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Physical Observations of Comets: Their Composition, Origin and Evolution

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The Active Comet P/Schwassmann-Wachmann 1

Comet P/Schwassmann-Wachmann 1 (SW1) is an enigmatical comet. Its orbit is virtually circular with perihelion at 5.77 au and aphelion at 6.4 au. Thus, it should have relatively constant solar insolation and should not display much activity. However, SW1 is known to undergo tremendous outbursts of as much as 8 magnitudes at random intervals. In 1978, we discovered that in addition to producing dust during the outbursts, the comet sometimes produces CO^+ gas. There appears to be no correlation between the gas and dust activity however.

We have observed SW1 during one observing run each in 1989 and 1990 and these observations have yielded significant new information. The spectra of December 1989 show the most well developed CO^+ coma ever observed for SW1. Our spectra showed that the fluorescence efficiency calculations of Magnani and A'Hearn are reasonably consistent with the data. We demonstrated that there was an asymmetry in the gas distribution along the solar/anti-solar direction. In addition, we detected for the first time emissions due to CN and also due to an unknown molecule. No evidence of OH was detected.

The December 1990 observations were obtained at a time when the comet was less bright than the December 1989 observations discussed above. On the first night of observation in December 1990, the CO^+ gas was barely visible. However, by the second night, the CO^+ emissions were quite noticeable and substantially stronger. We were able to determine a maximum rise time for the gas of 1.2 days. These observations represent the first detection ever of the turn-on of the gas. The CO^+ gas also showed signs of not being in equilibrium. We did not detect any CN emissions this observing run, although our upper limit for these observations is lower than our actual detection from the year before. Once more, OH was not detected.

At the distance from the sun of SW1, photoionization cannot be responsible for the creation of the observed CO^+. We have explored various creation mechanisms but have not been able to identify the process by which the CO^+ is ionized.

Near-Ultraviolet Observations of Comets

The near-UV (3000-3500Å) is a mostly unexplored spectral region for comets since it is not visible to spacecraft such as IUE and most ground-based detectors and spectrographs are not sensitive in the near-UV. We have a spectrograph at McDonald Observatory (the Large Cass Spectrograph or LCS) which is sensitive all the way down to the atmospheric cut-off at

3000Å. Recently, we used the LCS to observe two relatively bright comets, Austin and Brorsen-Metcalf, at 1Å resolution from 3000-3600Å. These observations have been carried on in collaboration with C. R. O'Dell and his graduate students from Rice and with C. Opal of McDonald Observatory.

With these spectra, we were able to confirm some previous barely detected features, to confirm the presence of features such as the CN Δ v=1 and OH (0-1) bands which were expected but never before detected, and to observe for the first time in the optical such features as H_2CO. These detections point to the near-UV as a powerful new spectral region in which to study comets.