

Understanding Chemical Complexity in Protostellar Outflows

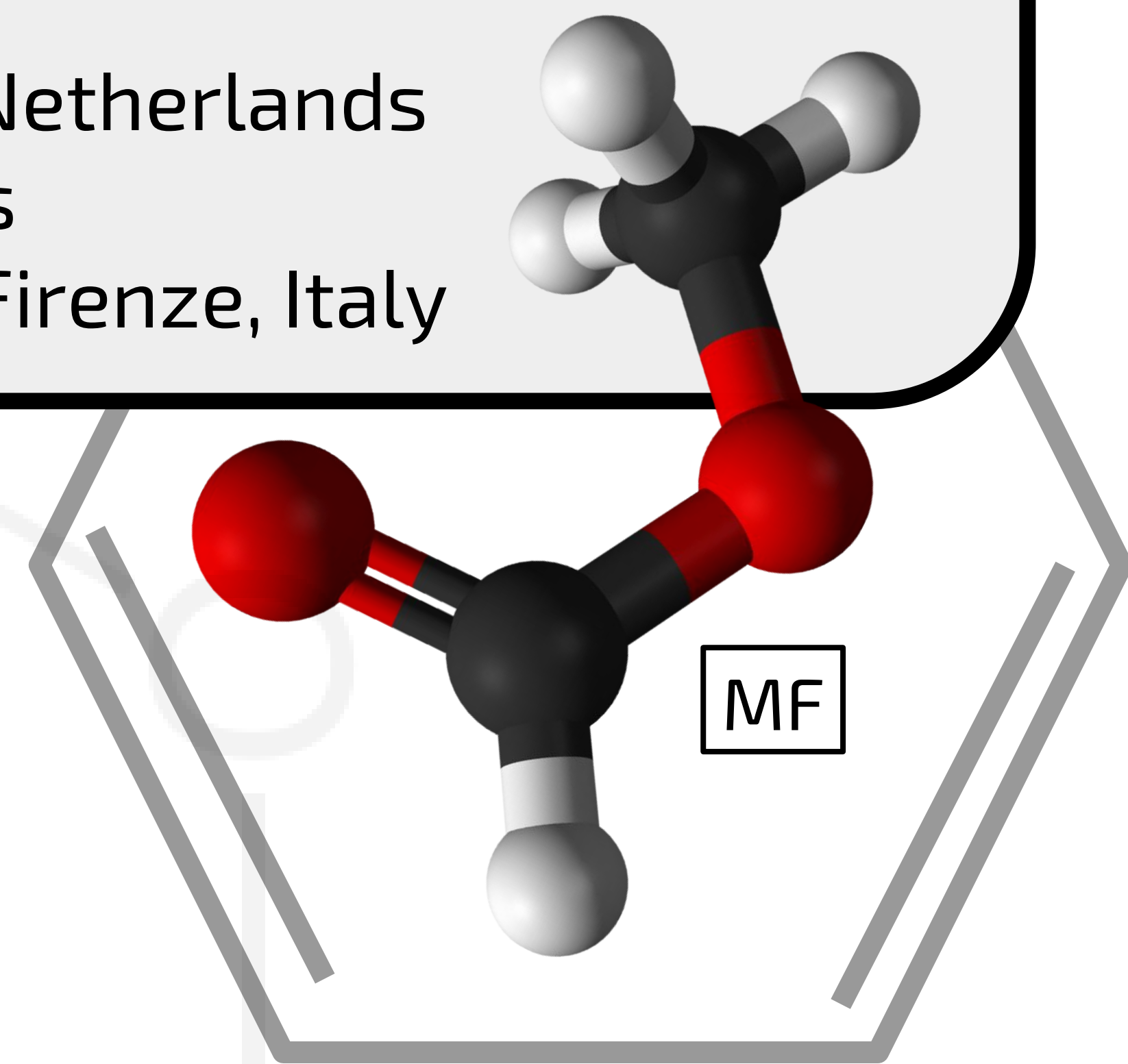
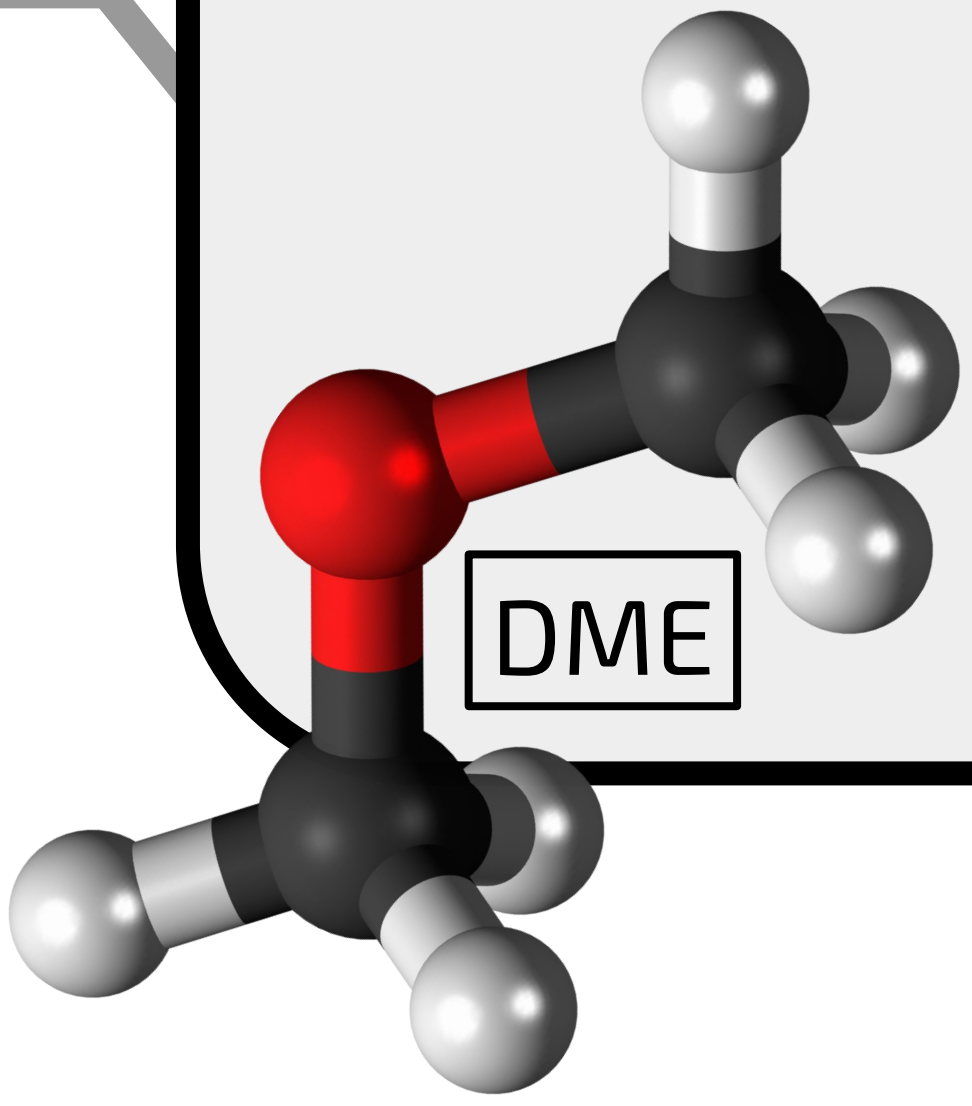
L1157-B1 Star Forming Region

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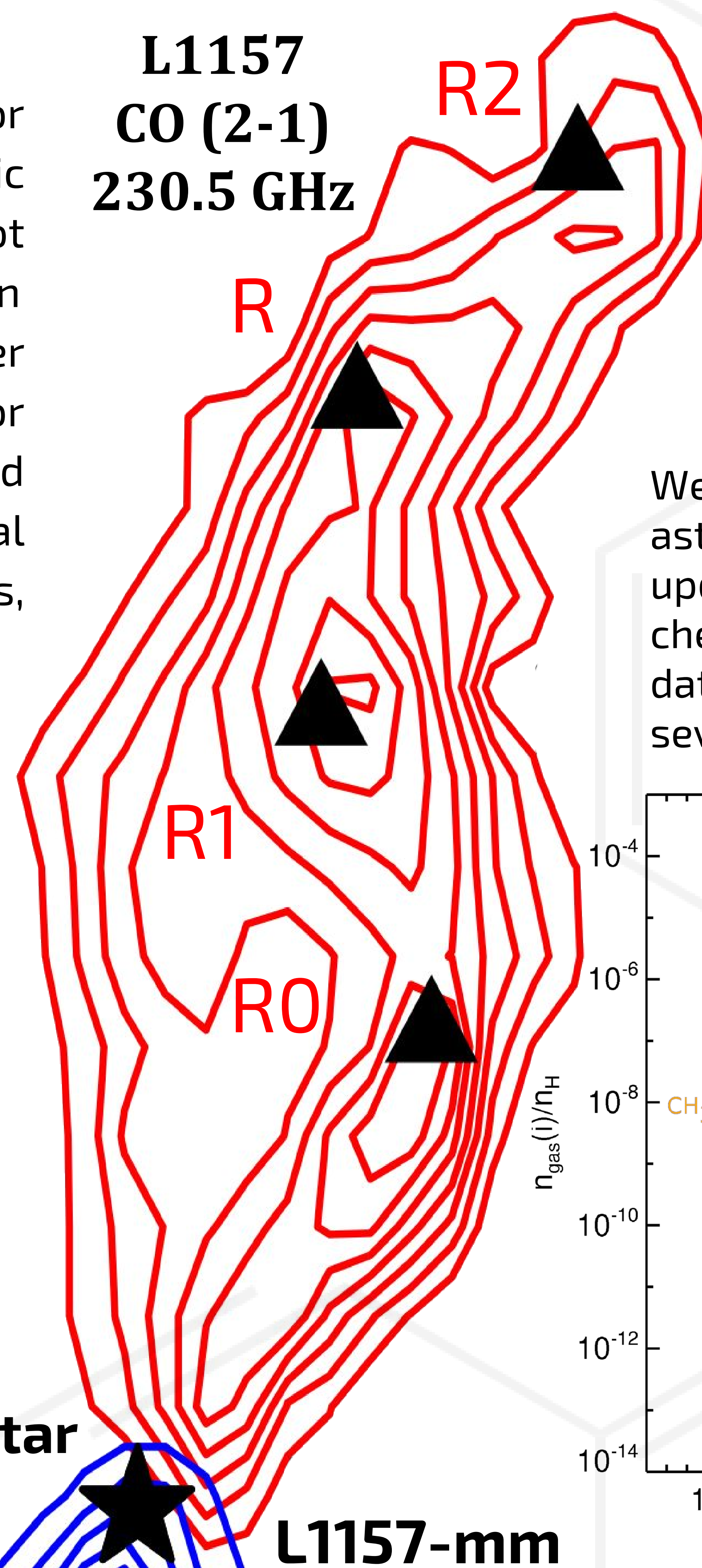
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Abstract

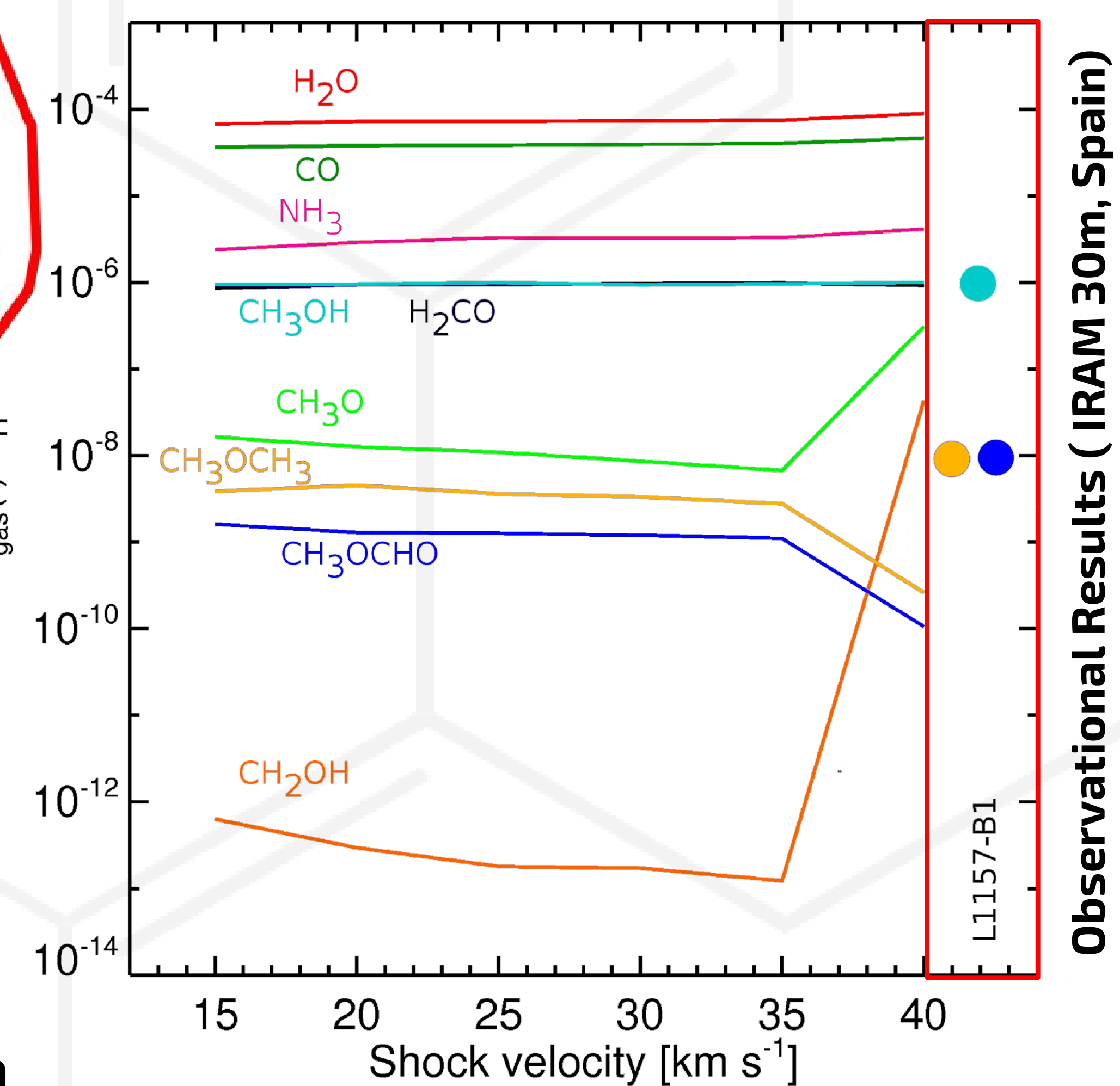
Complex molecules can be one of ideal tools for astrochemical studies. So far, complex organic molecules (COMs) have been detected only in hot core of star forming regions^{1,2}, e.g. black star in the centered figure. We have focused to whether COMs can be produced in molecular outflows or not. The main question is how are they formed through gas phase chemistry via neutral-neutral or ion-neutral reactions in protostellar outflows, e.g. black circle in the centered figure.

L1157
CO (2-1)
230.5 GHz

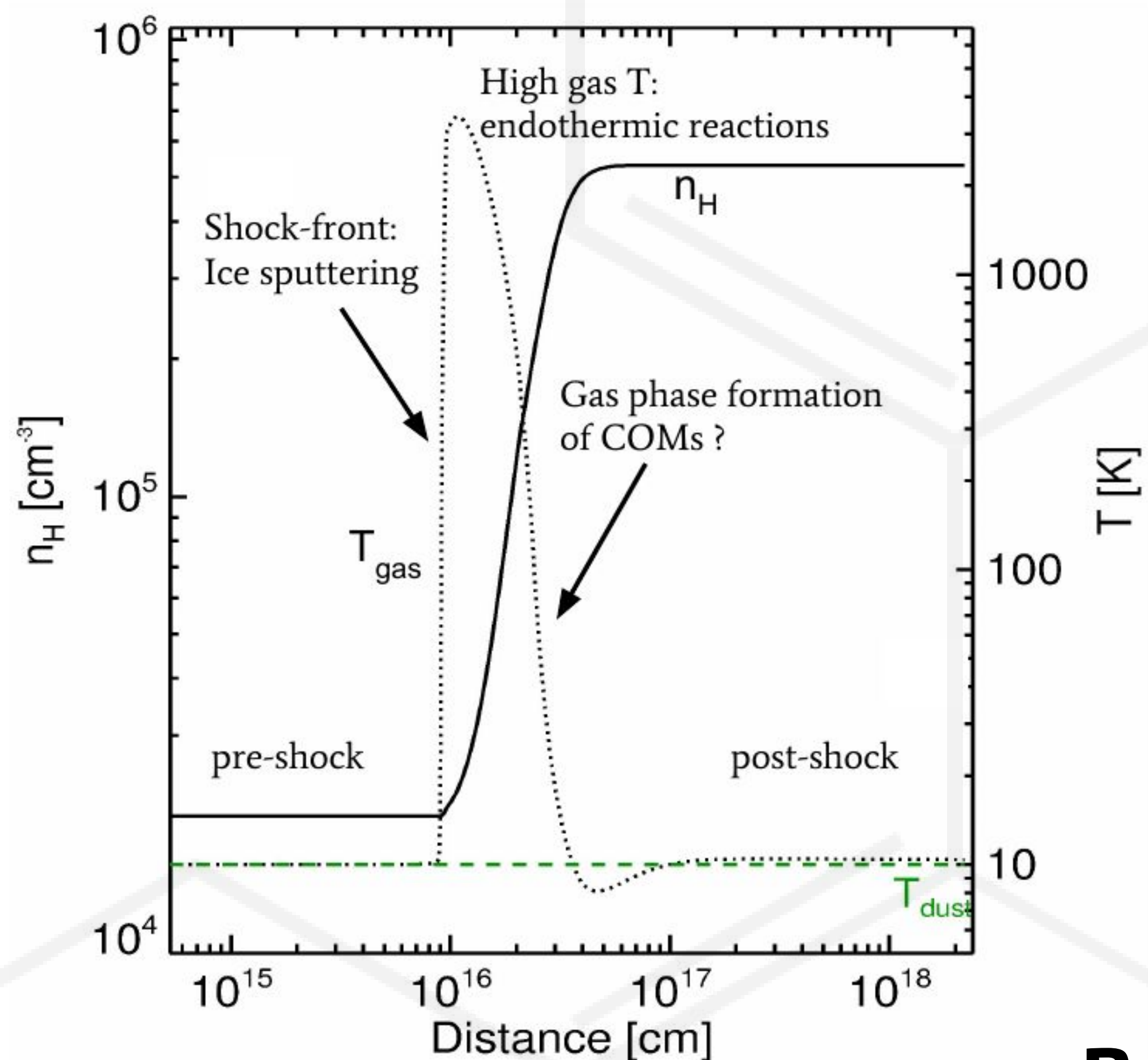


Model and Method

We use the GRAINOBLE gas-grain astrochemical model^{4,5} by using updated version of the hot core chemical network and KIDA database by updating the rate of several key reactions.



Shocks in Space

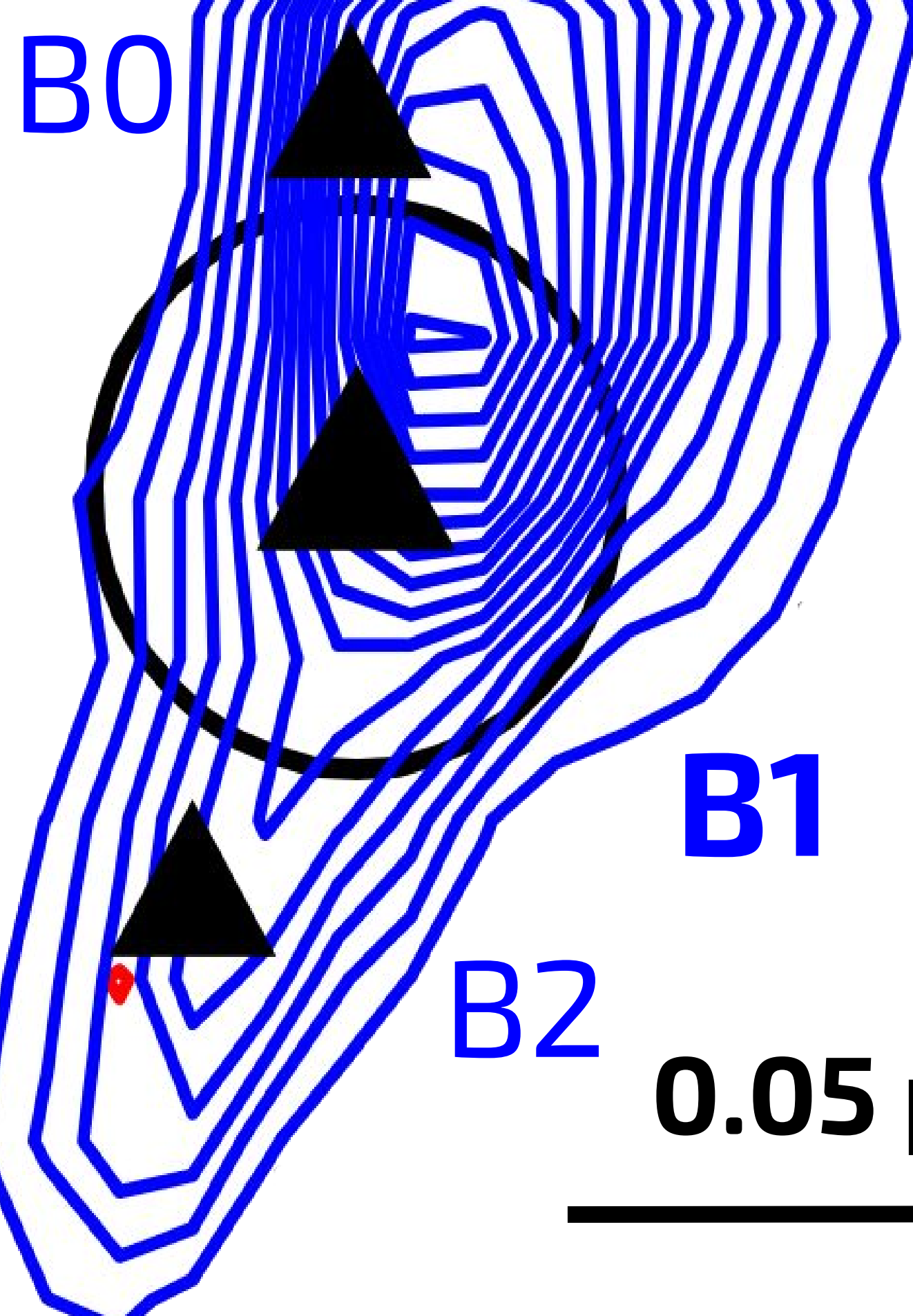
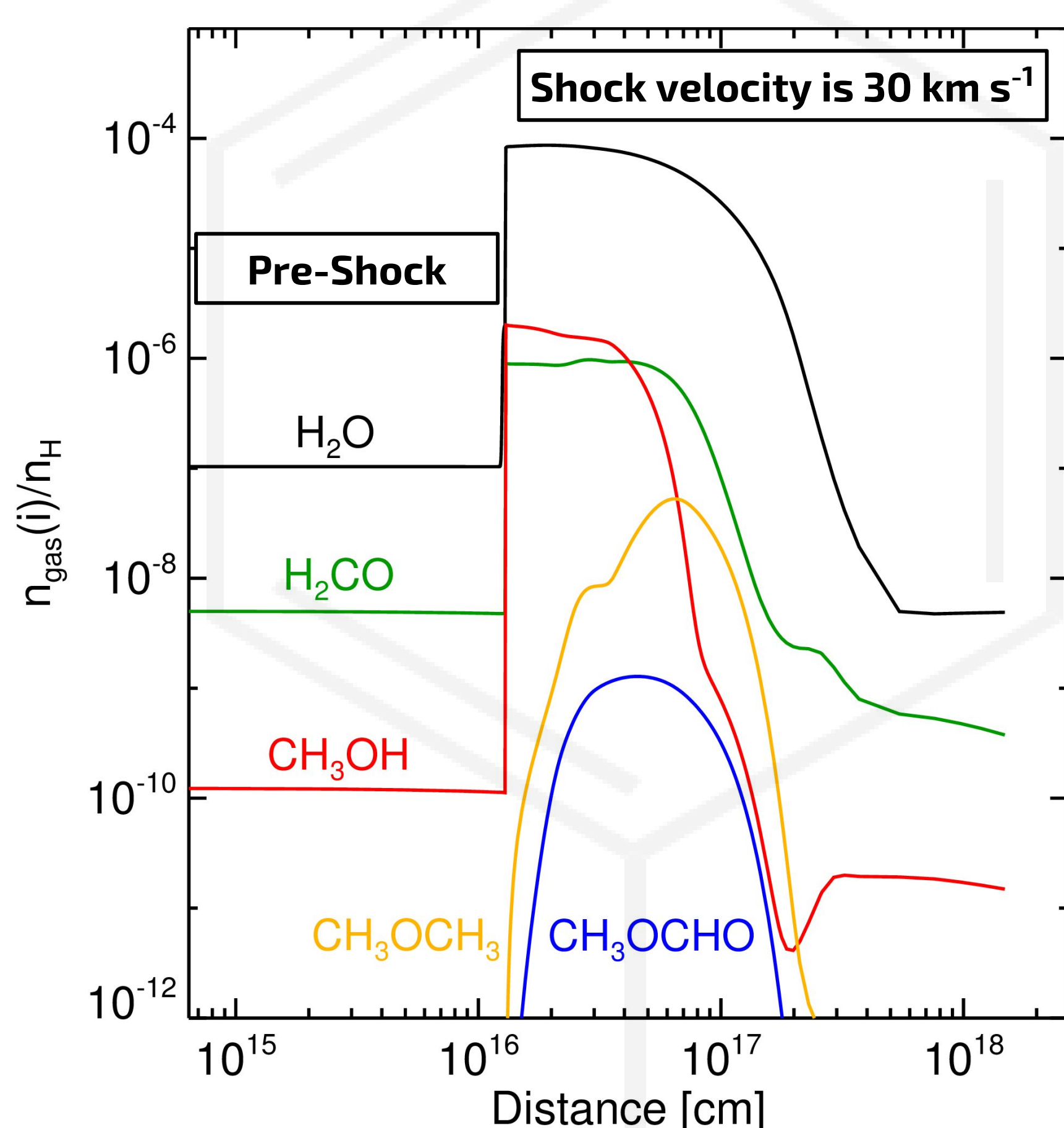


Dimethyl Ether (DME)

Questions?

- How are COMs formed in protostellar outflows in star forming regions?
- Can results of models explain observation of L1157-B1³? (see centered Figure)

Astrochemistry



Methyl Formate (MF)

Our Findings

- DME and MF, two most abundant COMs in star forming region, are formed at significant quantities in shock regions via neutral-neutral reaction in gas phase rather than ion-neutral reactions.
- The shock velocity does not impact the abundances of DME and MF between 15-35 km s⁻¹ of velocity.
- The abundances of DME, MF, and methanol are almost compatible with observations.

Interstellar Medium
COMs in outflows!
GRAINOBLE Code
DME & MF

REFERENCES

- Codella et al (2009), A&A, Volume 507, Issue 2, p. L25-L28.
- Codella et al. (2015), MNRAS: Letters, Volume 436, Issue 1, p.179-190.
- Lefloch et al (2017), MNRAS: Letters, Volume 469, Issue 1, pp. L73-L77.
- Flower D. R and Pineau des Forets, G. (2015), A&A, Volume 578, id. A63, 16 pp.
- Taquet et al. (2012), A&A, Volume 538, id. A42, 19 pp.

