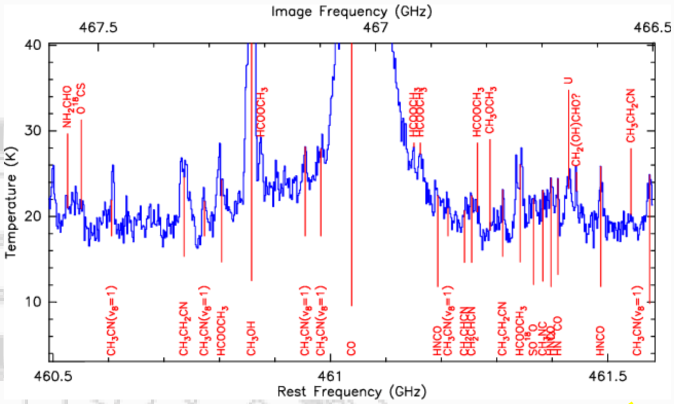
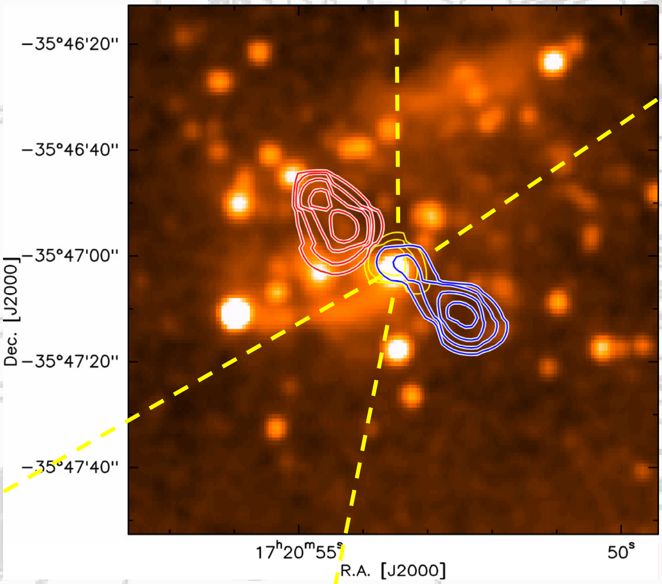
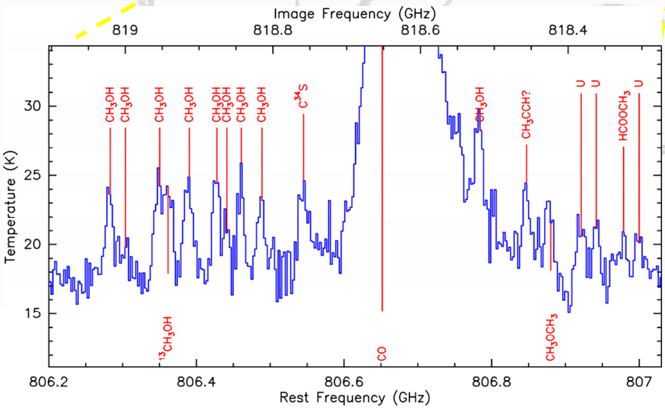
Interstellar Chemistry

Molecular Line Observations of NGC 6334

NGC 6334I, in which a cluster of high mass stars is forming, is part a prominent giant molecular cloud complex, which harbors also more evolved young stars and spectacular regions and gas ionized by them. NGC6334I is visible, but not very remarkable, in the near-infrared wavelength range, but is one of the strongest sources of molecular line emission in the Galaxy. A large bipolar outflow of length 0.5 pc or 1.6 light years, as seen in the CO(4-3) line with FLASH (below, red and blue contours) signifies the formation of extremely young stars. The yellow contours show the position of the molecular core, in which the massive protostars reside.

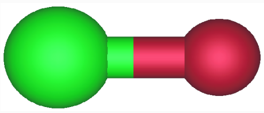






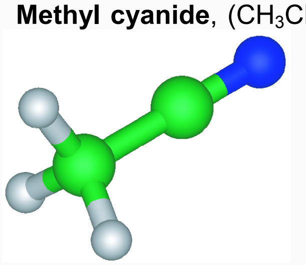
Particularly remarkable is the abundance of mole-cular lines from other species, as seen in the two spectra observed with FLASH close to the CO(4-3) and (7-6) lines (top and bottom spectrum, resp.). Strong methanol emission is detected in the higher frequency spectrum, but also lines from more complex organic molecules, as well as from vibrationally excited CH_3CN, which trace extremely hot gas and can be excited only very close to the central star. Observing and modeling these lines gives clues to the history of the site, since many of the observed molecules have evaporated from ice mantles that grew on dust grains when the cloud was cold before the newly-formed star ignited. They, thus represent a fossil remnant of the parental cloud's molecular content.

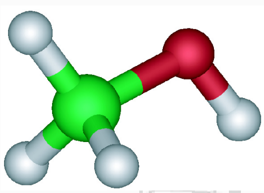
MPIfR Bonn, 14.07.05



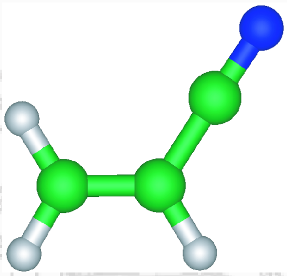
Carbon monoxide (CO) is, after molecular hydrogen, H_2, the second most abundant molecule in the interstellar medium. Since H_2 is a symmetric molecule and does not have an electric dipole moment, and therefore cannot easily be observed, CO is the most important tracer of molecular gas. It also has the advantage that it is easily excited, in contrast to many other molecules, and thus traces also cold and low density gas.

Methyl cyanide, (CH_3CN) is a symmetric rotor molecule, and can be used to determine the kinetic temperature of molecular gas. Chemically, it is found mostly in the hot cores aroung newly formed stars. Its chemistry is still not very well understood.

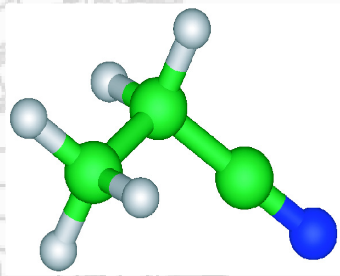


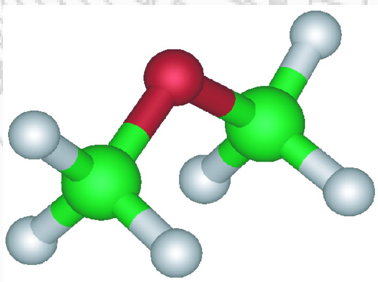


Methanol (or methyl alcohol, CH_3OH) is a slightly asymmetric molecule, which can be used to determine temperature and molecular density simultaneously.This molecule is thought to be produced on the surface of interstellar dust grains, reaction of CO with H_2. In the colder phases of evolution of a molecular cloud, methanol resides in the ice mantles coating the grains, and is only released into the gas phase once the star ignites and heats up the gas. CH3OH has many lines throughout the radio, mm und submm ranges. Its relatively strong lines make it an easy target for APEX.



Many more complex molecules can be observed in the interstellar medium. One can roughly distinguish between two varieties: the *primary* molecules (saturated ones such as ammonia, NH_3, formaldehyde, H_2CO, and **vinyl cyanide**, CH_2CHCN, above) are produced through chemical reactions on the surface of dust grains. *Secondary* molecules (**ethyl cyanide**, CH_3CH_2CN, right or **dimethyl ether** CH_3OCH_3, bottom) are supposedly produced in the gas phase, through chemical reactions involving the primary species, once these are released. In principle, the relative abundances of primary and secondary molecules can be used as a chemical clock, if the chemistry is understood.





Credit for Figures: Background for APEX contours: 2MASS J band near-IR image