Hydrocarbon chemistry in inner regions of planet-forming disks

Jayatee Kanwar[1,2,3], Inga Kamp[1], P. Woitke[2,3], C. Rab[4], W.F. Thi[4]

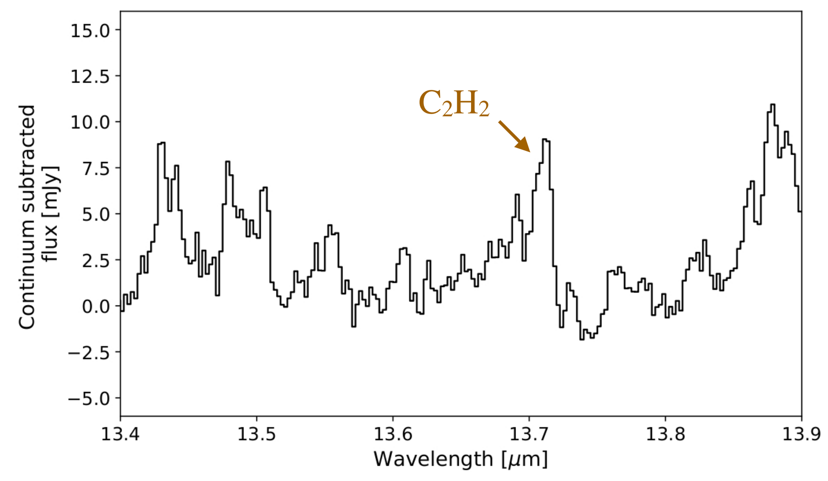
[1]Kapteyn Astronomical Institute, University of Groningen, Groningen, The Netherlands
[2]Space Research Institute, Austrian Academy of Sciences, Graz, Austria
[3]TU Graz, Graz, Austria
[4]Max Planck Institute for Extraterrestrial Physics, Giessenbachstrasse, 85741 Garching, Germany

kanwar@astro.rug.nl

AIM: Study the carbon chemistry in the warm, dense inner regions of planet forming disks and its influence on the C_2H_2 spectrum observed by Spitzer and JWST.

Objectives:

- Study warm carbon chemistry in the inner 10au of TTauri disks- nursery of planets
- Identify key destruction/formation pathways for C_2H_2 in the inner disk
- Study the impact on abundances and mid-infrared spectra.

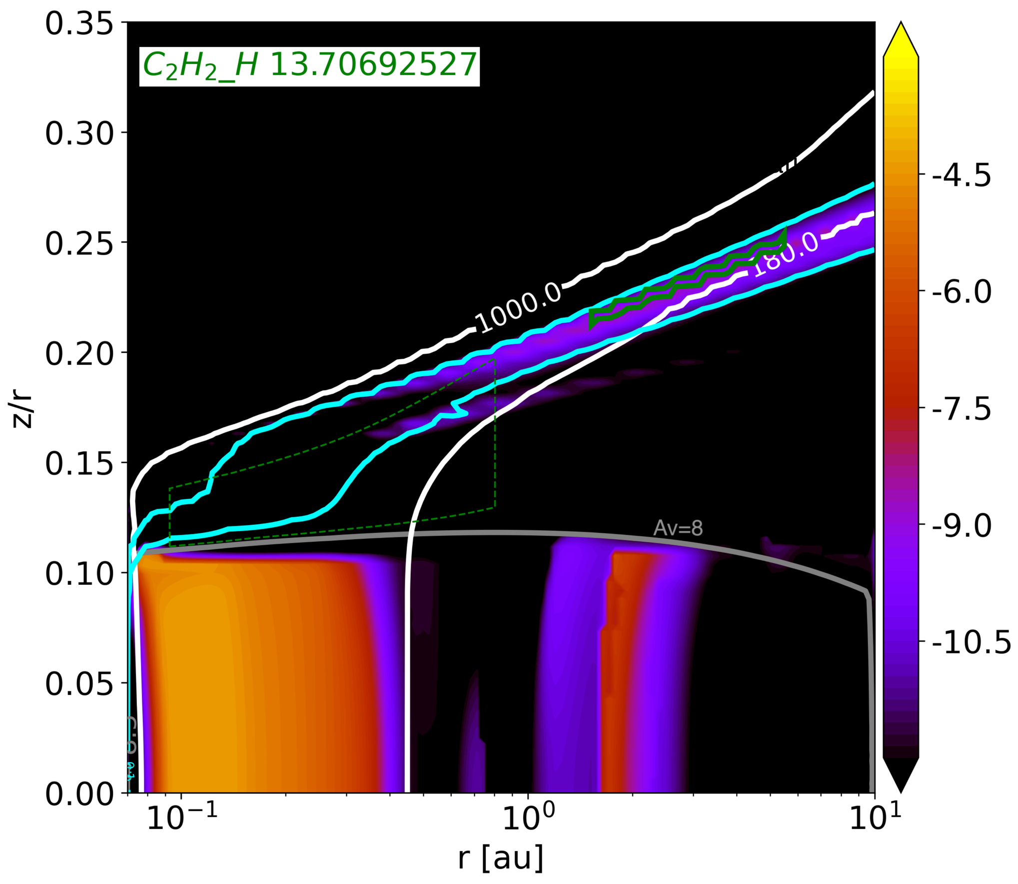


JWST-MIRI spectrum of GW Lup[1] at R=3000

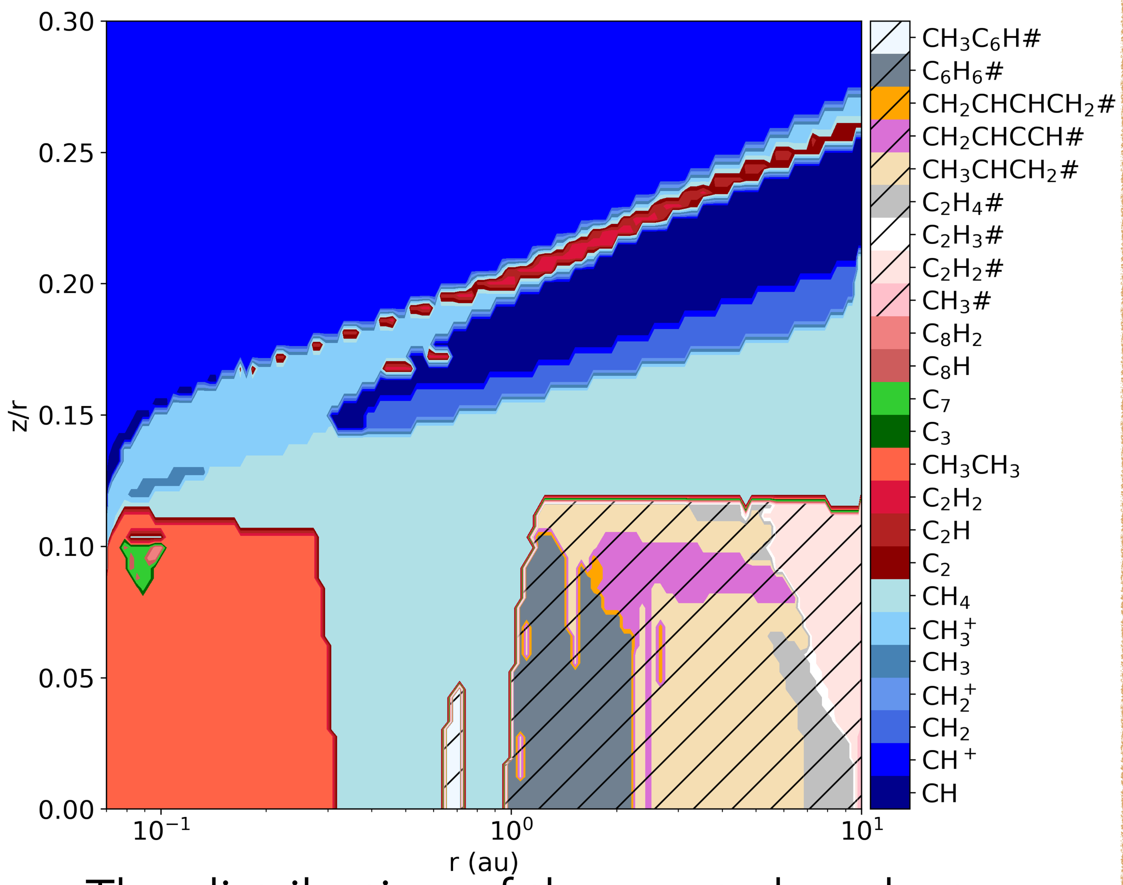
ProDiMo (Protoplanetary Disk Model)

The radiation thermo-chemical code ProDiMo [2] is used to model the warm chemistry in a standard TTauri disk assuming the steady state and solar C/O.

The large DIANA chemical network [3] forms species up to C_4H^+, the new extended chemical network has 92 species and can form hydrocarbons as large as $C_8H_5^+$ and takes into account isotopomers. Ices of neutral species are included in both the networks. UMIST2012 and KIDA 2014 rate databases are used to calculate reaction rates.



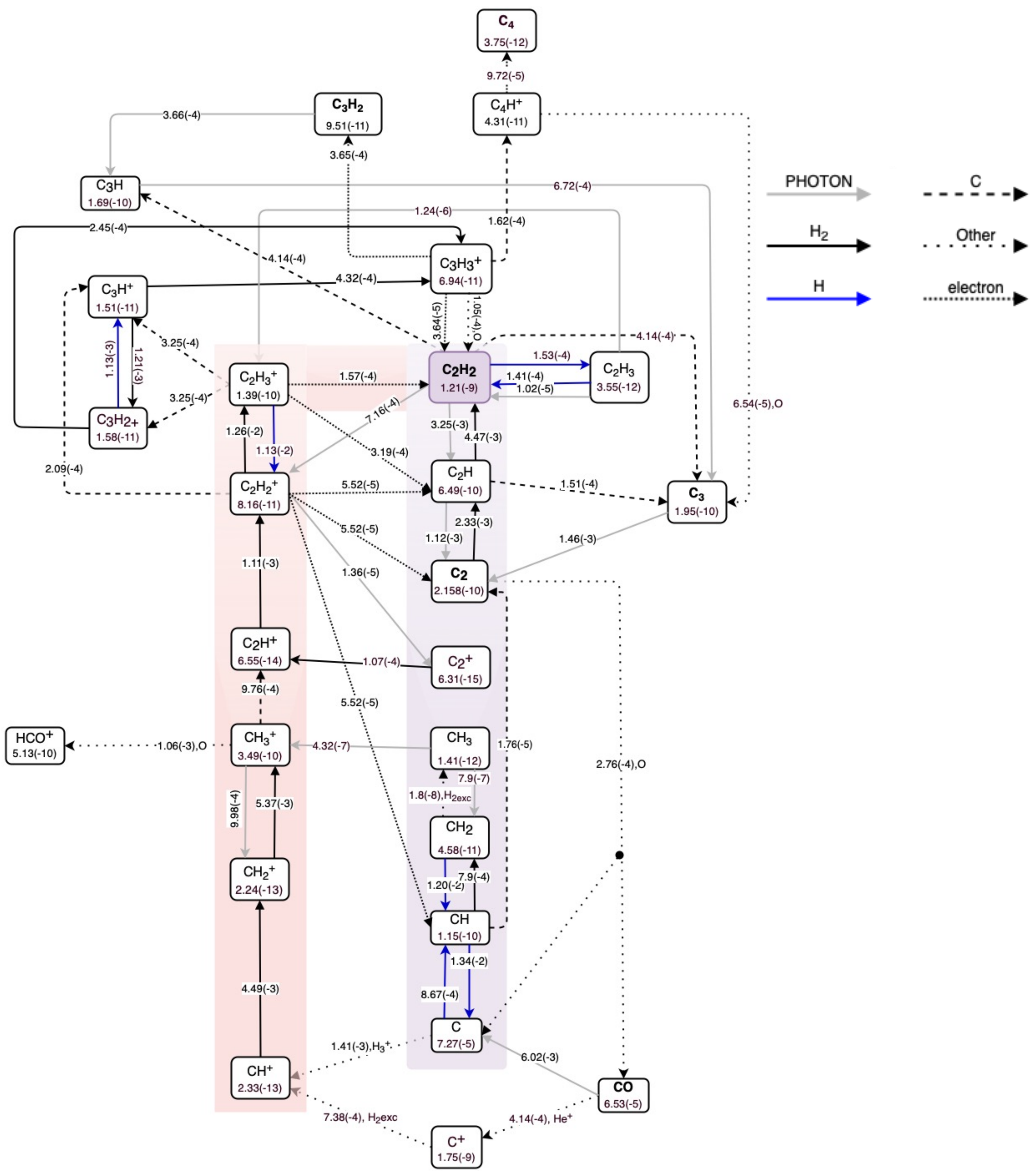
The abundance of C_2H_2 using the extended chemical network. *Solid green*: emitting region of C_2H_2 at 13.7μm.



The distribution of the most abundant hydrocarbons in the inner disk using extended chemical network (excluding C and C^+). The ices are represented by #.

Chemical Networks

The formation and destruction pathways for C_2H_2 in the region with T_{gas}= 270K and T_{dust}= 230K. The reaction rates are noted above the arrow as A(B) meaning $Ax10^B$.



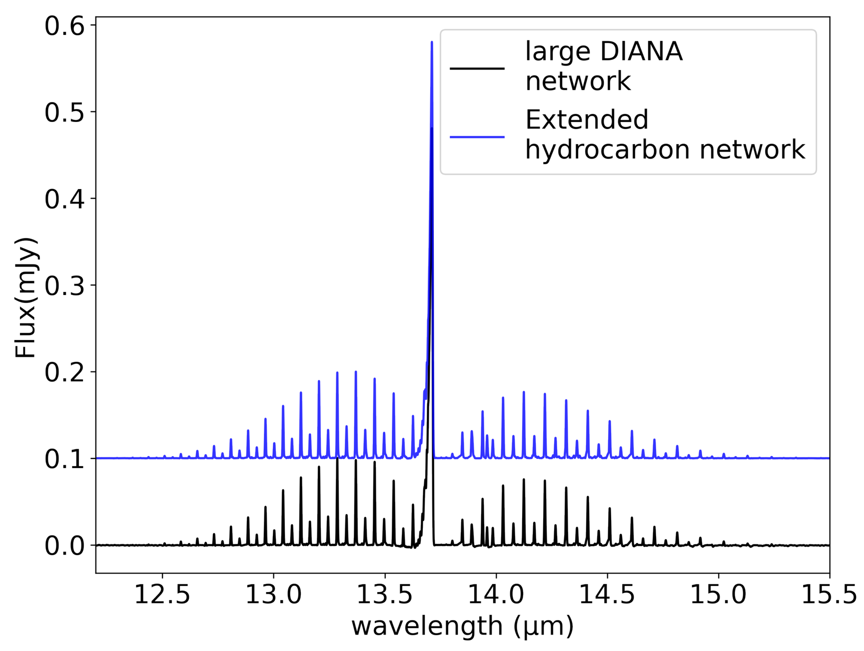
The reactions for C_2H_2 found in KIDA 2014 missing from UMIST 2012:

$C_2H_2^+ + C \rightarrow C_2H_2 + C^+$

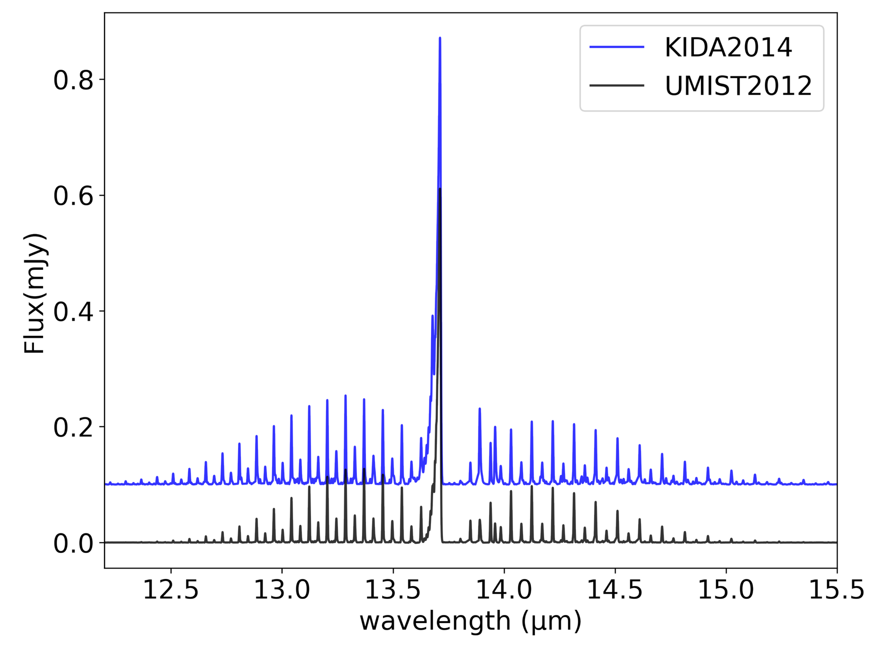
$C_3H_3^+ + e^- \rightarrow C_2H_2 + CH$

$C_4H_3^+ + e^- \rightarrow C_2H + C_2H_2$

Implications for Mid-Infrared Spectra



The flux emitted by C_2H_2 in the mid-infrared is modelled using FLiTs [4] at R=3000. The flux increases for the standard TTauri disk by ~20% relative to the large DIANA network showing the effect of adding larger hydrocarbons.



The modelled C_2H_2 spectra using the extended chemical network with the UMIST 2012 and the KIDA 2014 database. The fluxes differ as each database leads to a different abundances. The T_{gas} is kept fixed in both models.

Future Work

Investigating chemistry for varying C/O ratios in disks and its affect on mid-IR spectra.

References

[1] Grant, S. L.,et al. 2023, A&A
[2] Woitke, P., et al. 2018, A&A, 618, A57
[3] Kamp, I.,et al. 2017, A&A, 607, A41
[4] Woitke,P.,et al. 2018, A&A

We acknowledge funding from the European Union H2020-MSCA-ITN-2019 under grant agreement no. 860470.