The Warm and Dense ISM seen by Herschel

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ESTEC, May 5, 2010

The Warm and Dense ISM seen by Herschel

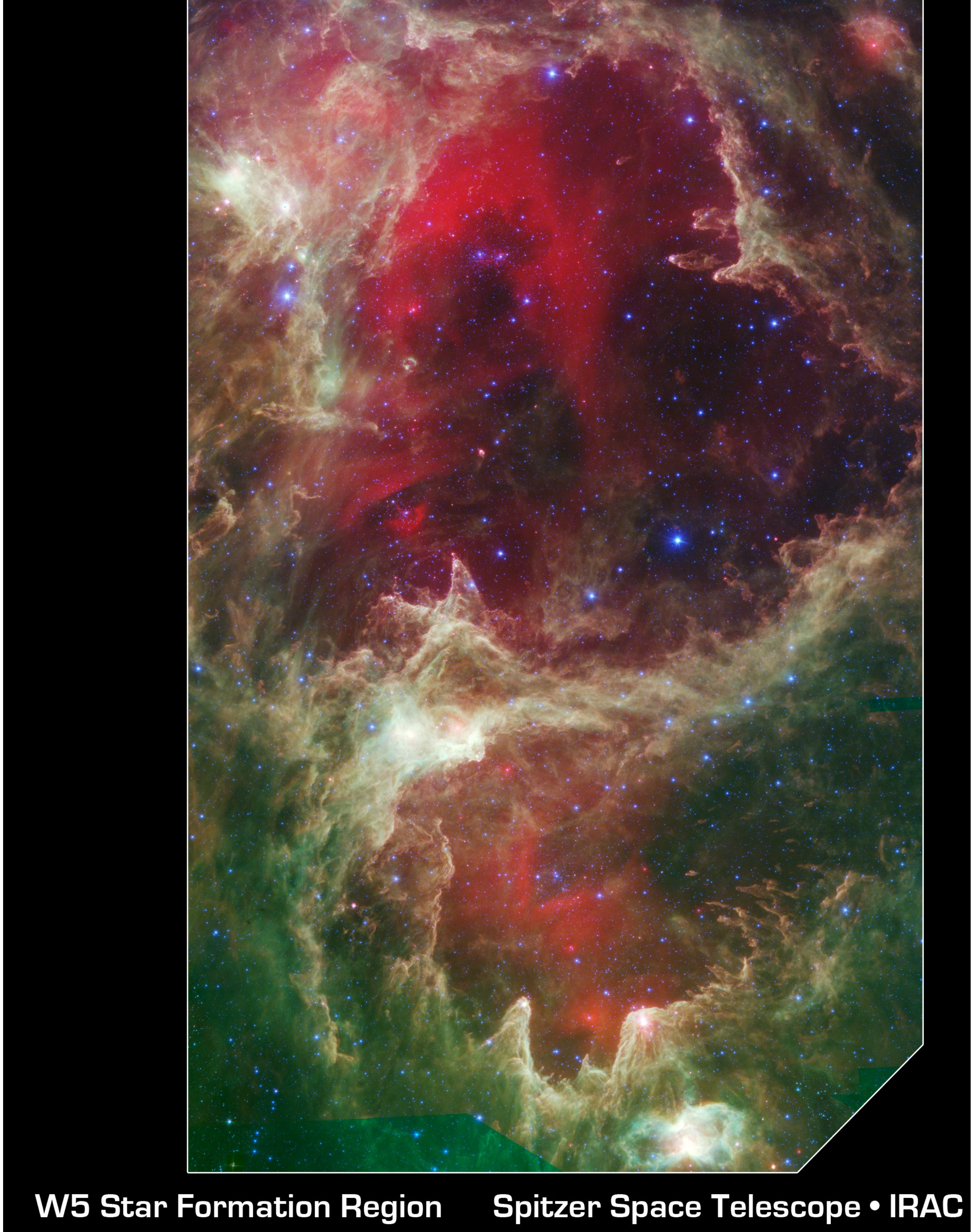
- Motivation
- The energy balance of the heated gas
- The chemical structure
- The dynamical structure

ESTEC, May 5, 2010

Volker Ossenkopf

Science goals

Understand the physical and chemical processes controlling the inter-action between stars and their environment.



WADI science goals

- Young stars affect their environment by UV radiation and shock waves

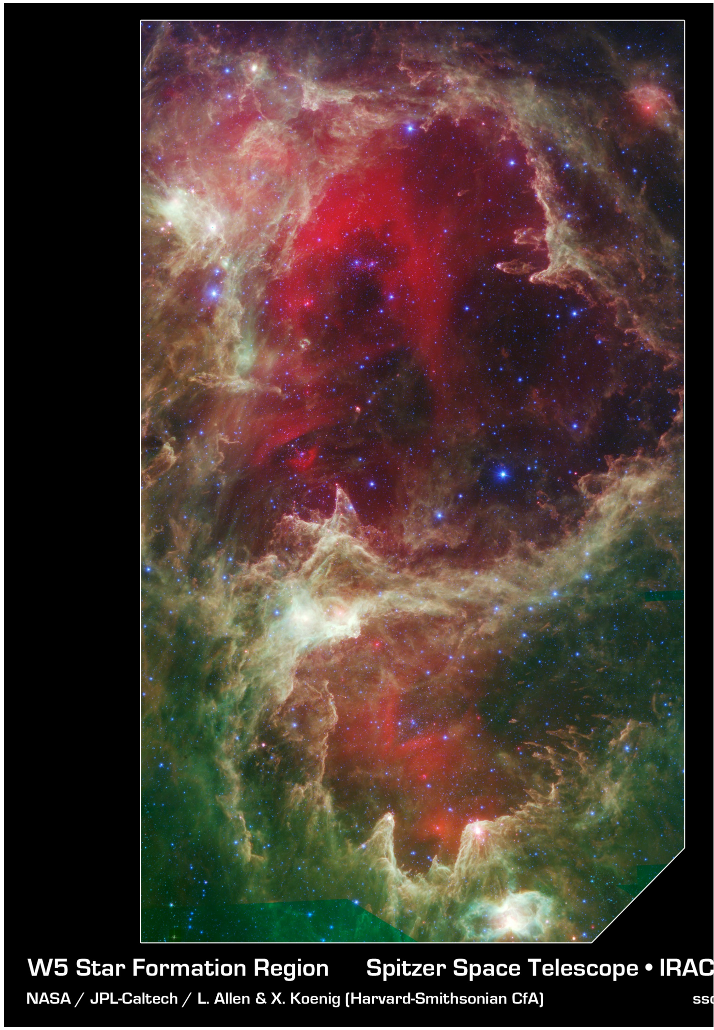
NGC7023 (Lula 2001)

IC443 (Cuillandre & Anselmi 2003)

- molecular clouds can be compressed → triggers further star formation
- molecular clouds can be dispersed → prevents further star formation

WADI science goals

- Impact of star-formation on neighboring molecular clouds
  - dynamic impact from winds and outflows
    - dispersion → prevents SF
    - compression → triggers SF
  - UV radiation heats the gas
    - temperature increase → prevents SF
  - UV radiation dissociates the gas
    - change of chemical structure
    - remove cooling agents → prevents SF
    - create cooling agents → triggers SF



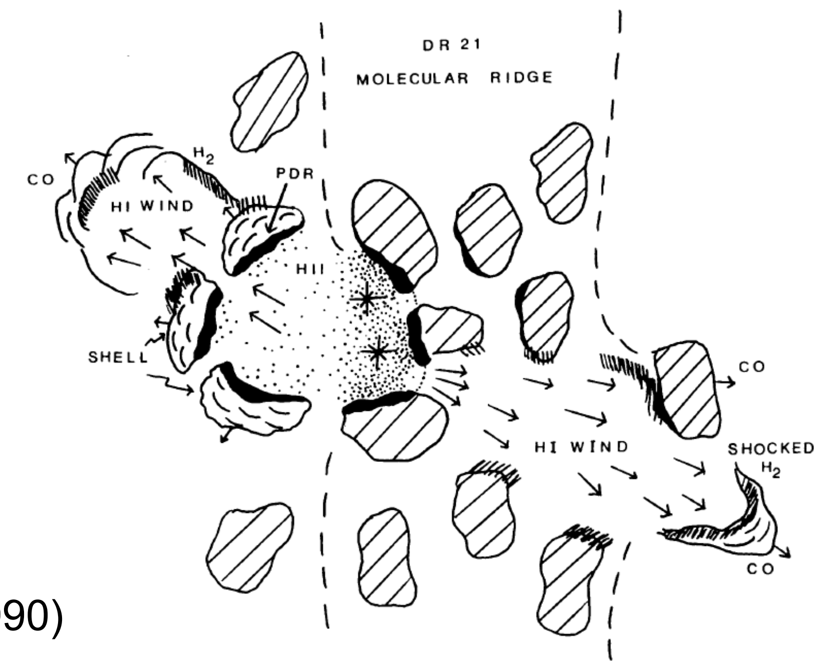
- Understanding energy balance, dynamics, and chemistry of the interaction regions is a pre-requisite to understand clustered star-formation.

Energy balance

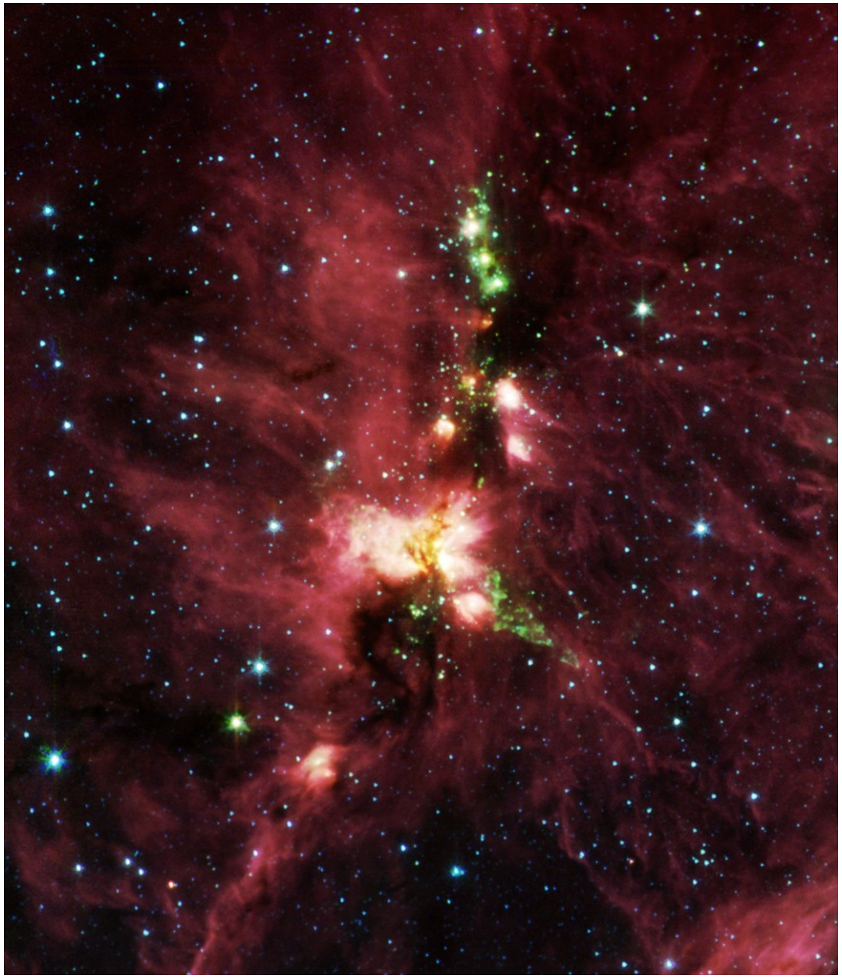
Questions:

- distinguish role of UV radiation from shock heating
- gas heating efficiency
- role of H_2O cooling and dust heating and cooling

Example:
DR21

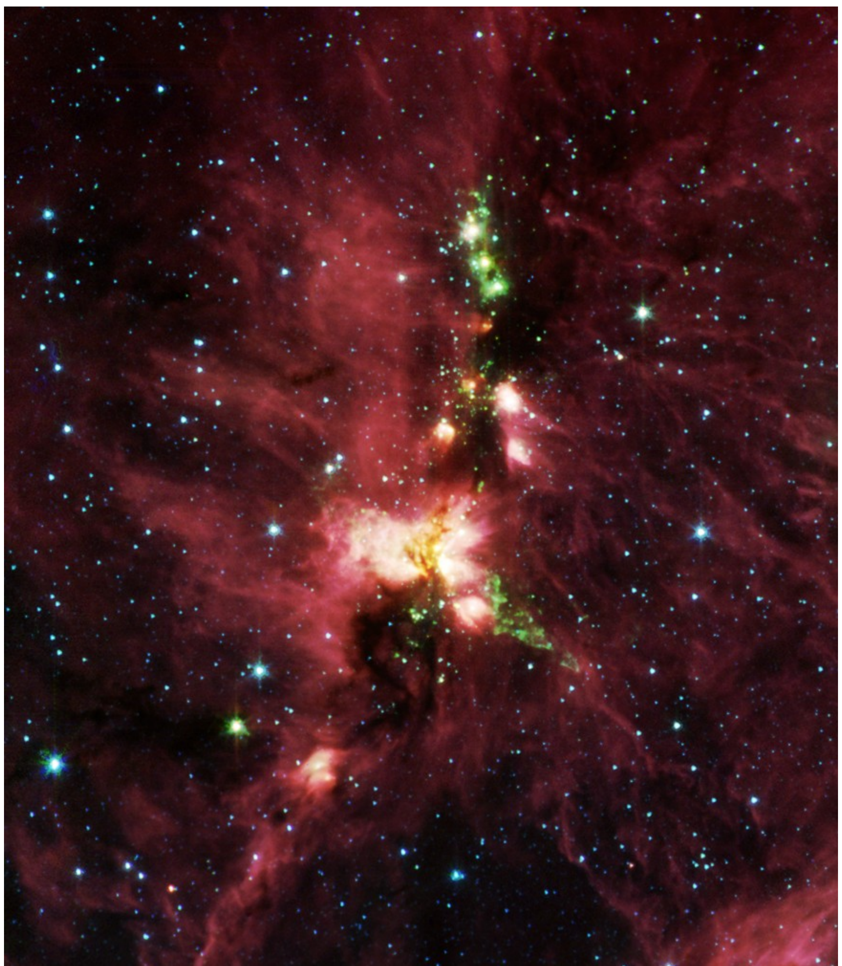


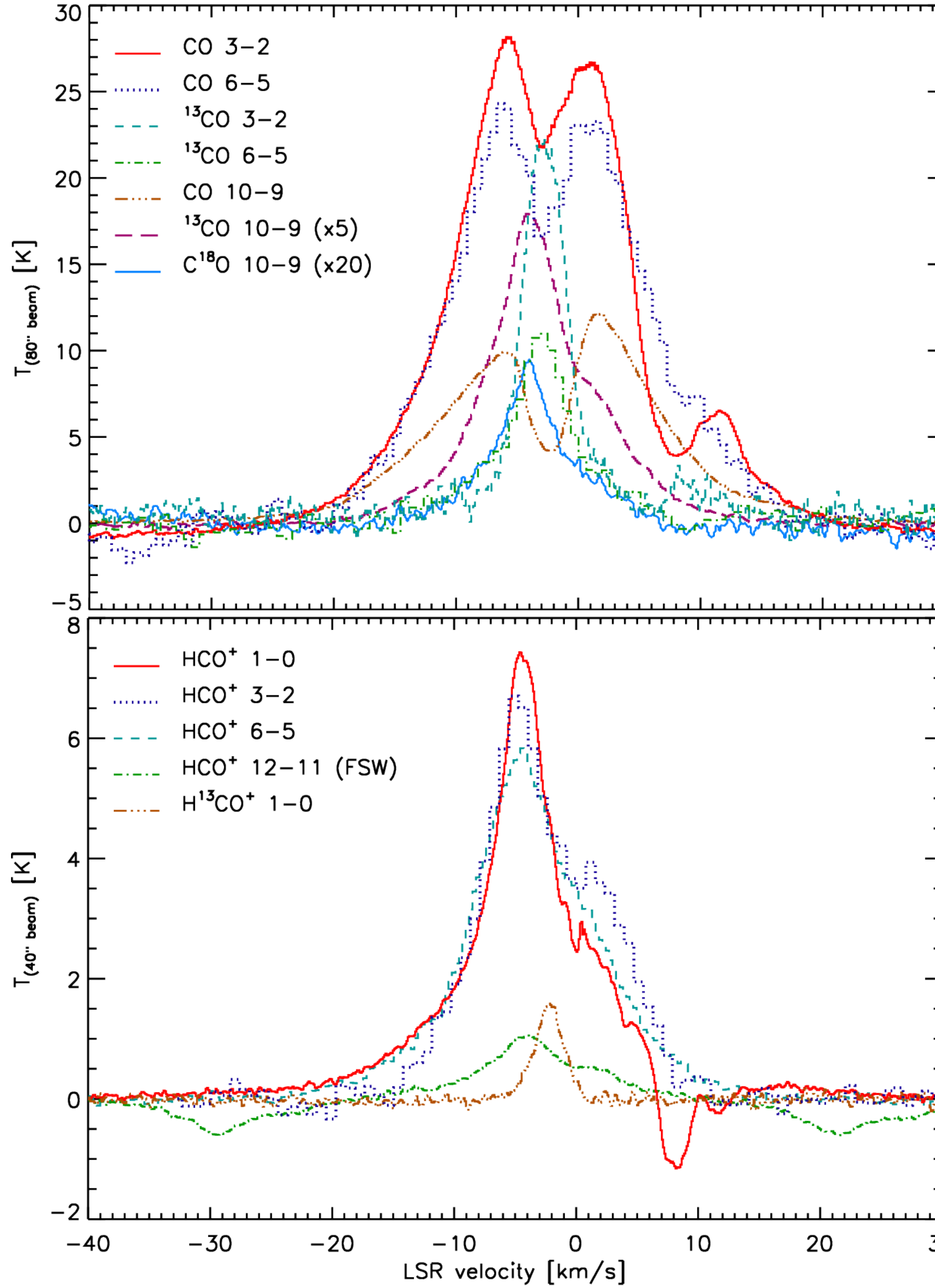
Lane et al. (1990)



DR21

- Line shape comparison with ground based lines





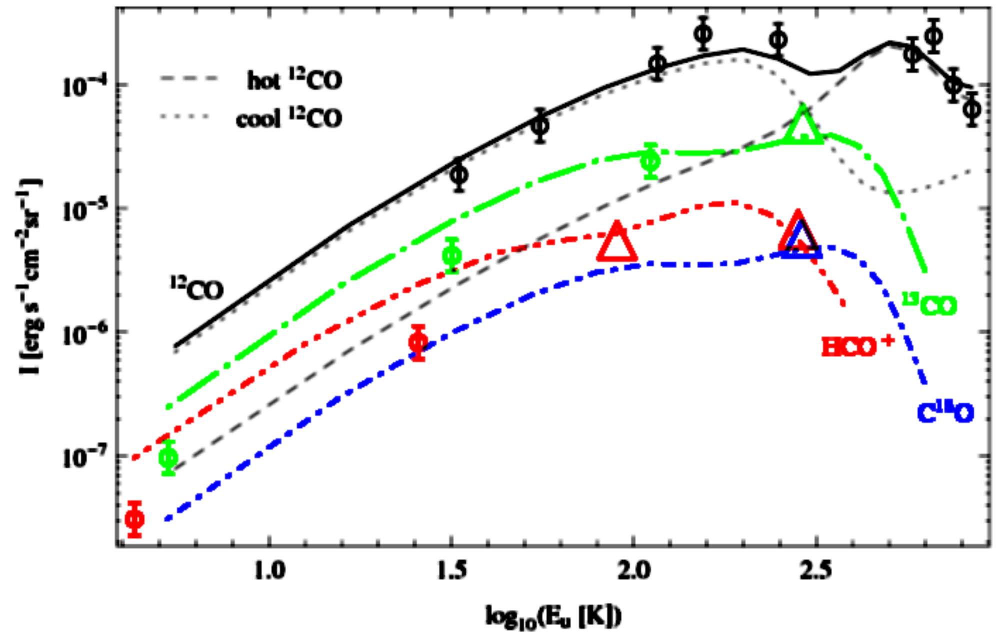
DR21

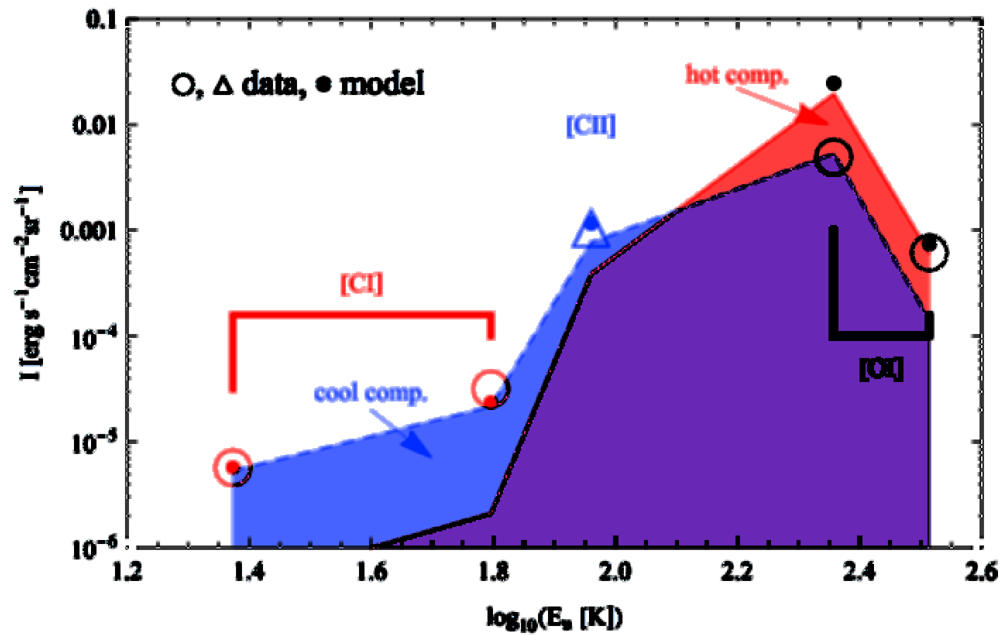
Line profiles allow to:

- Distinguish line intensities from different velocity components
- Optical depth correction of line intensities

Model fit:

- Two-component PDR model fit all lines
- New HIFI data show two distinct UV fields: $10^5\ \chi_D$ and $300\ \chi_D$
- Dense clumps facing the blister outflow + clumpy large scale distribution



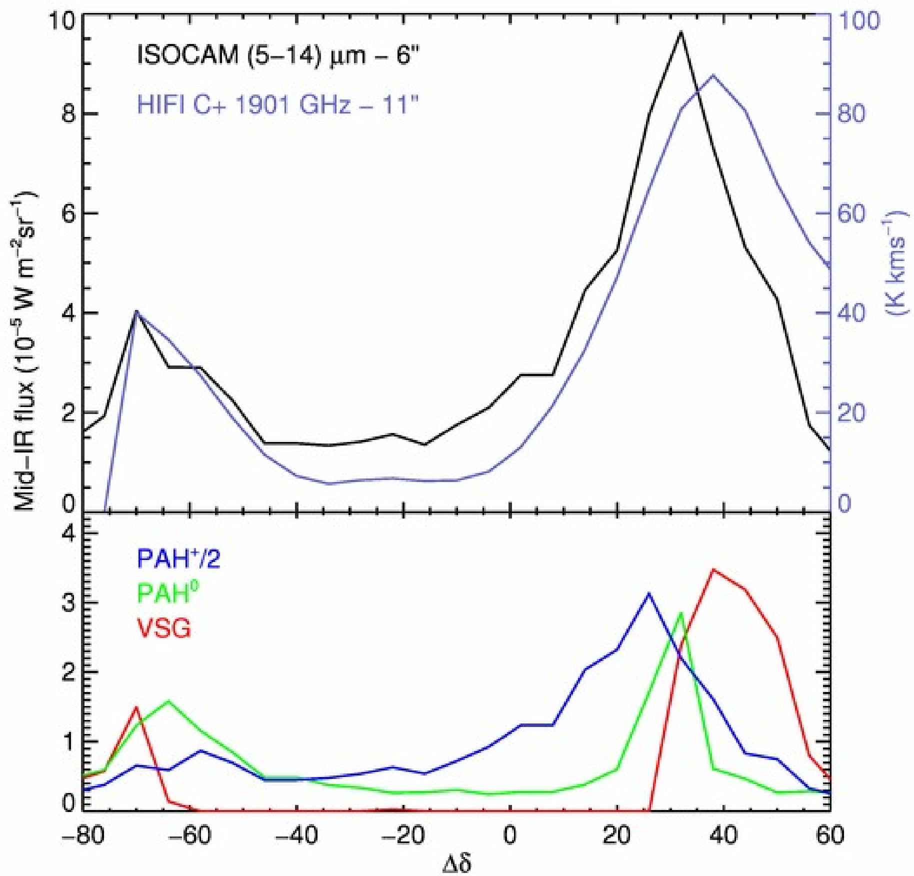


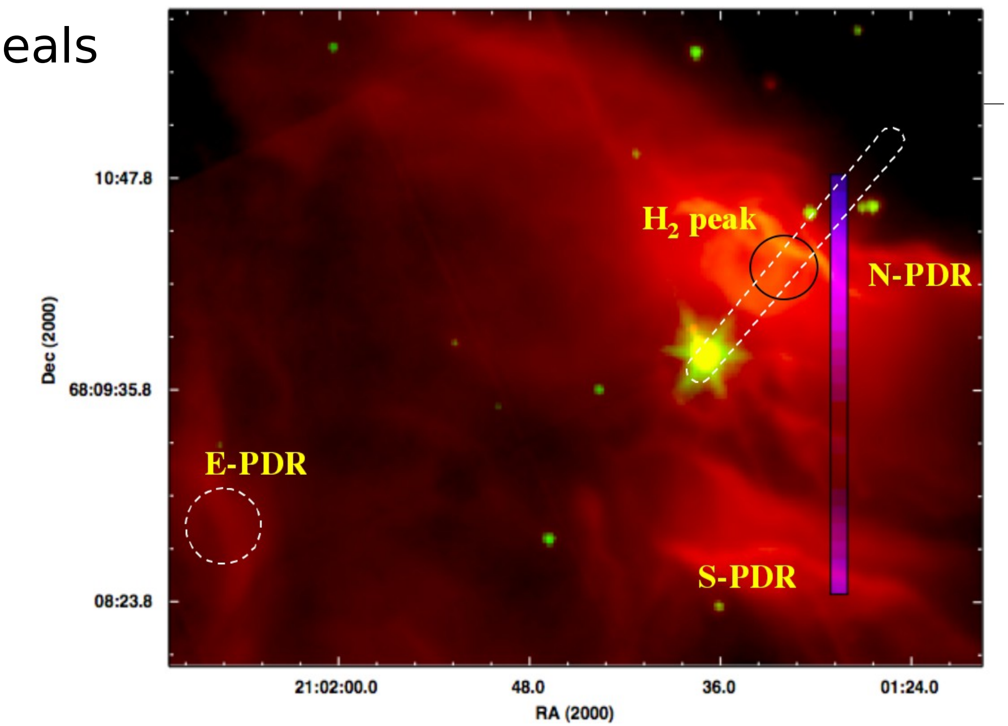
→ See P2.14 by M. Röllig

Photoelectric heating in NGC7023

[CII] traces PDR gas temperature

- Correlation with PAH distribution reveals their contribution for the PE heating





PAH^{+}s contribute much less photoelectic heating than very small dust grains

→ See P1.16 by P. Pilleri

Chemical structure

Molecule formation and dissociation

- Photo-induced chemistry
  - abundance profiles of light hydrides
  - H_3O^+ as central node in the chemical network
  - the influence of X-rays
  - sources of endothermic hydride formation
  - the role of surface-reactions and time-dependent chemistry
- Shock chemistry
  - Change of abundances of main coolants by the passage of shocks
  - the OH-water puzzle in shocked gas

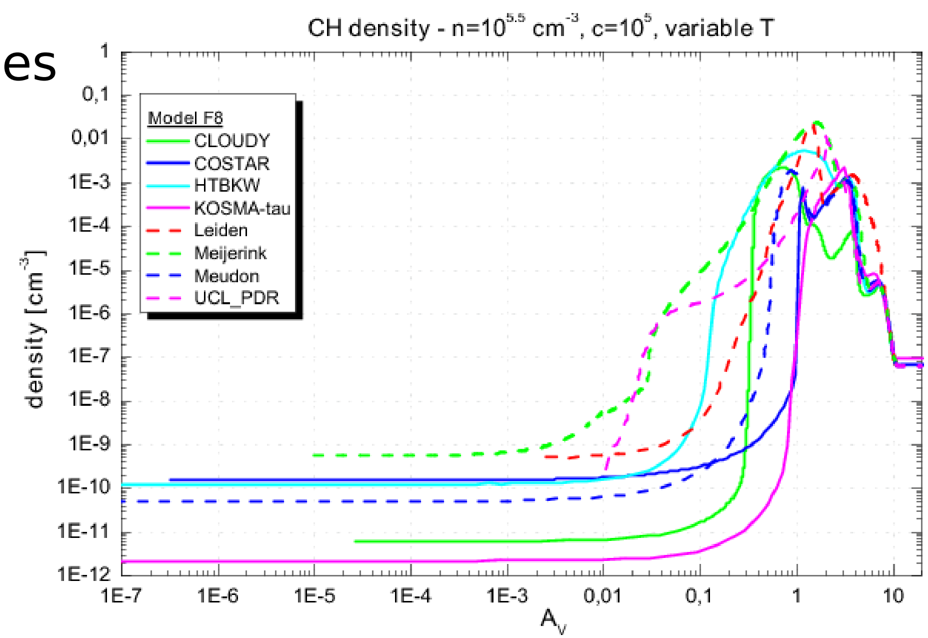
Chemical structure

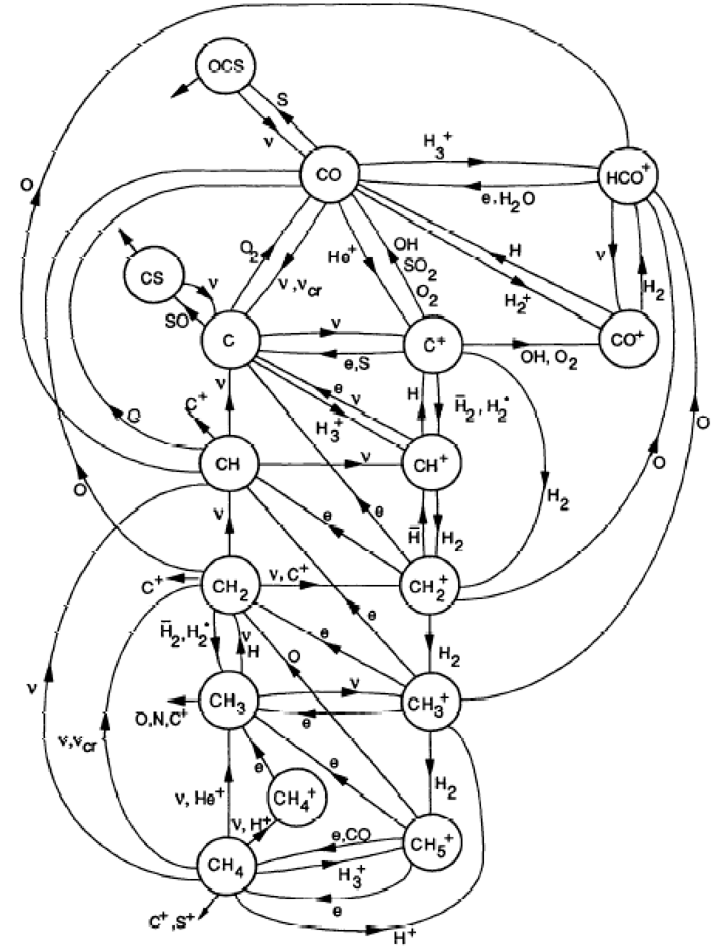
Observations

- Inventory the chemical network as function of UV intensity and shock velocity
- Simple hydrides as key nodes: CH, NH, H_2O, OH, CH^+, NH^+, OH^+, H_3O^+

"Calibration" of models:

Uncertainties in current models:

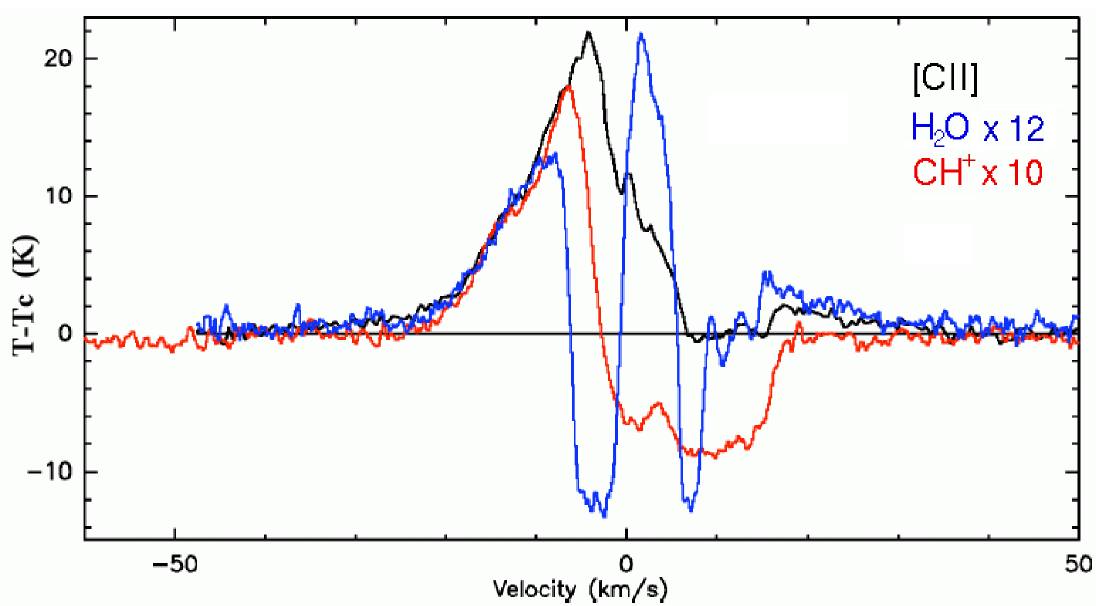


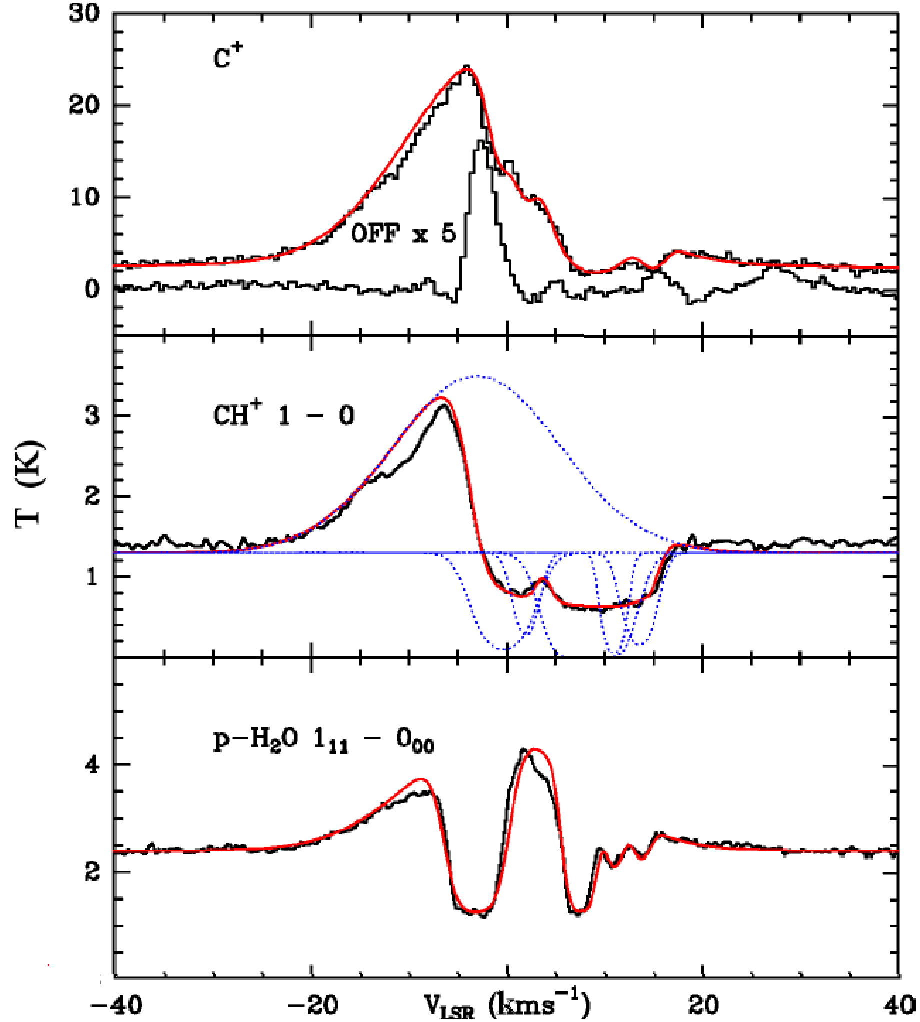


Röllig et al. (2007): CH distribution for a high-density, high-radiation-field PDR

CH^+ in DR21

- First frequency resolved CH^+ line
- Detailed modelling of absorption and emission profile:
    - 2.5 10^{14} cm^{-2}

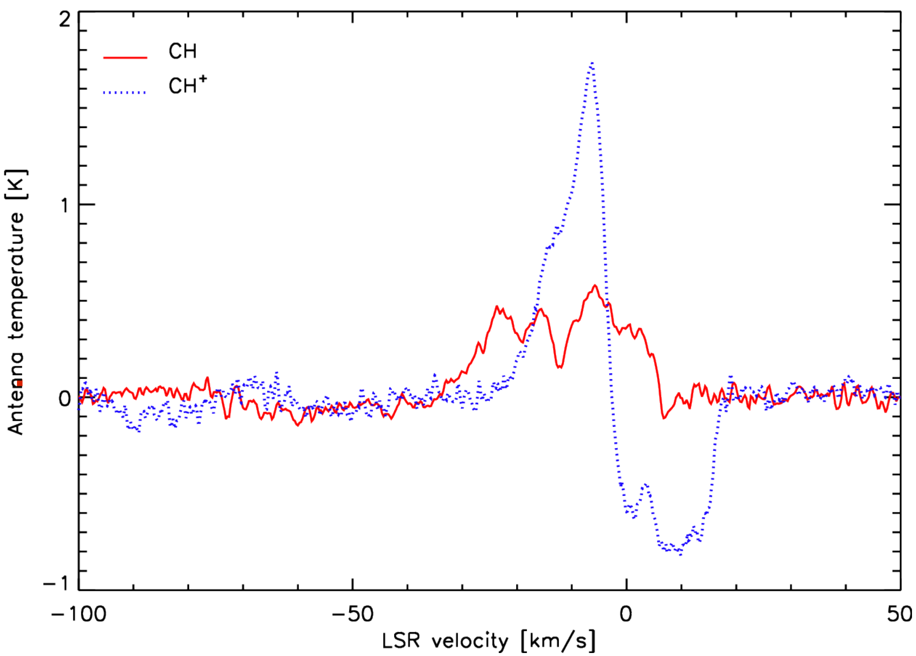




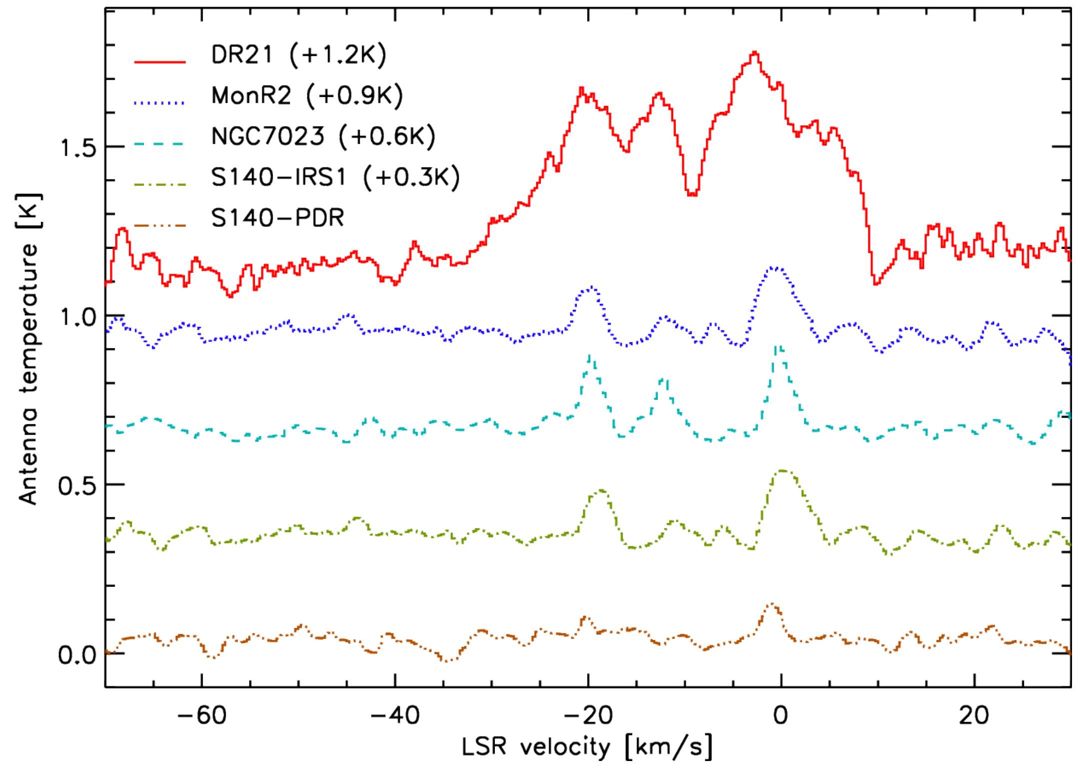
→ A&A paper by E. Falgarone

CH chemistry

- Combined emission-absorption profile of CH^+ in DR21
- Pure emission profile in CH



Seems to prefer turbulence driven-chemistry over UV-driven chemistry towards CH^+



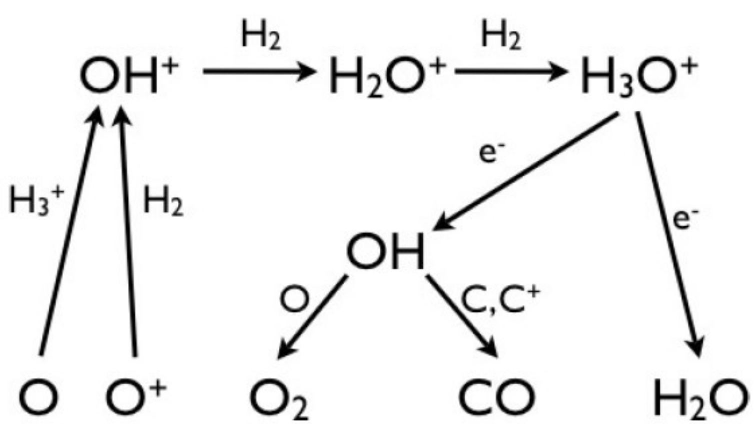
- CH relatively constant across different PDRs
→ Contradiction to PDR models

- CH only/mainly bright towards embedded sources

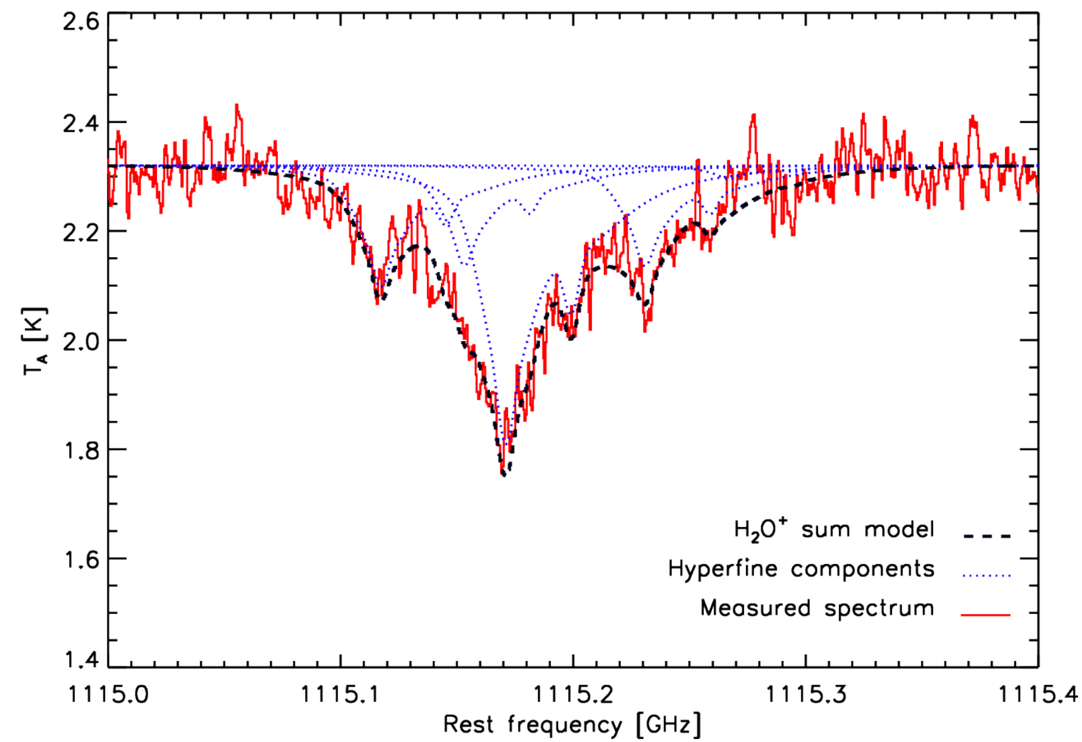
The gas-phase path to H_2O

Goal:

- Measure temperature and abundance of H_2O^+, H_3O^+, OH, and H_2O across the interfaces



Hollenbach et al. (2009)

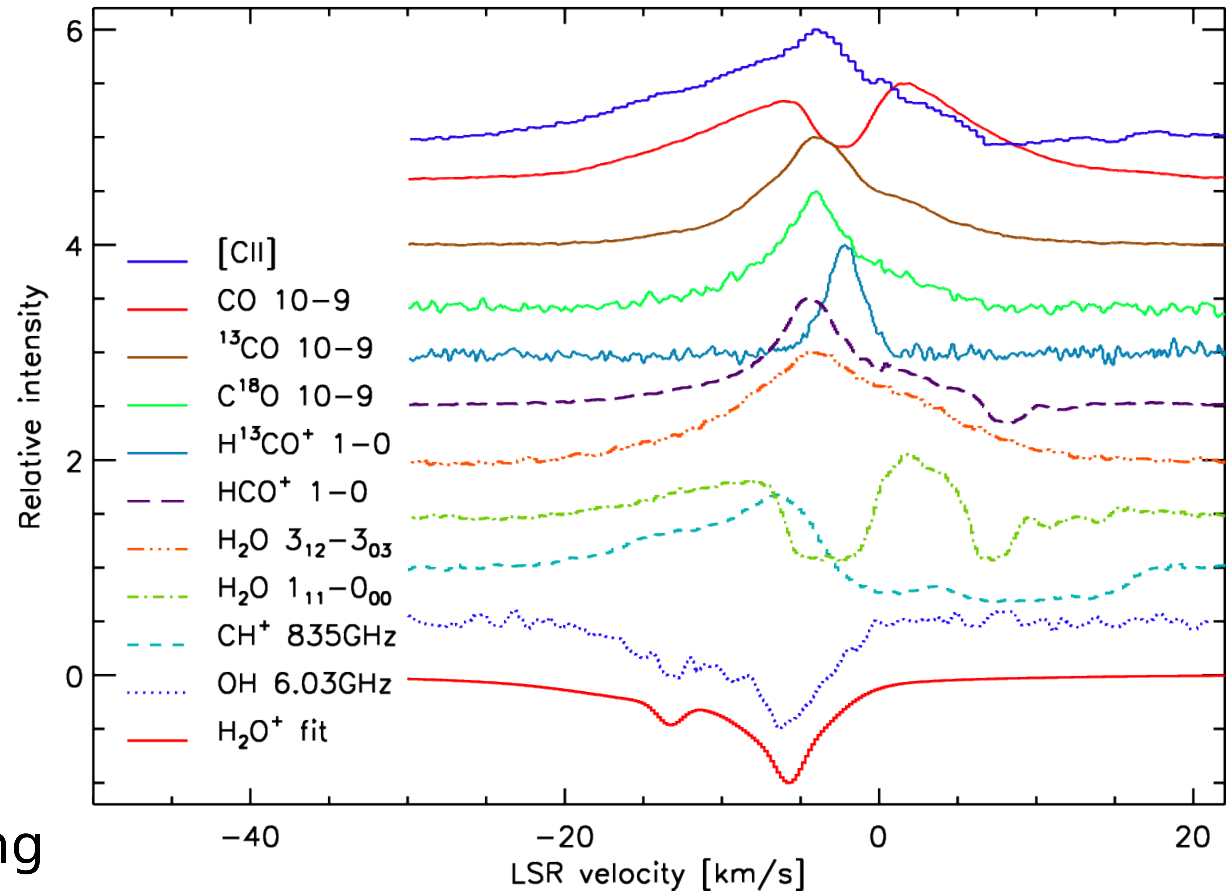


First detection of interstellar H_2O^+ in DR21

- Exact frequency determination
- Column density: > 2.3 10^{13} cm^{-2}

Chemistry from line shapes

Line shape comparison between HIFI lines and ground based lines

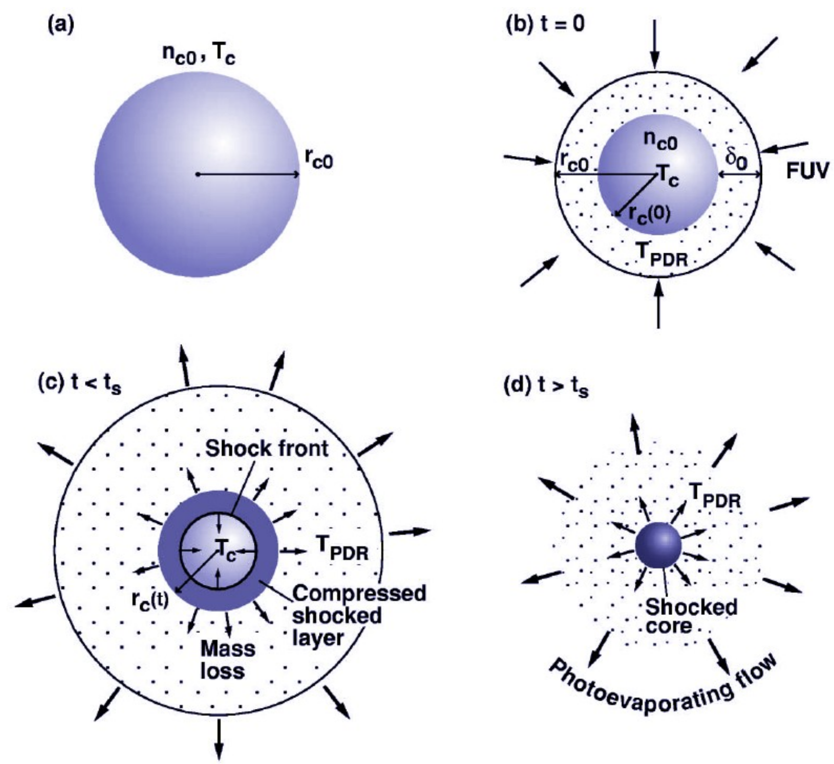


- H_2O^+ absorption matches
  - OH absorption
  - [CII] emission
  - CH^+ emission wing
  - H_2O 1_{11}-0_{00} emission wing
  - Nothing else!

→ Assignment of H_2O^+ to hot irradiated clumps traced by OH and [CII] and affected by the blister outflow

Dynamics and kinematics

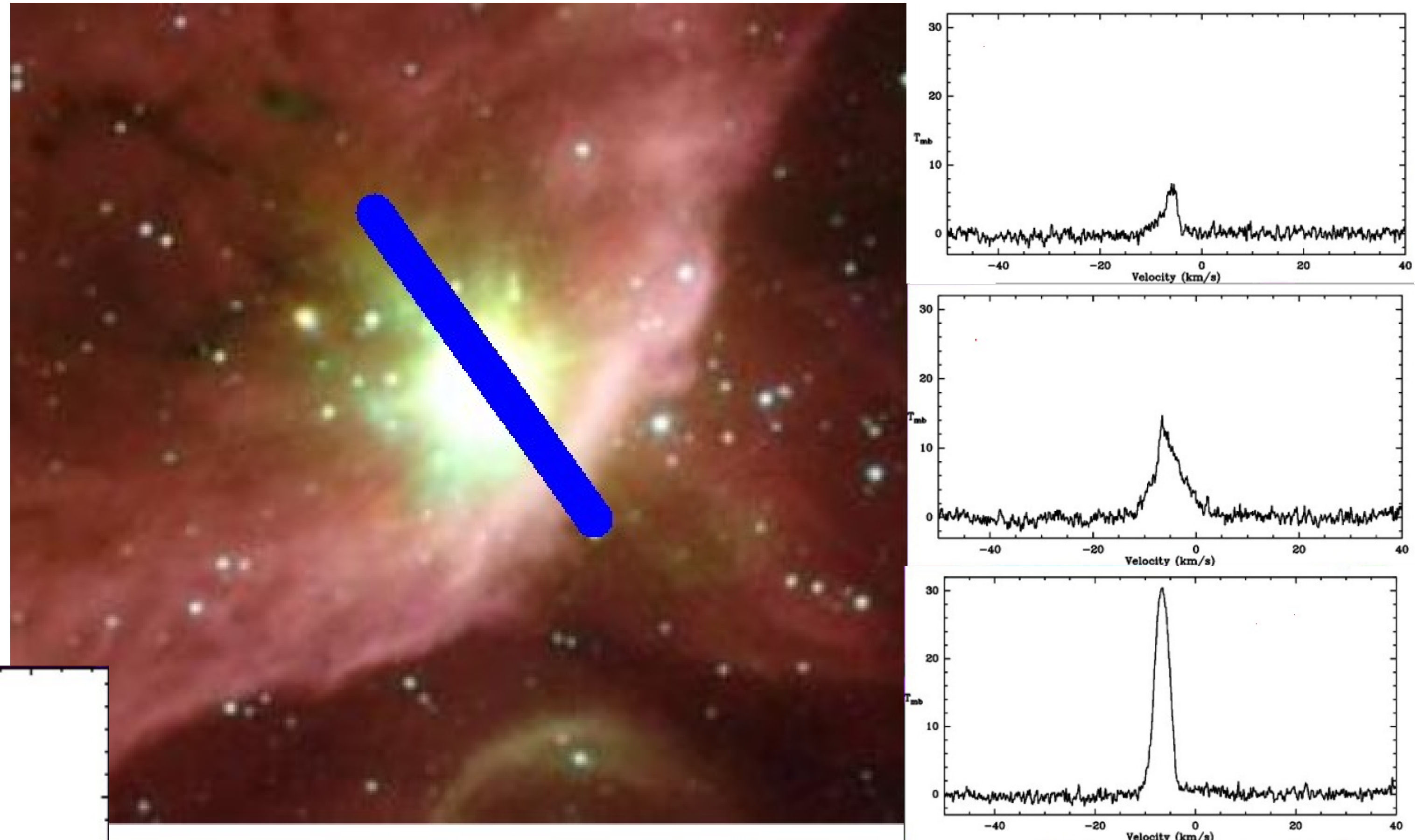
- PDR dynamics
  - turbulent pressure distribution from HII regions to molecular clouds
  - impact of advection and turbulence
  - photo-evaporation of PDRs

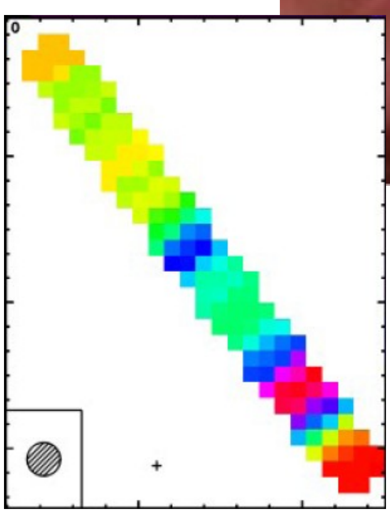


Gorti & Hollenbach (2002)

- Shock structures
  - temperature and density structure in the post-shock gas
  - actual distinction between J(ump) and C(ontinuous) shocks

[CII] mapping - S140





- [CII] strongest from the PDR
  - quiescent-gas line profile
- Broad (wind?) contribution from ionized gas at IRS1

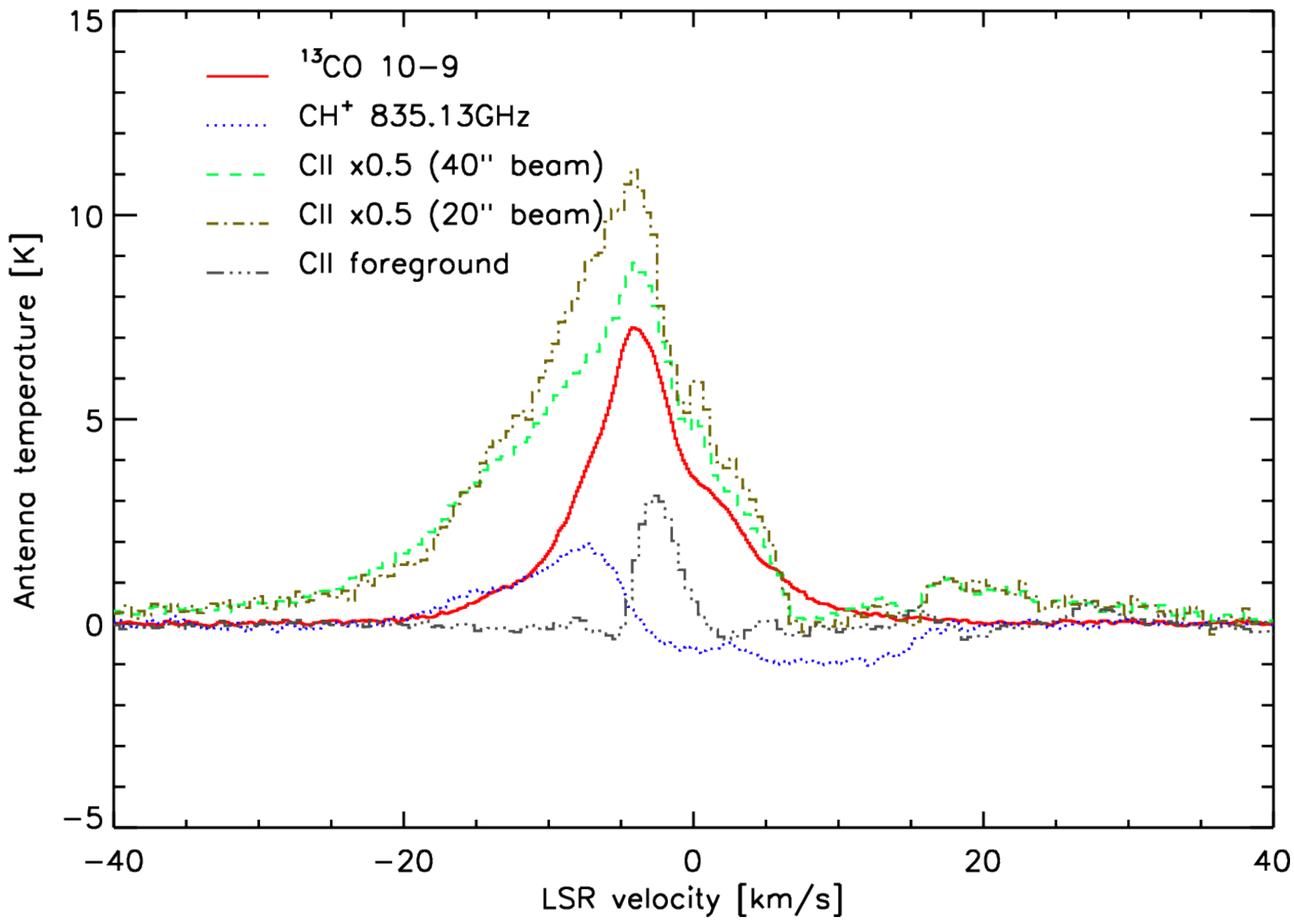
→ See P1.17 by C. Dedes

[CII] mapping - DR21

- Line shape distinguishes contributions from PDR and ionized outflow

- Extended fore-ground emission with velocity of the ridge

- Blue wing traces blister outflow



- Clump surfaces rather blown away than evaporating

Outlook

- Only 4.5% of the AORs (observing time) executed

  (another 936s in schedule for next week)

- No supernova remnant observations yet
  - shock chemistry
- No PACS observations yet
  - role [OI] cooling
  - high-J rotational lines from hot gas
- Majority of the target lines not covered yet
  - Most of the chemical analysis still to come
  - Science from the few observations already very promising

People and institutes instrument development/ICC

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