Modeling the Nascent Solar Nebula for Material to be Measured with Rosetta at Comet 67P/Churyumov-Gerasimenko

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Rosetta, an ESA cornerstone mission with a NASA contribution, is on its way to visit comet 67P/Churyumov-Gerasimenko in 2014. The mission carries a robust suite of instruments that will sample the primitive nucleus material, from a lander with a suite of experiments to study the comet regolith *in situ*, to several sophisticated mass spectrometers on the orbiter capable of sampling material up to 300 AMU that will examine coma material, daughter products. Dust detectors on the orbiter are capable of detecting grains of even larger sizes. The Rosetta Sensor for Ion and Neutral Analysis (ROSINA) will make *in situ* isotope measurements of the coma material. The Microwave Instrument for the Rosetta Orbiter (MIRO) will make a study of selected isotopes of oxygen: O^{17} and O^{18}, and its isotopologues, particularly of H_2O and of methanol. The Alice instrument, an ultraviolet spectrometer, expects to make unique measurements of the noble gases, some of which are expected to be remnants of the original material of the comet.

Questions related to origin of the solar system that these measurements are likely to help us address include:

a) What were the physical and chemical conditions when the comet material was formed?
b) What is the connection between comets and a dark molecular cloud out of which the nascent solar nebular might have formed: How much of the original material have comets preserved?
c) Did comets bring the terrestrial water (or at least a fraction of it)?
d) Can polycyclic-aromatic-hydrocarbons (PAHs) in comets provide a link between the interstellar medium and the solar system?
e) Relation to giant planets
f) Origin of Carbon
g) Comparison with meteorites

The interstellar medium (ISM) can be described as the co-existence and interaction of five components:

a) hot ionized medium (HIM)
b) warm ionized medium (WIM) – contains neutral atomic H ions: H+; sometimes called the diffuse Ionized Gas (DIG)
c) warm neutral media (WNM) – contains neutral H
d) atomic cold neutral medium (CNM) dominated by H and some H2
e) molecular cold neutral medium (CNM) dominated by H2; also known as dark clouds and/or molecular clouds

Heating processes in these regions include: collisional excitation of gas and atoms and ions by electrons and other atoms and ions and by absorption of UV photons.

Cooling processes in these regions include: electronic transitions of singly ionized and neutral atoms in the warm components and by vibrational and rotational modes of molecules in the cold atomic and cold molecular components.

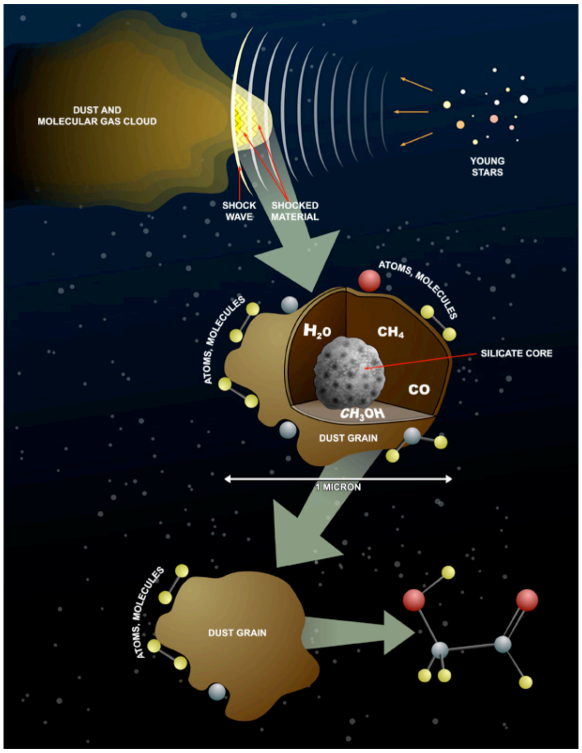

Image Credit: Bill Saxton, NRAO/AUI/NSFA

If the abundances of different molecules can be determined accurately then the variation in abundances in different environments can tell us how chemical processes work under different physical conditions. For example, molecular clouds in the surroundings of hot stars with strong UV background radiation can serve as a laboratory for photochemistry. Comets are believed to be bodies left over from the primordial solar nebula, and their chemical compositions may represent the state of the ISM from which the solar system formed. If you think of the exotic list of molecular species' found in comet, the large variety provides a glimpse of the chemical richness of the primordial solar nebula and a connection to the molecular cloud from which the solar nebula formed.

In this poster we explore mechanisms and pathways that produce abundances of various isotopologues. The basic chemical mechanism we employ includes formation of CO in diffuse interstellar clouds. Additional equations that explore the mechanisms of a diffuse cloud with isotopologues of Methanol have been employed. Many of these equations have no genuinely measured reaction rates, so a fair degree of approximations and assumptions have to be made. All the relevant assumptions will be discussed in the poster.

Pathway 1: (important at all cloud depths), CN and HCN are formed via neutral – neutral reactions. Pathway 2: an additional route to CN (but not HCN) – important for shielded regions. Pathway 3: third pathway were CN and HCN are produced via dissociative recombination. Different paths depending upon 'location' in evolution of the interstellar cloud.

Work on this project was supported by NASA at California Institute of Technology/Jet Propulsion Laboratory.