37.03

Molecular Observations of C/1995O1 (Hale-Bopp) with the IRAM Telescopes near Perihelion: Interferometric Maps and New Parent Molecules

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Comet C/1995O1 (Hale–Bopp) was observed in October 1996 and March 1997 with the Institut de Radioastronomie Millimétrique (IRAM) interferometer at Plateau de Bure (France). Interferometric maps of the HCN J(1-0) and CO J(2-1) lines were obtained in October 1996. In March 1997, the radio lines of eight species (CO, HCN, HNC, CH_3OH, H_2CO, H_2S, CS, SO) were mapped. The spatial resolution ranged from 1.5 to 3.5 arc sec and the map sizes were from 20×20 arc sec to 1×1 arc min. Our goal was three-fold: i) investigate the spatial distribution of parent molecules to relate gas and dust jets; ii) constrain the origin of CO, H_2CO, CS and SO which are thought to be released at least partly from a distributed source rather than from direct sublimation from the nucleus; iii) study the evolution of the excitation conditions of CH_3OH and CO as a function of radial distance, by mapping several of their rotational lines. A preliminary analysis of these observations will be presented. SO was clearly detected in single-dish mode whereas it was not in interferometry: this shows that it is mainly a photo-dissociation product.

In March 1997, the IRAM interferometer was also used with its five 15-m antennas in a single-dish mode to search for minor parent molecules. We obtained the first identifications of sulphur dioxide (SO_2) and formic acid (HCOOH) in a comet. Searches for minor volatiles with the IRAM 30–m telescope at Pico Veleta (Spain) in early April 1997 allowed the identifications of formamide (NH_2CHO) and methyl formate (CH_3OCHO). Abundances relative to CH_3OH are estimated to 0.5%, 3% and 3% for NH_2CHO, HCOOH and CH_3OCHO, respectively. The abundances of SO and SO_2 relative to water are significantly larger than upper limits derived from UV observations of previous comets (Kim and A'Hearn, 1991, *Icarus* **90**, 79). Stringent upper limits were also obtained for a number of species.

37.04

Long-term Evolution of the Outgassing of C/1995 O1 (Hale-Bopp) from Radio Observations

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C/1995 O1 (Hale-Bopp) has been observed on a regular basis since August 1995 with the Nançay, IRAM, JCMT and CSO radio telescopes. We observed the onset of outgassing of nine molecular species (OH, CO, HCN, CH_3OH, H_2CO, H_2S, CS, CH_3CN, HNC) and monitored their production rates as a function of heliocentric distance (r_h). As comet Hale-Bopp approached the Sun, these species displayed different behaviours. Far from the Sun, the most volatile species were found in general relatively more abundant in the coma, but there was no precise correlation between the over-abundances and the equilibrium sublimation temperatures of the species. The change from a CO–driven coma to an H_2O–driven coma occured at about 3 AU. The HNC/HCN abundance ratio increased with decreasing r_h, questioning its true value in cometary nuclei. At perihelion, the relative production rates approached those found in other comets near 1 AU.

The expansion velocity of the gaseous species, derived from the line shapes, increased with decreasing r_h with a law close to $r_h^{-0.5}$. The kinetic temperature of the coma, estimated from the relative intensities of the CH_3OH and CO lines, also increased, from about 10 K at 7 AU to 120 K at perihelion. The different spectral shifts observed for the OH and CO lines at $r_h > 3.5$ AU are taken as evidence that H_2O was then mostly sublimating from icy grains, in contrast to the more volatile CO species, which was mainly outgassed from the nucleus.

37.05

Multiwavelength Observations of the Nucleus and Coma of Comet Hale-Bopp

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We present multiwavelength observations of the nucleus and coma of the bright, giant comet C/1995 O1 (Hale-Bopp) in the optical, IR, and radio regimes. The nucleus was observed by NRAO's Very Large Array in a 66-hr observation, during 20 to 27 Mar 1997. This is the first detection of the nuclear thermal continuum radiation from a comet at that observatory. We also observed the occultation by the comet's nucleus and inner coma of a ninth-magnitude star on 5 October 1996; the analysis of the light-curve corroborates our microwave nuclear results, and also shows the inner coma of Hale-Bopp to be optically thick. To our knowledge, only one other comet nucleus was observed to occult a star with such a small impact parameter (the low-activity comet 95P/Chiron). We also present preliminary analyses of thermal-infrared imaging of the comet taken at NASA/IRTF (with the MIRAC2 and MIRLIN cameras) near perihelion. These data show the comet's rotation period, via the comatic morphology. We are working to explain the rotational behavior of the nucleus, as well as model the thermal behavior of Hale-Bopp's nucleus in all wavelength regimes.

37.06

Comet Hale-Bopp's Diffuse Sodium Tail

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We have imaged a diffuse sodium tail of comet Hale-Bopp, using large field-of-view observations from the McDonald Observatory in March 1997. We subtracted off-band images from sodium-filter images to obtain the atomic sodium tail. The sodium tail was between the dust and ion tails, as seen from the earth. It was broader than the dust or ion tails, and its radially integrated brightness increased with distance from the nucleus for at least 8 million km. It did not resemble the narrow sodium tail observed by Cremonese *et al.* (1997) in April, implying a new source mechanism began operating in the intervening time. Our preliminary analysis indicates that the sodium in the diffuse tail could not have traveled from the nucleus in atomic form, nor been liberated from molecular ions in the plasma tail. At this point, we find dust to be the most likely source for the sodium gas. However, since the brightest part of the sodium tail does not coincide with the visible dust tail, any sodium-producing dust must be either dark, or too small to backscatter visible light.

Cremonese, G., H. Rauer, A. Fitzsimmons, I.A.U. Circular no. 6643, Central Bureau for Astronomical Telegrams, Smithsonian Astrophysical Observatory, Cambridge, 1997.

FRIDAY

37.07

Sodium in Comet Tails

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In September, 1985, the International Cometary Explorer spacecraft, passed through the tail of comet Giacobini-Zinner 7800 km from the nucleus. The relative velocity was 21 km/s. Instruments aboard the spacecraft made magnetic field, energetic particle and ion composition measurements. The composition measurement showed the presence of water group and CO+ ions as well an appreciable but localized flux of ions with M/Q = 24 +/- 1. These observed ions were tentatively identified by Coplan *et al.* (J. Geophys. Res. 92, 39, 1987) as either C2+ or Na+. In this paper we reinterpret these measurements in light of the recent spectroscopic observations of sodium atoms in tail of the comet Hale-Bopp.