NOBEL SYMPOSIA

Report from the lecture presented by William Klemperer

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The lecture was followed by an interesting discussion.

Max Tegmark asked. What is the status of modeling interstellar cloud chemistry by computer simulation?

Klemperer replied. This is certainly an active field. One the active participants in this area is Prof. Eric Herbst. The gas phase reactions now considered number over four thousand. The modeling generally considers the problem in a time dependent manner. A considerable success in gas phase modeling is found in quiescent cores in dense clouds. A particular example here is the Taurus Molecular Cloud 1 in which the largest molecule, H–C_{10}–CN has been observed. The excess oxygen (over carbon) as well as molecular depletion on dust grains gives a time dependence to molecular abundance. In my talk I removed excess oxygen from the gas phase and did not discuss cloud dynamics. I think the very low abundance of gas phase oxygen species, H_2O, CO_2 , and O_2 in unheated interstellar molecular clouds is evidence for the gas phase oxygen to be essentially equal to that of carbon and also exist as CO. I have suggested in my talk that van der Waals species such as H_2– HCO^+ formed by radiative association of H_2 and HCO^+ together with its reaction product OC–HCO^+ reacting with H atoms provide a gas phase synthesis route for formaldehyde which has been taken to be formed by surface reaction.

Dick Zare asked. By discussing only radio frequency observations of molecular species are you only looking under the “street light”. What is your comment?

Klemperer replied. I think that for the discussion of interstellar chemistry the radio frequency observations have by far the highest quality factor taken as the ratio of line frequency to line width. These are clearly gas phase measurements with a very high reliability of molecular species

identification. (Note that the likely false identification of glycine is a result of use of extrapolated frequencies rather than precise laboratory measured frequencies and neglect of the absence of features, which should have been strong). I believe that the field of interstellar chemistry underwent a paradigm shift with the observation by Townes *et al* of the radio emission from polyatomic molecules in the direction of the galactic center. The low resolution infrared observations have not provided specific carrier identification. The laboratory spectrum of the polar polyaromatic hydrocarbon corannulene, $C_{20}H_{10}$, provides a most important new tool for examining the interstellar abundance of polyaromatic hydrocarbons. At present there is no indication of its presence in a popular source such as Taurus Molecular Cloud 1.

Martin Rees asked. What about H_2O masers?
Klemperer replied. I think that H_2O masers are usually associated with ionized hydrogen regions which are very hot and will have a different chemistry from the cold gas chemistry that we have mainly discussed .

Andre Linde asked. What are the limits to the complexity of molecules formed by low density gas phase processes?
Klemperer replied. I am not sure how large molecule, and in what abundance, will develop by purely gas phase synthesis. As a species gets larger the duration of its collisions lengthens, thus the rate constant for radiative association becomes larger. I think this is general for any condensation. We have emphasized the insertion of C^+, formed by the reaction $He^+ + CO = C^+ + O$, into carbon compounds as a means of increasing the carbon chain length. There are a number of other ion-molecule and molecule-molecule collisions leading to increased molecular size. The largest molecule thus far identified in the interstellar medium is $HC_{11}N$.