Complex Organic Parents during Star-Forming Infall

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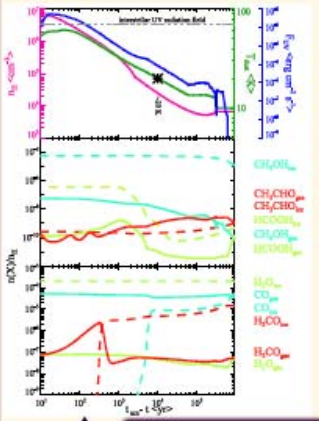
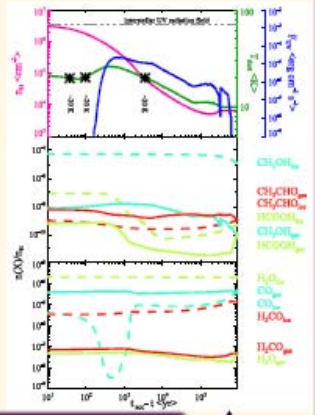
Hot Parcel



Cold Parcel



Motivation

- Young star forming systems set the initial conditions for planet and comet formation
- Complex organic molecules formed at the early stages of star formation may be important for the prebiotic chemistry of planetary systems
- Precise physical and chemical evolution with time may have profound significance on the complex organic compound budget
- Organic molecules formed during the cold (early) phase of star formation are the parents of other, more complex, species

The infall path influences the abundances of complex organics entering the disk

Model

2D, semi-analytical model (Visser et al. 2009, 2011)

pre-stellar core

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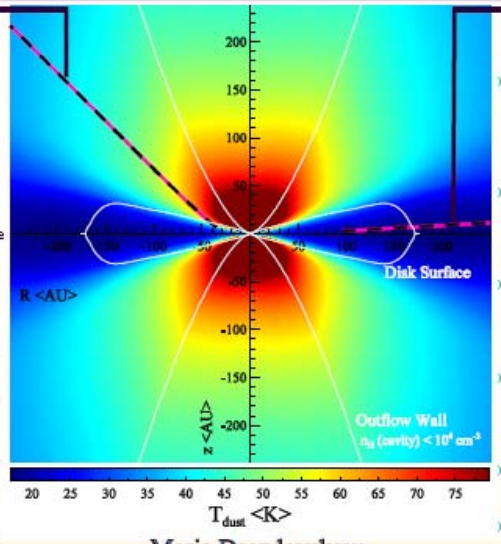
protostar & circumstellar disk

1. Physics of a collapsing envelope & viscously evolving disk
2. Full time-dependent radiative transfer treatment of the dust (RADMC3D, important for thermal desorption)
3. a. Chemistry for the quiescent pre-stellar stage (10^6 yr)
   b. Chemistry along trajectories for parcels of matter

Chemical network contains gas-phase reactions, grain-surface chemistry and gas-grain interactions. (McElroy et al. 2013, Walsh et al. 2010, Garrod et al. 2006 and references therein)



Results

- Solid-state CH_3OH is efficiently formed by grain-surface chemistry during the quiescent pre-stellar phase (up to $n(CH_3OH)/n_H = 10^{-1}$) and increases during infall by a factor of 5
- Gas-phase CH_3OH is released from the icy grain mantles via photodesorption during collapse; its abundance is enhanced by at least 2 orders of magnitude
- The stronger UV radiation encountered by the hot parcel releases more CH_3OH into the gas, in comparison with the cold parcel (by a factor of 3.5)
- HCOOH ice is also efficiently formed by radical-radical reactions on the grains, but at slightly elevated temperatures ($T_{dust} \gtrsim 26$K) and thus at later times than CH_3OH
- The pre-stellar abundance of CH_3CHO ice is preserved for both parcels
- Other complex organics are not efficiently formed for these trajectories in this particular model ($n(X)/n_H \leq 10^{-11}$)

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