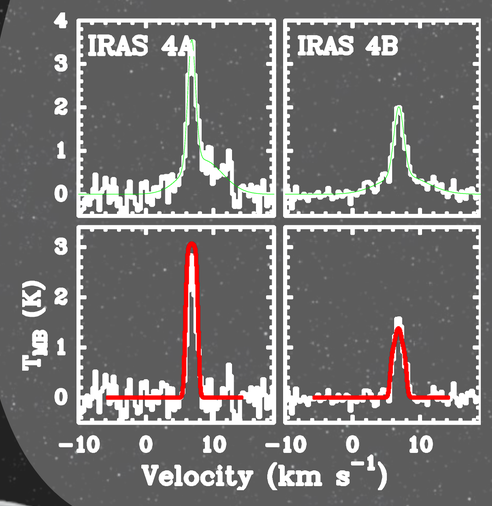


Radiative transfer models shows best fit to data X_{in}= 1×10^{-7} (CO=5.5×10^{-5}) above T_{ev}=25K. Note that $X_{in}< X_0$

UV-heated cavity walls

UV-heated gas is observed by the detection of extended narrow ^{12}CO and ^{13}CO 6-5 emission surrounding the outflow walls.

UV photons escape through the outflow cavities and either impact directly the envelope or are scattered into the envelope on scales of a few thousand AU.



The amount of UV-photon-heated gas and outflowing gas are quantified from the combined ^{12}CO and ^{13}CO 6-5 maps and found to be comparable within a 20" radius around IRAS 4A, which implies that UV photons can affect the gas as much as the outflows.

References

(1) Yildiz et al. 2012, A&A, astro-ph: 1203.2965
(2) Yildiz et al. 2010, A&A, 521, L40
(3) Kristensen et al. 2010, A&A, 521, L30
(4) Jørgensen et al., 2002, A&A, 389, 908; 2005, A&A, 435, 177
(5) Van Dishoeck et al, 2011, PASP, 123, 138

LOMASS

LOMASS is a public molecular line database of the reduced data for low-mass protostars observed with JCMT, APEX, Herschel.

Available in 2013

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