Molecular complexity in interstellar ices

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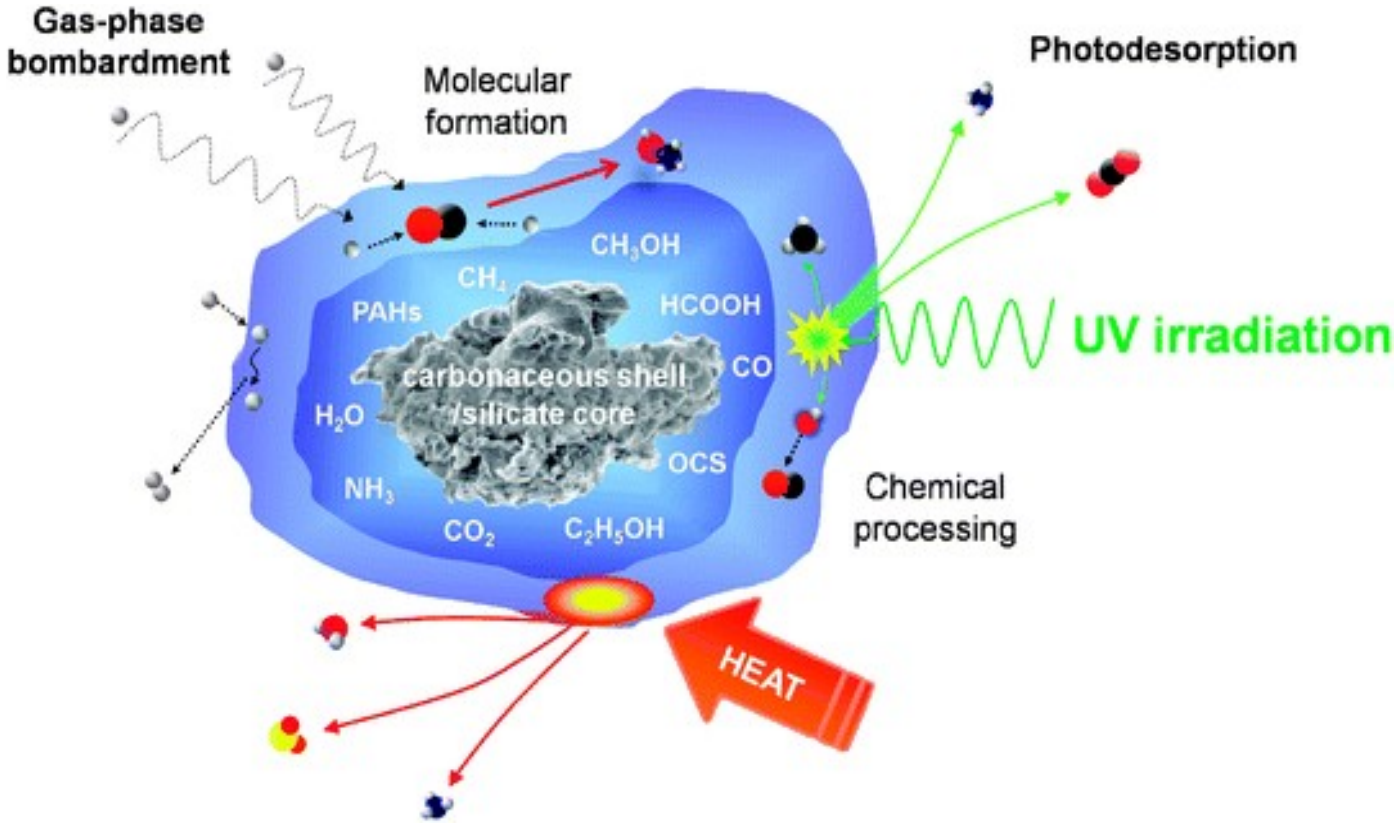
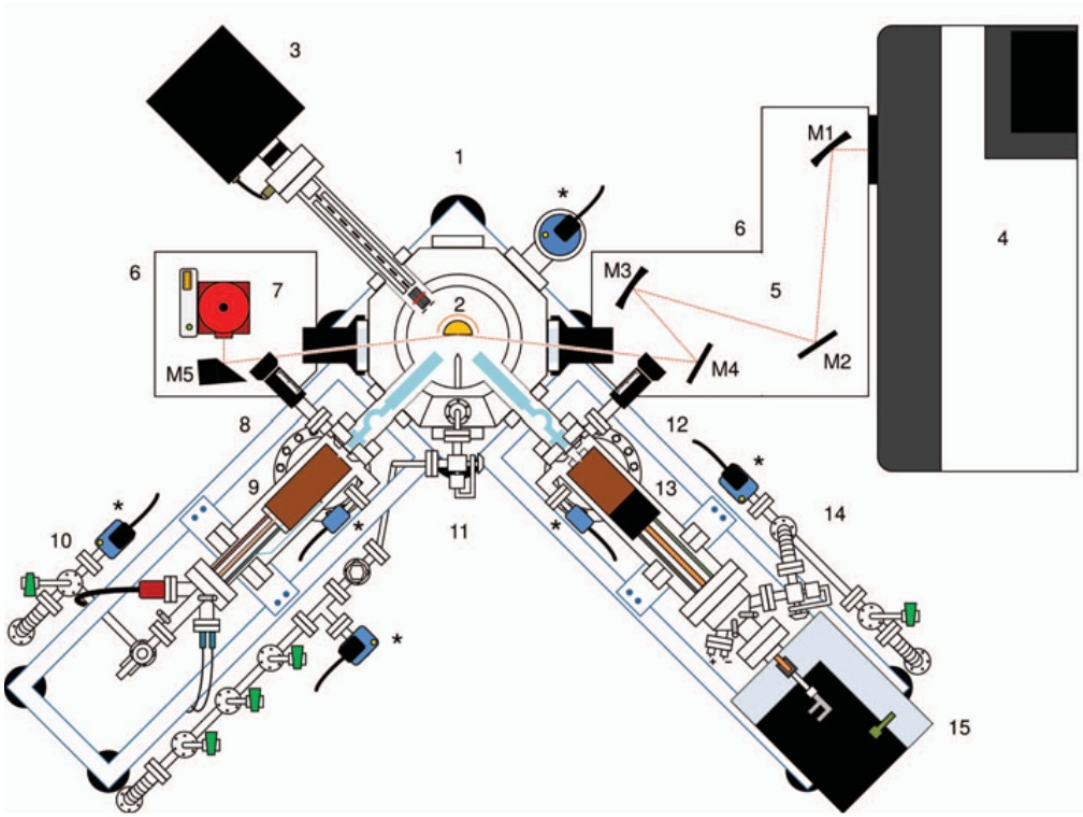
November 28th, 2018
DAN-II meeting at Leiden

Chemistry in the ice mantle



Burke & Brown 2010

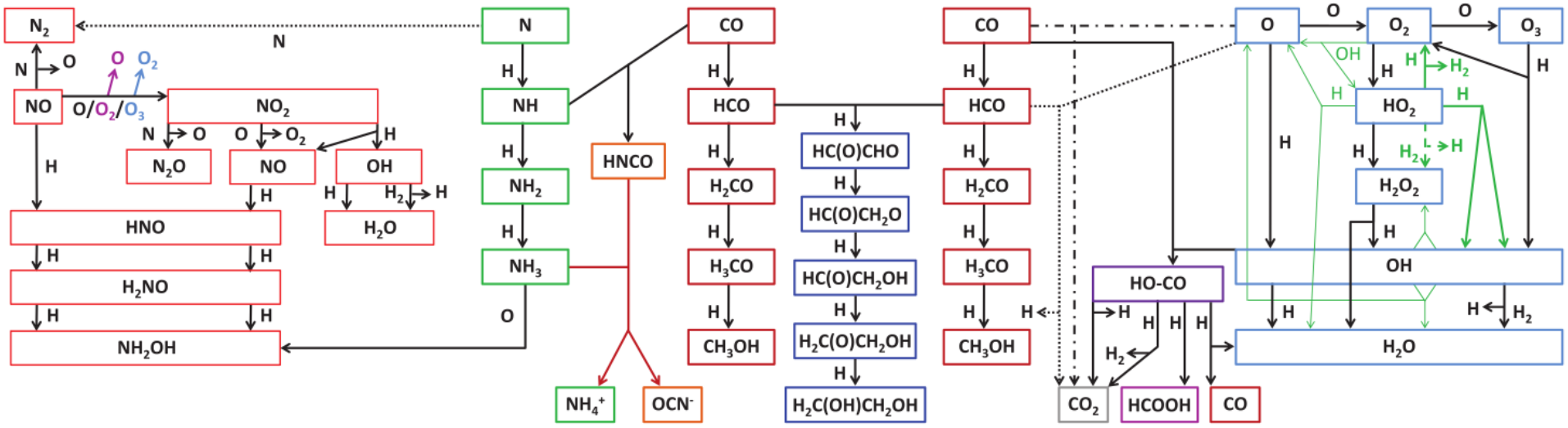
The SURFRESIDE^2 apparatus



SURFRESIDE^2

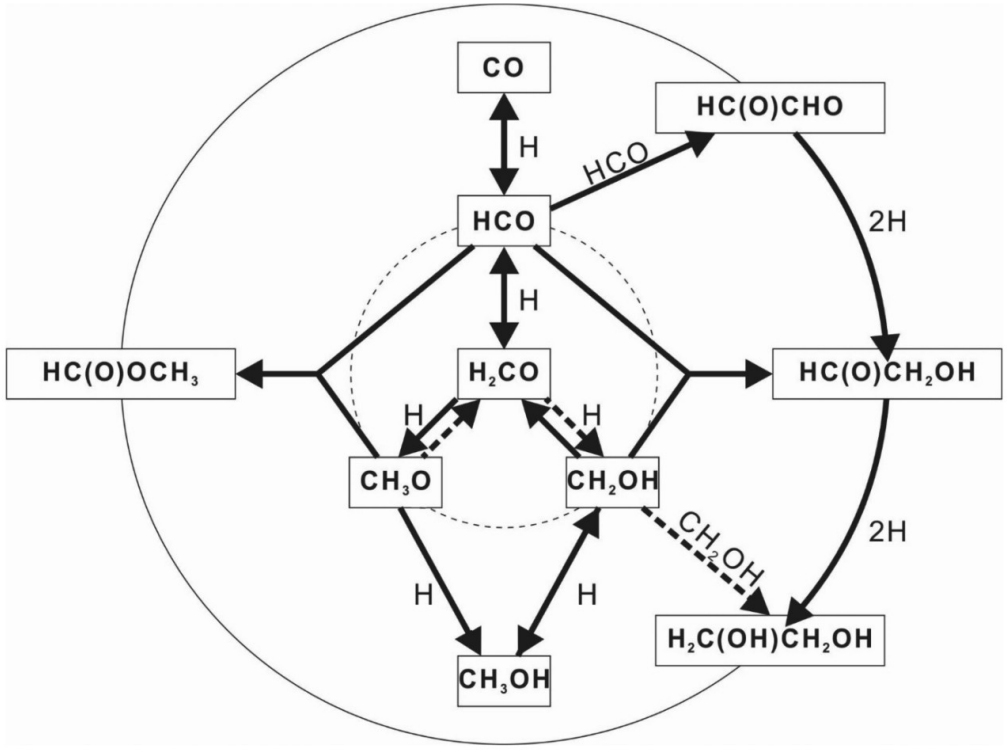
1 - MAIN CHAMBER
2 - GOLD SUBSTRATE (12-300 K)
3 - QMS
4 - FTIR SPECTROMETER
5 - FTIR EXTERNAL OPTICS
6 - PURGE BOXES
7 - MCT DETECTOR
8 - ATOM LINE I
9 - HABS
10 - DOSING LINE HABS
11 - DOSING LINE MAIN CHAMBER
12 - ATOM LINE II
13 - MWAS
14 - DOSING LINE MWAS
15 - MICROWAVE CAVITY
* - UHV GAUGES

Grain surface chemistry

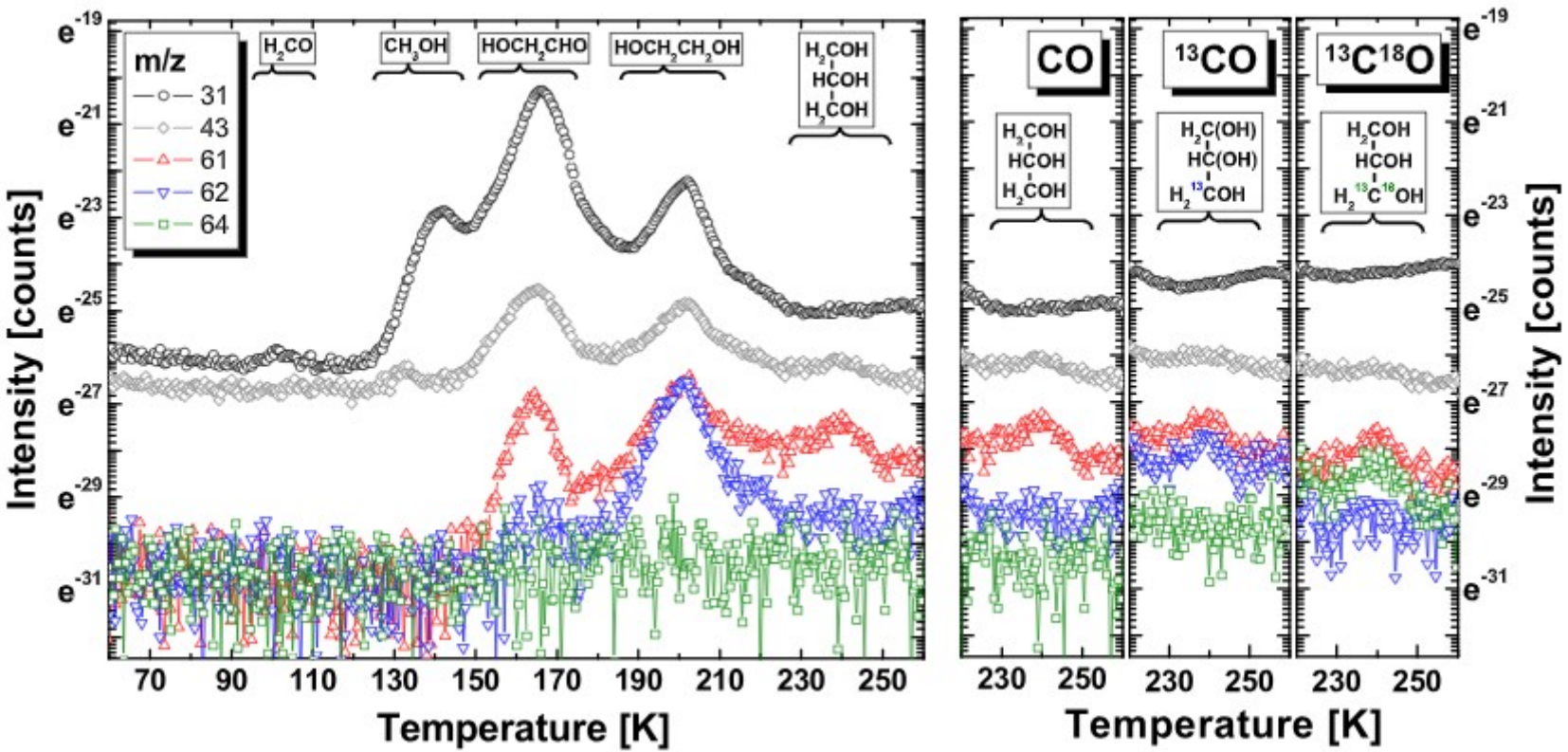


H. Linnartz+ (2015), International Reviews in Physical Chemistry, 34:2, 205-237

Chemistry in the CO-rich layer

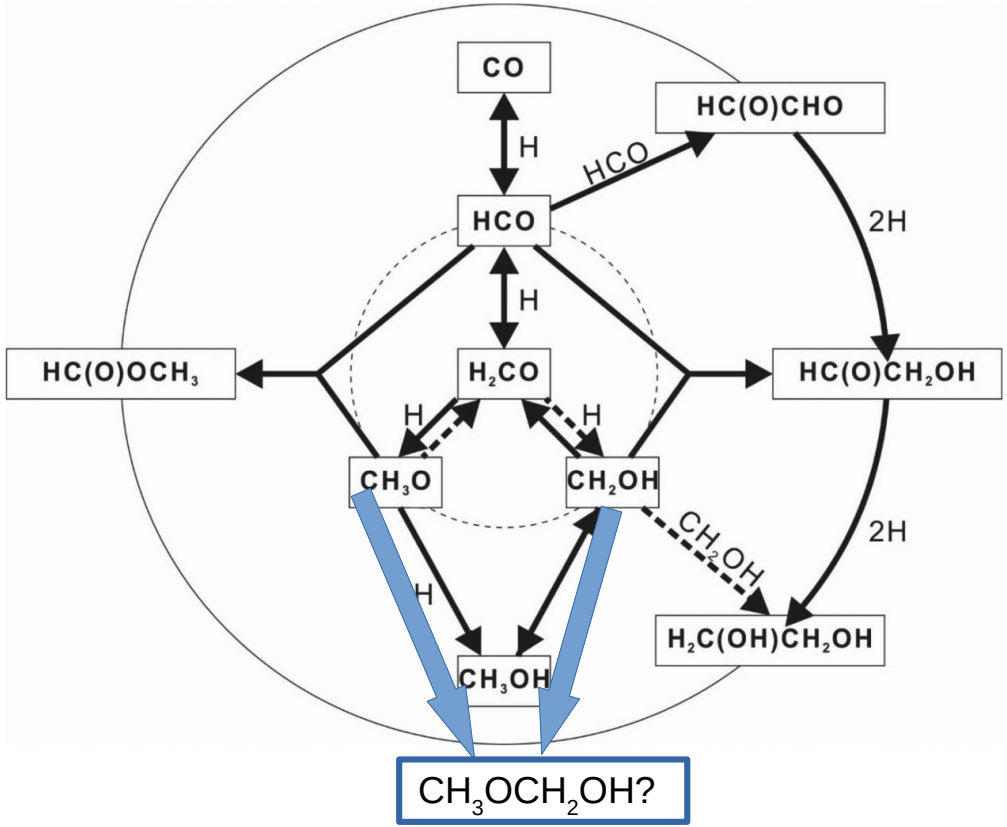


Formation of 3-Carbon COM---Glycerol



Fedoseev+ 2015

Chemistry in the CO-rich layer



Detection of Methoxymethanol

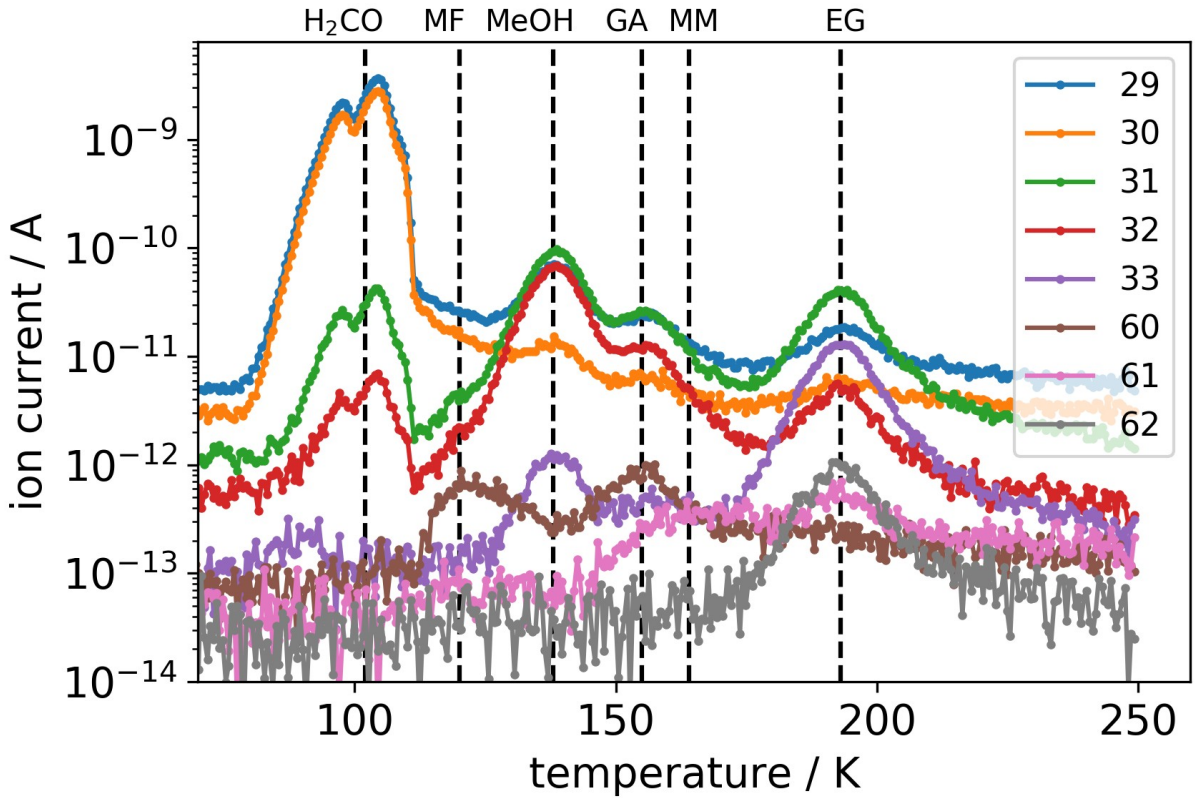
The Astrophysical Journal Letters, 851:L46 (8pp), 2017 December 20 https://doi.org/10.3847/2041-8213/aaa0c3

ALMA Detection of Interstellar Methoxymethanol (CH_3OCH_2OH)

	CH_3OH:CH_3OCH_2OH
Observation	34:1
Modeling	10^7:1

McGuire et al. 2017

Formation of methoxymethanol by H+H_2CO



H:H2CO=18:1 at 10 K + TPD

He+, in prep

Prior experimental study of methoxymathanol formation

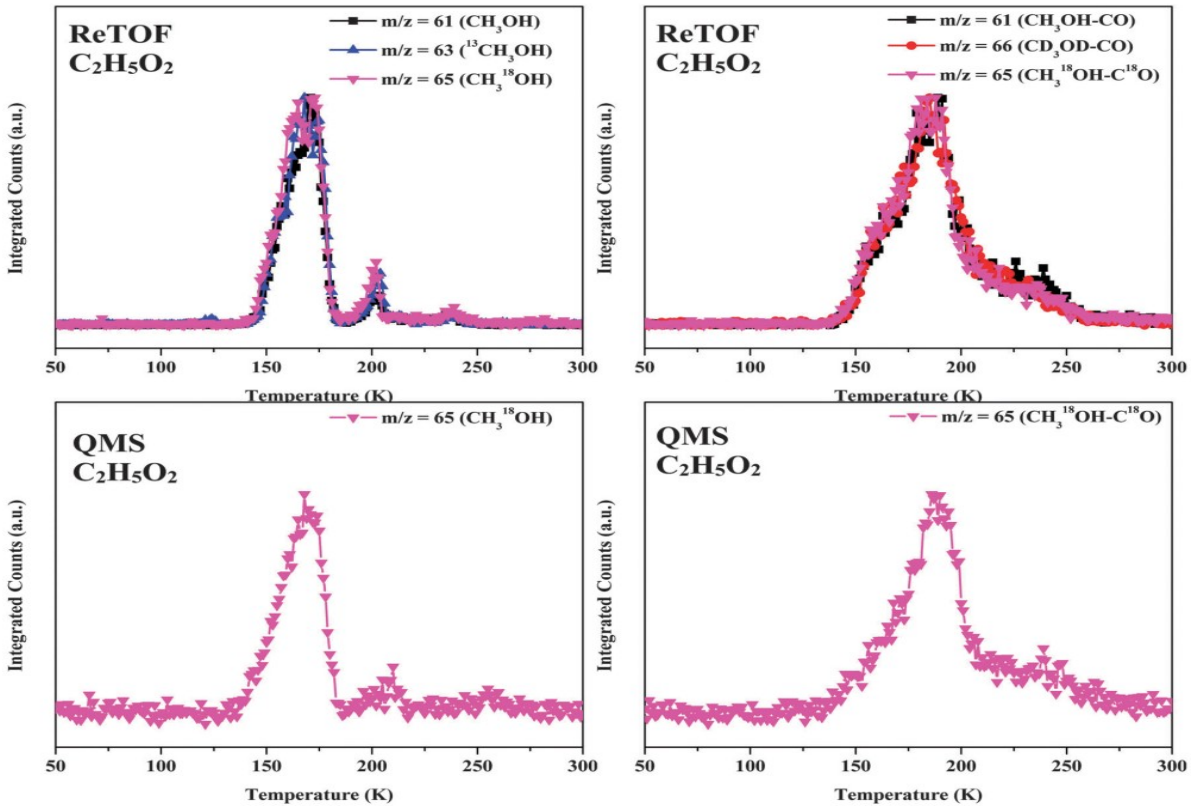
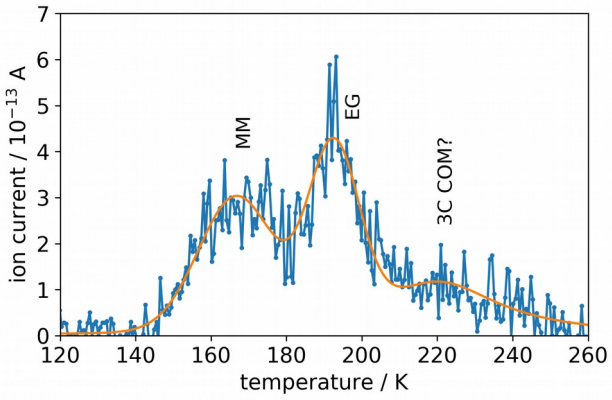
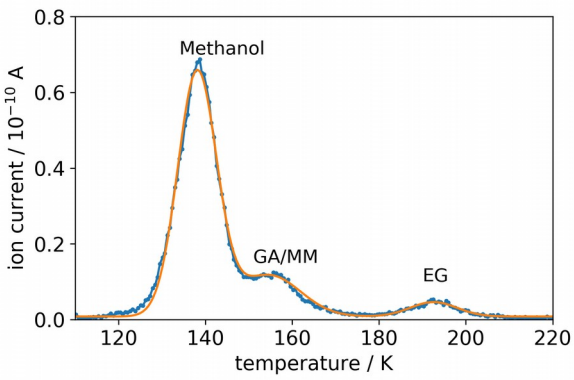


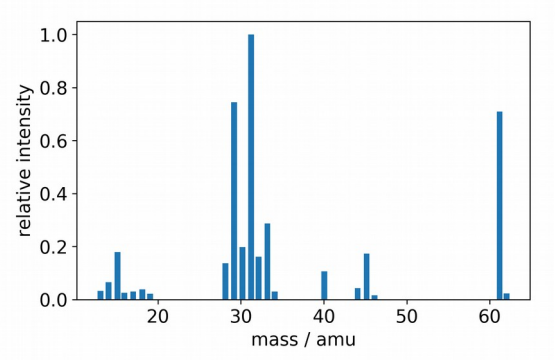
Fig. 8 ReTOF sublimation profiles and QMS traces of $C_2H_5O_2$ isotopomers of irradiated methanol ice systems (left) and methanol–carbon monoxide systems (right). Methoxy methanol (CH_3OCH_2OH) is assigned to the observed ion signal.

Maity, Kaiser &Jones 2015

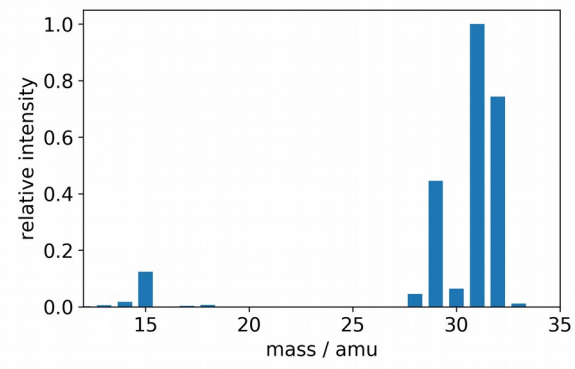
Calculate the MeOH:MM ratio







MM: m61/total=0.18



MeOH: m32/total=0.30

Experiment
MeOH:MM = 80

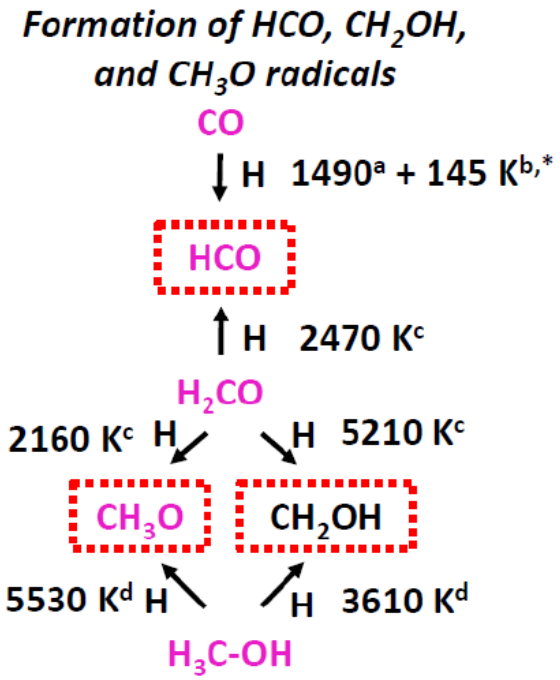
Observation
MeOH:MM = 34

Modeling
MeOH:MM = 10^7

$$(total\ ion\ counts) \propto (number\ of\ molecules) \times (ionization\ cross-section)$$

He+, in prep

Some remaining questions



- What is the branching ratio of H+H_2CO?
- What is the role of reactive desorption?
- Formation of COMs at 10 K versus during warming up

Qasim+, submitted

Conclusions

- Bottom-up atom addition reactions can build up the chemical complexity in interstellar ices.
- H+CO reaction network in the CO-rich layer is able to explain the formation of methoxymethanol in ISM.

Acknowledgement:
- Ko-Ju Chuang
- Danna Qasim
- Gleb Fedoseev
- Herma Cuppen
- Harold Linnartz

This research is supported by DAN-II