Herschel-HIFI Detections of Hydrides in Star Forming Regions: Envelope, Outflow or Foreground?

I. HIFI-detections towards AFGL 2591

- Light diatomic hydrides (NH, XH, X=O, N, S) hard to observe from ground, with frequency in the range of 1 THz
- Detection of CH, CH+, OH, and NH towards the massive star forming region AFGL 2591. Also H$_2$O detected (Bruderer et al. 2010b)
- CH and CH+ in emission, but OH, H$_2$O and NH in absorption
- Velocity of absorption agrees to foreground clouds

II. A scenario: FUV irradiated outflow walls

- AFGL 2591 has a large scale cavity along the outflow (several 1000 AU) (e.g. Preibisch et al. 2003, van der Tak et al. 2000)
- Tracers for warm and FUV irradiated gas detected towards AFGL 2591 (e.g. CO$^+$)
- Directly irradiated outflow walls (Bruderer et al. 2009b)

III. Physical/chemical models e.g. CH$^+$

- CH$^+$ Formation mechanism requires high temperature and FUV radiation
  \[ C^+ + H_2 \rightarrow CH^+ + H \]
- Detailed 2d physical/chemical model (Bruderer et al. 2009a, 2010a)
  1. Physical structure \rightarrow Density
  2. Transfer of the FUV radiation \rightarrow FUV radiation
  3. Dust radiative transfer \rightarrow Dust temperature
  4. Calculation of the gas temperature together with chemistry \rightarrow Gas temperature
  5. Chemistry \rightarrow Abundances
  6. Radiative transfer \rightarrow Molecular lines

- Calculated Density and Temperature structure and abundance profile (rel. to H$_2$)

- Thinner and hot layer (a few 100 AU with 1000 K) with strong enhancement of CH$^+$
- Modeled line map: Velocity integrated emission of CH$^+$(J=1-0)

- Comparison between model and observations
  CH$^+$(J=2-1): Measured 3.8 km s$^{-1}$
  Model: Hot Core only < 10$^{-4}$ K km s$^{-1}$
  Model: Outflow wall 8.9 - 30.8 K km s$^{-1}$ (depending on distance, inclination, ...)

- Outflow walls directly irradiated by the young protostar lead to warm and extended gas
- Outflow walls can explain CH$^+$ observations

References