Water in Low-Mass Star-Forming Regions

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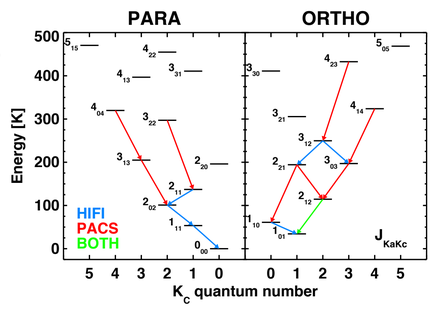
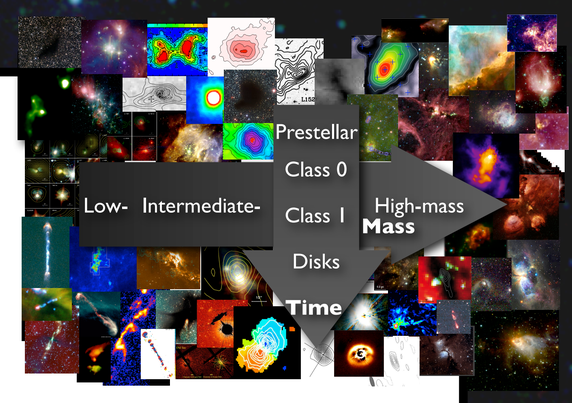
Water

- Key molecule for probing the physics and chemistry of star-forming regions
- Large abundance variations between warm/cold regions
- Capable of highlighting key episodes of stellar birth such as gravitational collapse, outflow injection, and stellar heating of envelopes and disk
- Chemical importance as one of the main oxygen reservoirs
- Direct association with life on Earth

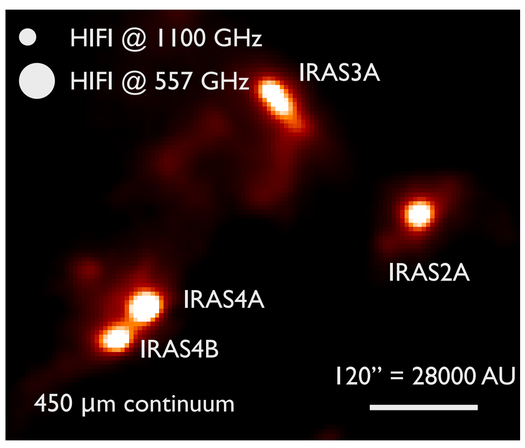




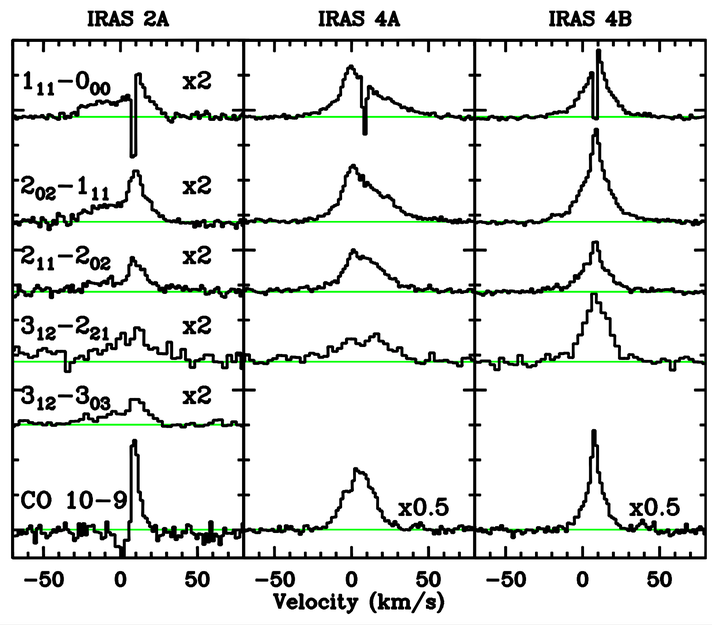
Water is a prime target for Herschel observations. The "Water in Star-Forming Regions with Herschel" (WISH) key programme is using HIFI and PACS to follow the water 'trail' from prestellar cores to planet-forming disks.

NGC1333

- Low-mass star-forming cluster in Perseus
  Four bright sub-mm sources: **IRAS2A**, IRAS3A, **IRAS4A** and **IRAS4B**; three observed with HIFI and PACS
- D ~ 235 pc
- Extensively surveyed from the ground and space.
- Currently forming stars like the Sun.



Data: NGC1333 HIFI



Results

Surprises:

- Multiple components: broad, even in $H_2{}^{18}O$ (~ 50 km s^{-1}) and narrow (~ 5-10 km s^{-1})
- Line centers off-set with respect to source velocity

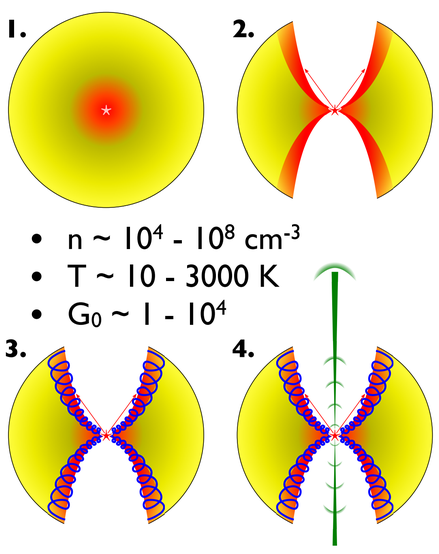
Interpretation:

- Broad component originates in shocks along cavity walls
- Narrow component is partly due to the envelope, partly due to UV-heating of cavity walls
- Geometry and excitation mechanism determine profiles. Further modeling required for full interpretation; in particular to determine the role of the passive envelope

Scenario

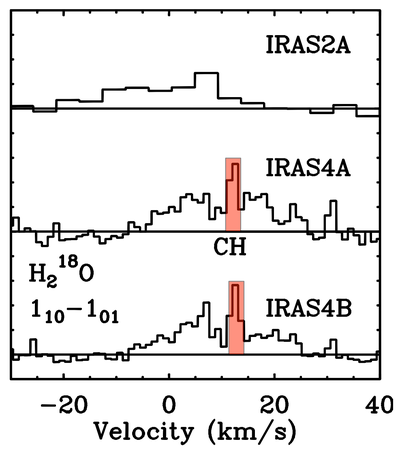
Components:
1. Passively heated envelope
2. UV-heated outflow cavity walls
3. Small-scale C-type shocks along walls
4. Jet responsible for outflow
5. Protoplanetary disk

(Visser et al. in prep.)



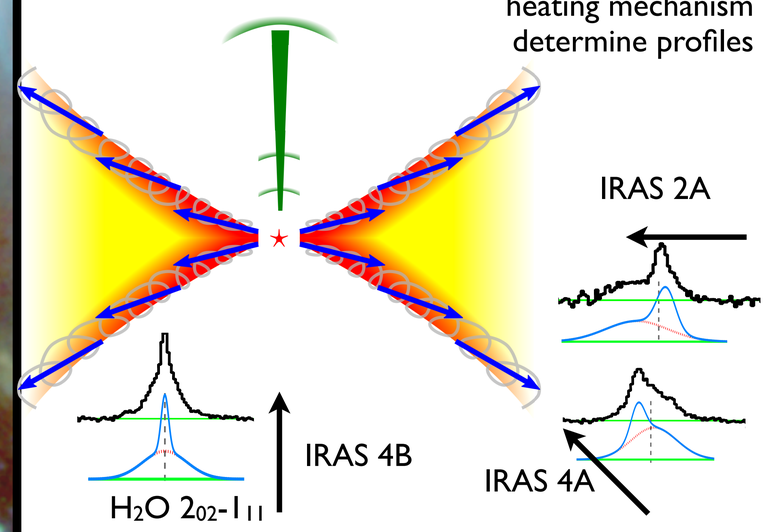
Data - isotopologues

- $H_2{}^{18}O$ 1_{10}-1_{01} (and CH)
- Primarily broad profile (~ 25 km s^{-1}) comparable to that of $H_2{}^{16}O$
- Narrow component weak or absent



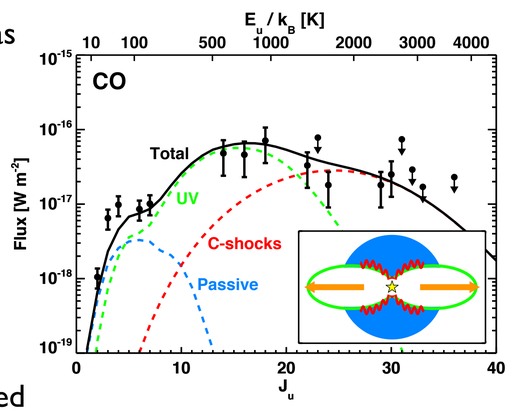
Scenario (cont'd)

Viewing angle and heating mechanism determine profiles



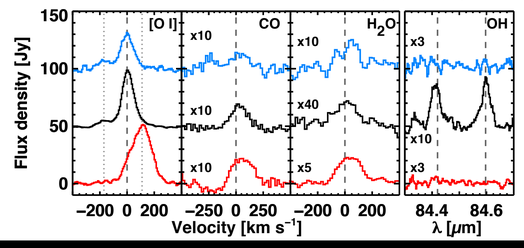
HH46 modeling

- Components as above
- Modeling as above with four components (no disk)
- CO emission from APEX and PACS reproduced up to J_u = 30



Data: HH46 PACS

- PACS line scan SDP observations (van Kempen et al. 2010)



Technical details

- Observations carried out on March 5-15, 2010 using HIFI in DBS mode. WBS spectra presented here.
- Linear baselines subtracted from all spectra.
- To be published in Kristensen et al.
- Similar results available for CO, ^{13}CO and $C^{18}O$ (Yildiz et al. in prep.)
- See also:
  http://www.strw.leidenuniv.nl/WISH/

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