THE NUCLEUS: PANEL DISCUSSION

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What I would like to discuss here is the chemical nature of the nucleus.

This implies the consideration of the vaporization of the nucleus into the coma because the coma is our only source of information on the nucleus. The nature of the parent molecules vaporizing from the nucleus has been for a long time the missing link for our understanding of the molecular processes. A major development has been brought about by the first identification of three neutral parent molecules HCN and CH_3CN identified in Comet Kohoutek, H_20 in Comet Bradfield, confirmed by H_2O^+ in Kohoutek.

The atomic resonance lines of carbon and oxygen will also play a fundamental role in our understanding of the cometary phenomena, because we will be able to make a balanced budget of all the atoms to explain the molecular abundances.

Incomplete as they are, the major feature that seems to emerge from these new results is the large depletion of hydrogen of the volatile fraction, at least as compared with a mixture of cosmic abundances. In particular, the H/O ratio points to an oxidation-reduction equilibrium, very much like that of carbonaceous chondrites.

For the first time we have rather good data on the total production rate of hydrogen, with rather good data on the oxygen forbidden line, which gives the lower limit to the total oxygen produced in a comet; finally, we have assessments on the production rates derived from the resonance lines of carbon and of oxygen.

The H/O and C/O ratios will certainly be revised in the future, and measured more accurately on bright comets. Let's assume that the present values are meaningful. They suggest a major departure from the early model of the nucleus. Instead of molecules like CH_4 and NH_3 containing large amounts of hydrogen, they suggest molecules with less hydrogen, like ethylenic, acetylenic or aromatic compounds, and hydrazine instead of ammonia. The fact that nobody has yet been able to detect CH_4 or NH_3 may not be very significant, but it goes in the same direction.

The probable presence with water, of much CO and CO_2 (suggested by C/O and by the ions CO^+ and CO_2^+) is also difficult to explain without a serious depletion in hydrogen. Of course, I do not really believe that thermodynamic equilibrium is likely to be reached. It is a trend that can be modified by different factors influencing the reaction kinetics, as exemplified by the Fischer-Tropsch (FTT) reactions proposed by Anders.

These FTT reactions were proposed in order to explain the hydrocarbons observed in carbonaceous chondrites. It may be significant that this same type of reaction would explain the parent molecules of C_2 and C_3, as being higher acetylenes.

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If the cometary stuff was made in deep space where triple molecular collisions are notoriously absent and where the radiation field is a diluted mixture of two Planckian distributions, roughly, at one hundred and ten thousand degrees, it is clear that the thermodynamic equilibrium has no meaning and that the depletion of hydrogen may simply translate the fact that hydrogen cannot easily stick, for eons, on interstellar grains. However, if Herbig's ideas have any sense, comets as well as interstellar molecules could have been formed in the primeval solar nebula and other primeval stellar nebulae, and the clues we have just found about the present redox potential of the cometary nuclei may simply mean that comets were made in the confines of the solar nebula, not with a solar mixture, like Jupiter and Saturn, but with a solar mixture already much depleted of its hydrogen and its helium, like Uranus and Neptune.

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