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Physical Observations of Comets: Their Composition, Origin and Evolution

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Strategy

We wish to study the composition, origins and evolution of comets. The composition will be studied using spectroscopic observations of primarily brighter comets at moderate and high resolution to study the distribution of certain gases in the coma. The origins will be addressed through an imaging search for the Kuiper belt of comets. The evolution will be addressed by searching for a link between comets and asteroids utilizing an imaging approach to search for an OH coma.

Progress and Accomplishments

We concentrated our spectral analysis on the weaker features in the spectra. These features include many UV features which were either rarely detected before or have never before been seen (although some, such as the $\Delta v=1$ band of CN were expected). This project is a collaboration with Chet Opal of Texas and with Bob O'Dell, Chris Miller and Dirk Valk of Rice University. Among the most interesting new features are the first detection in the UV of H_2CO and the confirmation of the presence of CO_2^+ throughout this region of the spectrum. We have published two papers already on the UV spectra (one in ApJ in press and one in a conference proceeding) and we are presently working on preparing a third paper on the high quality comet Austin data. In addition, these observations have constituted parts of two Masters projects for Rice University students (Chris Miller and Dirk Valk).

We have shown that the observed CH in comets can be explained easily if CH_2 is the direct parent of CH and CH_4 is the probable grandparent of the CH. CH_3 is not seen as a by-product of this reaction path in the lab so we consider it an unimportant step. From our data, we conclude that Halley had outflow velocities very different from other comets. We also do not have to invoke more complicated parents (although we cannot exclude them) to explain our CH data. These results were published in a conference proceeding.

We have analyzed high quality spectra of P/Schwassmann-Wachmann 1 and have detected the strongest CO^+ spectrum from this comet to date. We show that the fluorescence efficiencies of Magnani and A'Hearn (1986) are consistent with the data for the most part. We demonstrate that photoionization is unlikely to be an important mechanism for producing the CO^+ . In addition, we have detected for the first time an emission feature due to CN. We also detected an unidentified feature in the spectrum. In December 1990, we obtained a series of spectra which, for the first time, detected the turn-on of the CO^+ gas. From our data, we determined the maximum rise time of the gas to be 1.2 days. We show this

"outburst" to be a non-equilibrium process and also that the dust and gas event are not necessarily related. This work has resulted in 1 paper which is in press in *Icarus* (notes) and 1 paper which has been submitted to *Icarus* (notes).

We are working on the analysis of the gas and dust measures of a variety of comets from the Faint Comet Survey. Two papers are in preparation which will contain a wealth of new data on 18 comets. Correlations of dust, CH and NH₂ measures compared with CN data will be presented for the first time. The analysis of the continuum information in the Faint Comet Survey uses the Af_p formalism. Comparisons of the dust production rate with distance from the Sun, as well as the continuum brightness variation with distance from the nucleus and with wavelength, were reported at the Fall DPS meeting. The gas production was ratioed to the dust production to get a gas-to-dust ratio. This ratio is observed, in general, to increase with decreasing heliocentric distance.

Projected Accomplishments

We are concentrating on the imaging search for the Kuiper Belt of comets. We have defined our observing procedure and should be able to image easily to $m_v=24$. Our method of obtaining the data will actually allow us to probe a variety of different heliocentric distance depending on the way the images are stacked. We have had 2 observing runs and will have 2 more runs during the spring.

We will continue to observe brighter comets ($m_v < 15$) in order to study the distribution of the gas. We will concentrate on the emissions due to OH, NH, CH, and NH₂. If a really bright comet comes along, we will once more probe the near-UV region at 1 Å resolution in order to confirm our new detections from our Brorsen-Metcalf and Austin observations.

As time permits, we will be imaging a select group of asteroids with cometary orbits searching for an OH coma. We had an observing run for Hidalgo during which we encountered problems but this run did help us to define better the observing procedure.

Publications

"Are All Comets Created Equal?" (A. L. Cochran) in *Asteroids, Comets, Meteors III*, C.-I. Lagerkvist, H. Rickman, B. A. Lindblad, and M. Lindgren, eds., Uppsala Universitet Reprocentralen HSC, pp. 281-284, 1990.

"Methods for Determining the Water Production Rates in Comets" (A. L. Cochran) in *Asteroids, Comets, Meteors III*, C.-I. Lagerkvist, H. Rickman, B. A. Lindblad, and M. Lindgren, eds., Uppsala Universitet Reprocentralen HSC, pp. 285-288, 1990.

"NH₂ in Comet Halley" (W. D. Cochran and A. L. Cochran) in *Asteroids, Comets, Meteors III*, C.-I. Lagerkvist, H. Rickman, B. A. Lindblad, and M. Lindgren, eds., Uppsala Universitet Reprocentralen HSC, pp. 289-292, 1990.

"New Ultraviolet Spectroscopic Features Found in Comet Brorsen-Metcalf (1989o)" (C. R. O'Dell, C. O. Miller, A. L. Cochran, W. D. Cochran, C. B. Opal, and E. S. Barker) *Astrophys J.*, in press, Feb. 20 1991.

"Observations of CH in Comets P/Brorsen-Metcalf and P/Halley" (A. L. Cochran and W. D. Cochran) in "Proceedings of the Workshop: Observations of Recent Comets" held 15-16 June 1990, Albuquerque, NM, W. F. Huebner, P. A. Wehinger, J. Rahe and I. Konno, eds., Southwest Research Institute, pp. 22-27, 1990.

"The Near Ultraviolet Spectra of Comets P/Brorsen-Metcalf and Austin" (W. D. Cochran, C. R. O'Dell, C. O. Miller, A. L. Cochran, C. B. Opal, D. Valk, and E. S. Barker) in "Proceedings of the Workshop: Observations of Recent Comets" held 15-16 June 1990, Albuquerque, NM, W. F. Huebner, P. A. Wehinger, J. Rahe and I. Konno, eds., Southwest Research Institute, pp. 50-54, 1990.

"The First Detection of CN and the Distribution of CO⁺ Gas in the Coma of Comet P/Schwassmann-Wachmann 1" (A. L. Cochran and W. D. Cochran) *Icarus (notes)*, in press, March 1991.

"The Development of the CO⁺ Coma of Comet P/Schwassmann-Wachmann 1" (A. L. Cochran, W. D. Cochran, E. S. Barker and A. D. Storrs) *Icarus (notes)*, submitted, 1991.

