Abstract P-3-1

COORDINATED OBSERVATIONS OF COMET HALE-BOPP BETWEEN 32 AND 860 GHZ

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Coordinated simultaneous multifrequency continuum observations, successfully used for the first time on Comet Hyakutake, were applied to Comet Hale-Bopp. We used the Heinrich Hertz Submillimeter Telescope (HHT) with the four color bolometer between 250 and 870 GHz, the IRAM 30m telescope at 250 GHz, the MPIfR 100m telescope at 32 GHz, and the IRAM interferometer near 90 and 240 GHz. Near-simultaneous measurements were done between February 15 and April 26, 1997, mainly concentrated in mid March shortly before perigee of the comet.

The measurements gave the following preliminary results:

1. interferometer detection of the nuclear thermal emission. The derived mean diameter is of order 50 km.

2. the comparison of the interferometric continuum emission with the simultanously obtained molecular line observations (Bockelée-Morvan et al., this conference) shows that the origin of the strongest line emission is concentrated on the nucleus.

3. a radio halo with a gaussian FWHP of ~ 11 arcsec, corresponding to a diameter of 10000 km at geocentric distance of 1.2 a.u.

4. a spectral index of $\sim$3.0 for the total bolometer signal (nucleus plus halo).

Assuming an average cometary density of 0.5 g cm^{-3}, the mass contained in the nucleus is $\sim$3 10^{19} g and $\sim$$10^{12}$ g in the particle halo.

Abstract P-3-2

ON THE PECULIARITY OF THE WATER 22 GHz EMISSION LINE IN COMETS: SL-9, HYAKUTAKE AND HALE-BOPP

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The 22 GHz water transition occurs between the rotational levels 6 (16) $\rightarrow$ 5 (23) at 643 K above the zero point energy and may be inverted in some regions of the cometary coma but it seems that the column densities of the rotational levels are much too small to produce a detectable signal. Many attempts to detect this radio line have been carried out in the past on different comets,but no reliable results could be achieved.

Due to the exceptional impact of comet SL-9 with the Jupiter atmosphere we were able,by using a fast multichannel spectrometer coupled with the 32 m dish of the Medicina radiotelescope,not only to detect this line but to discover also the first water MASER emission in the solar system (1). The observations of Comet Hyakutake at perihelion gave also positive results, and the observed puzzling behavior of neutral water molecules,travelling at speeds of 20-40 Km/sec in the cometary coma,opened a new insight in the complex plasma-grain interaction physics (2).

We attempted to detect this line also in comet Hale-Bopp in the period March-April 1997 and a careful analysis of the data is still in progress. Preliminary results show no evidence of emission lines in the 22 GHz range but further observational tests are foreseen.

In this paper we will compare the results in the three comets and discuss the observational constraints.

1) C.B. Cosmovici, S. Montebugnoli, A. Orfei, S. Pogrebenko and P. Colom Planet. Space.Sci., 44, 735, 1996

2) C.B.Cosmovici, S.Montebugnoli, A.Orfei, S.Pogrebenko and S.Cortiglioni, Planet.Space.Sci, in press, 1998

Abstract no. P-3-3

MAPS OF OH MASERS AROUND COMET HALE-BOPP

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Comet Hale-Bopp has been observed at both OH mainline frequencies (1665 and 1667 MHz) using the Lovell radio telescope. On 28 March 1997 absorption was seen at velocities relative to earth $V_\oplus \approx -2$ km s^{-1} which was close to the comet core velocity at this time. There was an emission peak at $V_\oplus \approx 1$ km s^{-1}. This is consistent with the pumping scheme for OH masers proposed by Despois et. al (1981) A&A **99** 320 and Gérard et.al (1987) A&A **187** 455. The maser inversion is produced by solar UV line emission. The heliocentric velocity of the gas containing the OH radicals determines whether the upper or the lower level of the masing transition becomes overpopulated, and so whether absorption or emission is seen. The coma expands away from the comet at several km s^{-1} so that the side nearest the sun (largely overlapping the side nearest the earth at this epoch) has a more negative heliocentric velocity than the far side. The model predicts maser emission for $-1 \leq V_\odot \leq 5$ km s^{-1}, and absorption at velocities a few km s^{-1} outside this range.

There were two seven-hour imaging sessions close to perihelion on 1 April 1997. In each, seven pointing positions of the Lovell telescope were used in a hexagon $15'$ in diameter centred on the comet nucleus. The comet was tracked in position and velocity using the NASA ephemeris. 1667 MHz spectral spectral line maps were made with a spatial resolution of $5'$ and a velocity resolution of 0.5 km s^{-1}. The most intense emission, 0.1 K, was observed on 1 April 1997 close to the core velocity. Some absorption was also seen offset in both position and velocity. The average intensity ratio of 1667:1665 MHz emission is 1.9 ± 0.4.

These observations can be used to constrain maser pumping models and mechanisms for the production of OH. It may be possible to relate them to the jets containing water vapour which were seen to outgas from the core of Hale-Bopp.

Abstract P-3-4

OBSERVATIONS OF THE OH RADICAL IN COMET HALE-BOPP WITH THE NANÇAY RADIO TELESCOPE

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The OH radical has been monitored in comet C/1995 O1 (Hale-Bopp) between August 1995 and September 1997 using the Nançay radio telescope. The first detection of the 1667 MHz and 1665 MHz lines of the OH radical occurred in April 1996, at a heliocentric distance of 4.7 AU. Since then, the comet has been observed on an almost daily basis.

From October 1996 to July 1997, the comet was systematically observed at the nucleus position and several beam offsets East and West. These observations, together with those made previously on comet C/1996 B2 (Hyakutake), allow us to improve the modelling of the collisional quenching of the OH maser lines.

We will present the evolution of the OH production rate of the comet, which reached 10^{31} s^{-1} at the end of March 1997. The water expansion velocity, derived from the line shape, increased with decreasing heliocentric distance. Owing to the strong activity of the comet, several new phenomena were observed such as OH thermal emission, anisotropic collisional quenching and water sublimation from grains.

Abstract P-3-5

COLLISIONAL QUENCHING OF OH RADIO EMISSION FROM COMET HALE-BOPP

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The 18-cm OH radio line arises from the molecule's ground state lambda doublet. In comets, the excitation of these energy levels is usually dominated by a process involving absorption of solar UV photons followed by a radiative cascade back to the ground state. This process generally leads to either a strong inversion or anti-inversion of the population of the lambda doublet, and the comet may then amplify or absorb background radiation to produce a strong spectral line. In comets with a high gas production rate, however, the OH radio emission is usually weaker than expected because collisional excitation thermalizes the levels, effectively "quenching" the radio emission.

The high gas production rate of Comet Hale-Bopp provided an excellent opportunity to study this quenching phenomenon and constrain densities in the inner coma. Regular observations were carried out at the NRAO 140-foot antenna during August 1996 — September 1997 to monitor the gas production rate and, when the comet was sufficiently bright, map the OH radio emission. Maps of the emission provide strong constraints on the amount of quenching in the coma. Analysis of the total radio OH flux and maps of its radial brightness distribution indicate a quenched region on the order of ~500,000 km during March and April. This large value is generally consistent with previous observations of radio OH quenching in lower production rate comets when the high production rate of Comet Hale-Bopp is considered.

Abstract P-3-6

THE LINEWIDTHS OF MOLECULAR EMISSIONS OF COMET C/1995 O1 (HALE-BOPP)

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We extensively observed Comet Hale-Bopp at the National Radio Astronomy Observatory 12-m telescope, when the comet was on the incoming branch of its orbit. Our most important objective was to attempt to understand how parent species are released from the nucleus as the comet nucleus gets progressively heated by sunlight. Carbon monoxide emission was detected and monitored at 230 GHz beginning at 6.5 A.U., well before the first OH emission was detected near 5 A.U. This indicates that water was not then the main outgassing nuclear species, as it later becomes when the comet penetrates inside of 5 A.U. We also detected and monitored emissions by H_2CO, CH_3OH and HCN.

Among the most interesting features in the data we collected beyond 4 A.U. was the fact the line characteristics differ widely from one species to another. The most obvious difference is that the CO lines are narrower and more highly velocity shifted towards the sun than the other lines. To interpret those observations requires us to thoroughly investigate the line excitation mechanisms and the nature of the production paths of the species. The key question is to establish whether the observed "parent" species are released at the nucleus, or from grains in the coma, or both.

For CO, the response is straightforward as the molecules cannot efficiently be excited by collisions outside the very inner coma when the comet is still at large heliocentric distances. Thus, only the population of molecules coming from the nucleus can be observed. Progressively, fluorescence becomes more effective as the comet approaches the Sun, and two excitation processes compete to form the observed lines. In this way an extended CO source becomes then detectable. The shape and the velocity offsets of the other lines we detected indicate that at large heliocentric distances there is either production from unknown parent species or production from grains that have to be dragged out of the nucleus by CO, the most abundant coma molecule before H_2O sublimation begins.

Abstract P-3-7

A SEARCH FOR VARIABILITY IN THE HCN/H_2CO RATIO OF HALE-BOPP

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Our group made submillimeter observations of comet Hale-Bopp using the Heinrich Hertz Telescope in Arizona. One of our goals was to search for temporal variability in coma abundance ratios that might be caused by inhomogenities in the nucleus and any "jets". At this time, we report no clear evidence for HCN/H_2CO variability and suggest that in late March 1997, the bulk ratio in the coma varied by less than 20%. The HCN/H_2CO ratio was chosen for monitoring due to a fortuitous alignment in our double sideband system that allowed us to simultaneously observe the HCN (4-3) line at 354.505 GHz and an H_2CO line at 351.768 GHz. Simultaneous observations result in scan-to-scan calibration errors being removed from our measured ratio, and give us the ability to recognize changes on the shortest possible time scales. A further reason to monitor the HCN/H_2CO ratio comes from the Giotto spacecraft, which may have observed an H2CO rich jet from the Halley nucleus. We measured the ratio with 10 minute integration times from 29 March 1997 03:30 to 06:30, 29 March 22:10 to 30 March 01:15, and 30 March 05:50 to 06:50, all times GMT. An analysis of half the data failed to resolve any unambiguous variations. At the time of the conference, a full analysis of our complete HCN/H2CO data set will be presented, including mapping of the spatial distribution of the two species.

Abstract P-3-8

INFRARED SPECTROSCOPY OF COMET HALE-BOPP

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High resolution ($\lambda/\delta\lambda \sim 20,000$) spectra of comet Hale-Bopp (C/1995 O1) in the 2-5 μm region were obtained during UT 2-5 March UT using CSHELL at the NASA Infrared Telescope Facility (IRTF) on Mauna Kea. Complementary moderate resolution spectra were obtained during the same period using CGS4 at the United Kingdom Infrared Telescope (UKIRT), also on Mauna Kea. The heliocentric and geocentric distances of the comet were 1.0 AU and 1.5 AU, respectively. The CSHELL spectra revealed emission lines of the gas-phase molecules CH_4, C_2H_6, HCN, C_2H_2, H_2O, and CO. The UKIRT spectra showed little or no evidence for gaseous emissions due to the overwhelming strength of the continuum emission from dust. The P8-P11 lines of HCN and the P7 line of C_2H_2 were detected in the 3.0 μm region. The estimated rotational temperature of HCN was $\sim$80 K, which we assume was valid for C_2H_2 as well. Estimated production rates at the nucleus were $\sim 7.4 \times 10^{27}$ molecules sec^{-1} for both species. Assuming a water production rate of 4.0×10^{30} molecules sec^{-1} (Dello Russo et al., IAUC 6604), we derive relative abundances of $\sim$0.18% for both HCN and C_2H_2. Lines of OH were also present in the CSHELL spectra, and NH_2 lines were probably detected as well. Additional previously unidentified emissions will also be discussed.

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Abstract P-3-9

A MOLECULAR SURVEY OF COMET C/1995 O1 (HALE-BOPP) AT THE IRAM TELESCOPES

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We present observations of minor parent volatiles in comet Hale-Bopp undertaken near perihelion with the Institut de Radioastronomie Millimétrique (IRAM) telescopes at Plateau de Bure (France) and Pico Veleta (Spain). They resulted in the first detections of HCOOH, SO_2, NH_2CHO and $HCOOCH_3$ in a comet. HDO was detected through its $3_{12} - 2_{21}$ line at 225.897 GHz, complementing the observation of the $1_{01} - 0_{00}$ line at 464.925 GHz at the James Clerk Maxwell Telescope (Meier *et al.* 1997, BAAS 29, 1048). Several unidentified lines are present in the spectra.

Observations of HC_3N, HNCO, OCS, SO, CN, CO^+, HCO^+, in addition to more "classical" species CO, HCN, HNC, CH_3CN, CH_3OH, H_2CO, CS and H_2S (Biver *et al.* 1997, this meeting) permit us to make out an extensive inventory of the composition of the coma of comet Hale-Bopp at its perihelion. In addition, stringent upper limits on the abundances of a number of species of peculiar interest are obtained. A comparison with abundances found in interstellar hot cores believed to reflect the composition of interstellar grains is presented and discussed.

Abstract P-3-10

AN ATTEMPT TO DETECT THE INTERCOMBINATION TRANSITION LINES IN COMET HALE-BOPP

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The C_2 molecule is a well-known species in the cometary spectra, since it appears as one of the brightest emission feature in the visible range, and was observed for the first time more than one century ago. The fluorescence process of this molecule, nevertheless, is still not completely explained by astronomers. One of the reason of this poor knowledge is the key role played by intercombination transitions occuring between the singlet and triplet states. These transitions are normally forbidden by quantum mechanical laws, nevertheless their existence is due to the perturbations occuring between the different states.

The knowledge of these transitions is due, so far, either to theoretical work or by a comparison of the "classical spectra" (mainly the Swan bands, appearing around 500 nm) with fluorescence calculations including some intercombination transitions.

In order to get more information on these transitions we tried to detect directly their existence by the emission lines predicted in the infrared. Indeed, even if the transition probability corresponding to these transitions is very weak, it is compensated by the fact that they arise from one of the two electronic ground states (either singlet or triplet), i.e. from a state having an important relative population level. The fluorescence efficiency of these transitions should be important enough to allow the direct detection of the emission lines.

We conducted an observational program with the Cerro Tololo Interamerican Observatory 4 m telescope, located in Chile, on September 14^{th} and 15^{th}, 1997. The spectral range covered was 1.98 - 2.15 μm, in order to detect the emission lines of the X→a (3,0) band, which bandhead should be located at about 2.12 μm and degraded to the blue. This band was chosen because of its expected brightness and its wavelength, corresponding to an atmospheric window and a relatively low sky background. In our talk we shall present the results obtained with these experimental data.

Abstract P-3-11

IR ALBEDO OF THE DUST RELEASED BY AN OUTBURST OF COMET HALE-BOPP (C/1995 O1)

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The comet Hale-Bopp has been observed in the infrared (1–2.5 μm) with the Nordic Optical Telescope (NOT) equipped with the Arcetri NICMOS3 camera (ARNICA). The observations were performed at the beginning and at the end of September 1996, when the comet heliocentric distance was about 3 AU.

During the second run the effects of a strong outburst, occurred on the day before the beginning of the observations, have been observed. In the first three nights of observations (24.8–26.8 Sept.) a dust shell expanding in the northern quadrant is clearly evident. The shell expanded and moved with an approximate projected velocity of 0.14 km/s and the dust production rate increased by a factor ≈ 3 during the outburst.

A change in the IR color indexes J-H and H-K, well correlated with the dust shell, is clear in the first night of observations. This is an indication that the material released by the outburst has a different composition and/or size distribution than that in the "quiescent" dust coma.

In this poster we present the evolution and the characteristics of the dust shell and discuss possible candidates for the material released by the outburst.

Abstract P-3-12

THE OBSERVATION AND RESEARCH OF COMET HALE-BOPP IN CHINA

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Since comet Hale-Bopp was discovered on 1995 July 23, many Chinese astronomers were involved in monitoring and studying it. A wealth of optical, IR and radio observations of comet Hale-Bopp and theoretical studies have been obtained. In this paper, we will give a brief account of the observation and research of comet Hale-Bopp in China. We present following principal contents:

(1) CCD photometric images in BVRI broadband;
(2) Slit spectra;
(3) Large scale photographic images;
(4) Radio observation;
(5) Theoretical researches.

Abstract P-3-13

SURFACE PHOTOMETRY OF COMET HALE-BOPP CARBON IMAGES

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A very long series of photographic observations of the comet with enormous brightness, Comet Hale-Bopp, has been made in January-April 1997 with a double astrograph (400/2000) at the Main Astronomical Observatory of National Academy Science (Kyiv,Ukraine). Some of the cometary photos were obtained with two wide-band filter combinations.One of these combinations isolates C_2 (1-0) emission, the other – cometary continuum near this emission. The plates were digitized by means of AMDPH-XY machine. Then we calibrated the plates following traditional procedure. We substracted the continuum images from corresponding C_2 images and obtained carbon emission images. The distribution of the surface brightness in the carbon coma of Comet Hale-Bopp was studed.

Abstract P-3-14

THE NARROW-BAND PHOTOMETRY OF COMET C/1995 O1 (HALE-BOPP)

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Photometric observations of comet C/1995 O1 (Hale-Bopp) carried out at the Stará Lesná Observatory during 10 nights, since February to April 1997, are analyzed and discussed. The comet was observed mostly in the pre-perihelion phase about two months at the ranges of heliocentric and geocentric distance 1.3-0.9 AU and 1.9-1.3 AU, respectively.

The observations were performed by a photoelectric photometer, installed in the Cassegrain focus of the 600/7500 mm reflector. The measurements were carried out with the narrow-band filters CN, C_2, C_3, Cont. 365 nm and Cont. 484.5 nm. Three diaphragms, 76", 119", and 196" in diameter, were used. The comet passed only rarely in a vicinity of standard stars. That is why 14 stars, not measured before in the filters, had to be used. Their magnitudes in the mentioned filters were obtained additionally, during September and October 1997, when they could be observed under better conditions – at smaller air masses.

Emission band fluxes F_e and continuum fluxes F_c are presented, from which the total numbers of molecules M in the columns of the coma encircled by diaphragms are calculated. The production rates Q/v are estimated from the conventional Haser model.

Abstract P-3-15

SOURCES OF CN IN COMET C/HALE-BOPP

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Images of Comet C/Hale-Bopp in the CN-emission at 3880 Å were taken in August 1996 with the 1.5m Danish telescope at the European Southern Observatory, Chile. The heliocentric distance of the comet was 3.4 AU.

The spatial structure of the CN-emission is similar to that seen in HCN. Dust jets visible in near-simultaneous continuum images are not detectable in CN. From that we conclude that dust is no significant source of CN in comet Hale-Bopp at large heliocentric distance.

Attempts to use the Haser-model to derive scaleheights and production rates of CN yielded inconsistent results, showing evidence that the Haser-model might be unappropriate to describe the gas-distribution of a bright comet at large heliocentric distance.

Abstract P-3-16

NARROWBAND PHOTOMETRY OF COMET HALE-BOPP (C/1995 O1) NEAR PERIHELION

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Narrow band electrophotometric observations of comet Hale-Bopp have been made with the AZT-14 telescope at the station Lisniki of Kyiv University Astronomical Observatory. The standard set of IHW cometary filters have been used. Total numbers of cometary observations were more than 620 during interval 13 March - 29 April 1997. The photometric reduction took account because there were possible variations of atmosphere transparency and photometry response. The comet nucleus gas productions rates Q of C_2 and C_3 have been calculated on the basis of the star magnitudes of comet for these filters. The calculations had been made with the help of the Haser model for neutral cometary atmosphere. The value $Af\rho$, which is some characteristic of the dust nuclear production rate, have been determined too. Mean values of the production rates near perihelion are $\log Q(C_2) = 28.4$; $Q(C_3) = 27.2$; $Af\rho_{BC} = 6.0$. These values are close to ones obtained other observers, for example (T.Farnham et al.(1997). The difference of $Af\rho$ values for the BC and RC filters shows the presence of the RC filter emission excess in comparison with the Sun and increases according to the law $\log[(Af\rho_{BC})/Af\rho_{RC}] = -0.00066t - 0.061$, where t - time in days from perihelion. It is possible to describe such difference for UC and BC filters as $\log[Af\rho_{UC}/Af\rho_{BC}] = 0.0045t - 0.0055$.

References: T.Farnham, D.Schleicher, S.Lederer (1997). Comet C/1995 O1 (Hale-Bopp). IAUC 6589.

Abstract P-3-17

OBSERVATIONS OF HIGH RESOLUTION SPECTRA OF COMET HALE-BOPP AT THE SAO OF THE RAS

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High resolution spectra give a possibility to study isotope ratios in comets, the presence of the cometary continuum of the nonsolar origin and peculiarities of rotational structure of different cometary emissions. Succesful spectral observations of comet C/1996 O1 (Hale-Bopp) at Special Astrophysical Observatory of the Special Astrophysical Observatory of the Russian Academy of Sciences (Northern Caucasus, Nizhny Arkhyz, Mount Pastukhov) with the 1-meter Zeiss reflector and echelle-spectrometer (resolution 0.01 nm), CCD and long slit, oriented along and perpendicular to radius-vector "Sun-comet direction" were made. Nine spectra of the comet were obtained before perihelion at the heliocentric distances of 3.85-3.79 A.U. and the geocentric distances 2.85-2.81 A.U. during July 7-12 (observers are F.Mussaev, I.Bikmayev, G.Galazutdinov and V.Kleshchonok) and five spectra of the comet after perihelion at the heliocentric distances 0.96-0.97 A.U. and at the geocentric distances 1.55-1.58 A.U. during April 17-19 1997 (observers are F.Mussaev and K.I.Churyumov) were obtained. Emissions of CN, C_3, C_2, CH, NH, Na , NH_2, H_2O^+ and others and many unidentified molecular or atomic emissions of different strengths were detected in obtained spectra of comet Hale-Bopp. Fig. shows train of rotational transitions of the $C_2(0-0)$ spectral band in the spectrum of comet Hale-Bopp April 17, 1997. The results of the exploration of the high resolution spectra of comet C/1995 O1 obtained before and after perihelion are discussed.

Abstract P-318

SPECTRA OF COMET C/1995 O1 (HALE-BOPP) OBTAINED WITH 6-M BTA REFLECTOR AT MOUNT PASTUKHOV

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In July 1996 - April 1997 uniqie series of spectral observations of the comet with anomal brightness C/1995 O1 (Hale-Bopp) succesfully obtained with the planetary spectrograph (+CCD) of the 6-meter BTA reflector at the Special Astrophysical Observatory of Russia Academy of Sciences (Northern Cuacases, Nizhny Arkhyz). Comet at that time was at the heliocentric distances of 3.81-3.79 A.U. and at geocentric distances of 2.82-2.81 A.U. and had 6 magnitude. Observations were held with a long slit oriented as well as along and perpendicular a prolonged radius-vector (Sun-Comet direction) and perpendicular to the direction of the comet motion. Spectrograph was installed in the primary focus of 6-m telescope. In the CCD-camera of the spectrograph the matrix with dimension 530x580 pixels was applied. During the observations diffraction grate with the dispersion of above 0.3 nm per pixel with the spectral resolution 0.5 nm was used. The image scale along the slit (perpendicular to dispersion) is 0.41" per pixel. During three nights of observational time July 10-12, 1996 87 spectra and April 15, 1997 5 spectra of the comet Hale-Bopp were obtained with the 6-m telescope. The distribution of energy in spectra for different distances from the nucleus in the coma are built. The hypothesis about unknown cometary spicies near $\lambda = 620nm$ in the spectrum obtained July 10, 1996 is made. It is found effect which was observed for real number of comets and is caused by contribution of fluorescent of cometary dust. The final aim is on the basis of the spectral observations of comet Hale-Bopp with 6-m telescope to built the detailed spectral map of the comet head and to study spectral peculiarities active (with jets and shells) and inactive region of the coma as well as far from perihelion and close to one.

Abstract P-3-19

CCD OBSERVATIONS OF COMET HALE-BOPP ON SHAJN TELESCOPE. I. COUDE SPECTRA.

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Spectroscopic observations of Comet Hale-Bopp were made on the 2.6m Shajn Telescope of the Crimean Astrophysical Observatory. Some spectra were obtained with high spectral resolution, FWHM=0.2÷0.4 Å, in the coude focus on February 22 and 26, 1997. The observations were made in selected spectral windows (4805÷4872 Å, 6528÷6595 Å, 7186÷7253 Å, 8276÷8408 Å). The spectrograph slit was centered on the nucleus and had dimensions of 0.6×22.5 arcsec^2 on the plane of the sky. The continuum spatial profiles were extremely asymmetrical toward the Sun. However, the continuum-subtracted spatial profiles of the molecular emissions were symmetrical relative to the nucleus, except for C_2. The shape of the spatial profiles of the C_2 emissions is similar to that one of continuum but is more smoothed. So, indications are that dust can be an additional source of the C_2 radicals in the cometary coma. The main aim of our research was identification of the cometary emissions. Using recent laboratory spectroscopic data we identified new lines of C_2 associated with the transitions from high rotational levels in the 4805÷4872 A spectral region. We detected cometary H-alpha emission as well. New emissions of CN (Red system), NH_2 and C_2 (Phillips system) were find in the red spectral windows. Some emission features are still unassigned.

Abstract P-3-20

FIBEROPTICALLY MULTIPLEXED MEDIUM RESOLUTION SPECTROSCOPY FROM THE WIYN TELESCOPE, SINGLET D NEUTRAL OXYGEN, NH_2 and H_2O^+

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The WIYN 3.5–meter telescope and its Multi–Object [Bench] Spectrograph have been used to obtain simultaneous spectra at many points in the coma of Comet Hale–Bopp. Between 1996 October and 1997 April in excess of 7500 individual spectra were obtained, typically 96 at a time.

On six nights the "Hydra" fiber positioner was used to sample a ring pattern of points about the nucleus with a minimum spacing of 40 arc seconds and a maximum radius of 22.5 arc minutes. On four nights a new "Densepak" fibercable was used. In this configuration a 7 x 13 rectangular pattern of 91, 3 arc second fibers on 4 arc second centers was used. In most cases the bench spectrograph was used in the echelle configuration with an interference filter to isolate a single order. The wavelength range $\lambda\ \lambda$ 6100 - 6400 Å was recorded with resolution $R \approx 15,000$. This spectral region contains the emission features of [O I], C_2, NH_2 and H_2O^+. From this mass of data we are beginning to extract the radial, azimuthal and temporal variations of many different spectral features. The radial profiles of [OI] λ 6300 Å and NH_2 are reasonably well representable by the Haser model formalism, that of H_2O^+ is not.

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Abstract P-3-21

OBSERVATIONS OF C_2 MOLECULES IN THE COMA OF COMETS AT MITAKA

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In order to realize the nature and to find various phenomena of comets, we continually made the near-nucleus imaging observations. Now we report on the results of the observations of two spectacular comets. One is the analysis of photometry of C_2 emission images in the coma of comet Hyakutake (C/1996 B2). By the comparison of production rates of C_2 radicals with C_2H_2 molecules in its coma, most C_2 were originated from C_2H_2 but some of them were made by other parents.

Another is the analysis of morphology of C_2 emission images in the coma of comet Hale-Bopp (C/1995 O1).

An asymmetrical distribution of neutral gas in its coma was detected. The results of these two comets would suggest that a portion of C_2 were formed by the collapse of the small organic dust grains, so-called 'CHON' particles.

Abstract P-3-22

COMPARATIVE STUDY OF THE OPTICAL SPECTRA OF COMETS C/1996 B2 (HYAKUTAKE) AND C/1995 O1 (HALE-BOPP)

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CCD spectra of comets Hyakutake (16 spectra in pre-perihelion phase) and Hale-Bopp (22 spectra in both pre- and post-perihelion phase) have been obtained on the 1.5 meter telescope. In most cases, the wavelength regions studied range from 4000 to 4900 Å and from 6250 to 6900 Å, at the dispersion 38 $Åmm^{-1}$ and 28 $Åmm^{-1}$, respectively. Emission bands of the molecules C_2, C_3, CH, CN, CO, NH_2, H_2O and other species have been detected, as well as the atomic emission lines of [OI]. We have measured relative intensities and equivalent widths (EW) of the emission features. The EW of the emission features in the spectra of Hyakutake are greater than those in the spectra of Hale-Bopp at the same heliocentric distance. This fact reflects difference in the gas-to-dust ratios in two comets. We try to make rough estimates of this ratio as well as of relative production rates of some species. One higher dispersion spectrum of Hale-Bopp obtained on April 6, 1997 covers the spectral region around 5900 Å where the emission lines of NaI have been reported to exist, but no definite emission features were present in our spectrum.

Abstract P-3-23

HUBBLE SPACE TELESCOPE OBSERVATIONS OF COMET HALE-BOPP

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The *Hubble Space Telescope (HST)* has been systematically monitoring comet Hale-Bopp since September 1995, except that solar elongation angle constraints precluded observations from late-October 1996 through late-August 1997. The post-perihelion observations with *HST* began on 27 Aug 1997 (at r=2.476 AU and Δ=2.989 AU), and were made using the newly-installed Space Telescope Imaging Spectrograph (STIS). The STIS CCD was used to image the comet, and useful spectroscopy was performed between 2100-3190 Å using the G230LB and G230MB gratings. The morphology of the images closely resembled that obtained at similar heliocentric distances pre-perihelion (i.e., "porcupine" appearance), but the dust production rate was slightly lower post-perihelion. From the observed emission in the OH(0,0) band, we derived a preliminary value for the water production rate of $\sim 3 \times 10^{29}$ molecules s^{-1}, which is comparable to the pre-perihelion value. The 2-dim nature of the STIS data allowed us to map the spatial distribution of the OH emission, and the $\sim$6 Å resolution of the G230MB grating permits a detailed examination of the OH excitation. Preliminary analysis indicates that a conventional vectorial model can reproduce the observed OH spatial distribution. Emissions from CS and the OH(1,0) band were observed in the G230LB data. A second set of *HST* observations of Hale-Bopp were obtained on 11 Nov 1997 (at r=3.375 AU and Δ=3.305 AU), and the final observations in our program will probably take place in mid-Feb 1998.

Support for this work was provided by NASA through grants GO-6663 and GO-7713 from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-26555.

Abstract P-3-24

OBSERVATIONS OF HALE-BOPP WITH THE SHUTTLE-BORNE SWUIS TELESCOPE

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Our team flew an innovative new wide-field ultraviolet (UV) imager to observe comet Hale-Bopp from the Space Shuttle Discovery during flight STS-85. The instrument is called the Southwest Ultraviolet Imaging System, or SWUIS (pronounced like "swiss"). The primary objective of the SWUIS Hale-Bopp Imaging experiment was to obtain image sequences of Hale-Bopp to study its coma and tail morphology and response to solar wind conditions during the scientifically-interesting, classical turn-off phase as the comet moves outbound beyond 2 AU. We will discuss the results of obtained by SWUIS during the mission. We collected more than 300,000 useful frames in the ultra-violet and visible during 9 orbits on 5 days of the mission, August 14-19, 1997.

Abstract P-3-25

GROUND-BASED OBSERVATIONS OF HALE-BOPP WITH THE SOUTHWEST UV IMAGING SYSTEM (SWUIS)

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We have successfully used our existing Southwest Research Institute (SwRI)-owned Southwest UV Imaging System (SWUIS), to demonstrate the acquisition of ground-based multispectral images of comet Hale-Bopp in the visible for time-evolutionary studies of its coma and tail during the March-April 1997 time frame when Hale-Bopp was near perihelion. The SWUIS hardware, consisting of an 18-cm diameter Maksutov-Cassegrain telescope coupled to a low-light level intensified charge-coupled device camera, was taken to two remote locations in the desert Southwest (White Sands Missile Range, NM and McDonald Observatory, TX) to make observations of Hale-Bopp. During these observations, SWUIS was able to capture detailed images of Hale-Bopp's inner coma region where gas and dust activity from the comet's active nucleus was observed and recorded. From these observations, we were able to compute a nucleus rotation period of $\sim$11.5$\pm$0.6 hrs based on an estimate of the dust expansion velocity from jet activity in the nucleus. These observations were made in conjunction with imaging tests to characterize SWUIS for observations of Hale-Bopp from the Space Shuttle *Discovery* during the STS-85 mission in August 1997. We shall describe the SWUIS hardware as well as present the ground-based imaging data results of Hale-Bopp taken with the SWUIS instrument.

Abstract P-3-26

WIDE-FIELD IMAGING OF ION TAIL OF COMET C/HALE-BOPP 1995 O1

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A sequential imaging observation of ion tail of Comet C/Hale-Bopp 1995O1 was carried out in February-March 1997 with a wide-field CCD imaging camera using narrow band filters for two ion species; CO^+ and H_2O^+ along with those for blue and red continuum.

From the surface photometry of the ion tail of two species, we derived a relationship between distance from nucleus and plasma density. The local velocity of the ion flow as a function of the distance from the nucleus was also estimated on the basis of some assumptions. We report preliminary results of our analysis, and discuss some characteristics of cometary plasma and its interaction with interplanetary magnetic field (IMF).

Abstract P-3-27

THE INTERACTION OF C/1995 O1 HALE-BOPP WITH THE SOLAR WIND AS RECORDED IN COCAM IMAGES

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The CoCam instrument of the Isaac Newton Group of Telescopes on La Palma recorded the large-scale structure of Comet Hale-Bopp during several weeks around perihelion. Among the images obtained were narrow-band images of the cometary H_2O^+ ions. An overview is given of the state of the comet's ion tail during the period of data acquisition. The tail's morphology and dynamics are described, as well as the inferences that can be drawn from these parameters.

Abstract P-2-28

CAN THE MAGNETIC RECONNECTION MODEL BE A POSSIBLE TRIGGERING MECHANISM TO EXPLAIN THE DISCONNECTION EVENT IN COMET HALE-BOPP?

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Occasionally, the entire or partial plasma tail separates from the comet and drifts away (antisunward), and this is followed by a renewal of the plasma tail. The cyclic nature of this phenomenon, called a disconnection event (DE), was noted long ago (Barnard, 1899, 1920).

Disconnection events (Niedner & Brandt, 1979; Jockers, 1985; Celnik *et al.*, 1988; Delva *et al.*, 1991; Voelzke & Matsuura, 1997) are common. They occur over wide ranges in heliocentric distance, heliospheric latitude, and the phases of the solar cycle. Although the mechanism for DEs remained unresolved, the solar wind was thought to play a major role in the phenomena of comet plasma tail DEs. In order to explain the cyclic phenomena of DEs, many ideas were suggested (Brandt, 1990). This work, that is just beginning, compared cometary and solar wind data for the purpose of determining the solar wind conditions associated with comet plasma tail DEs.

The current competitive theories to explain the onset of DEs can be grouped into three classes based on the triggering mechanisms (Brandt, 1990): a) Ion production effects (Wurm & Mammano, 1972), b) Pressure effects (Ip & Mendis, 1978; Ip, 1980; Jockers, 1985) and c) Magnetic reconnection effect (Niedner & Brandt, 1978; Russel *et al.*, 1986).

The Hale-Bopp's DEs, in this work, will be interpreted in terms of the location of the magnetic sector boundaries based on the magnetic field data from the Sun in the "surface-source" (Hoeksema *et al.*, 1983) and the expansion of the solar wind.

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Abstract P-3-29

2D BI-ION FLUID SIMULATIONS OF COMETARY TAIL RAYS

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The interaction of the solar wind with a cometary ion source is described by a 2D bi-ion fluid model, in which both ion components are coupled by electromagnetic fields only. It was found that tail rays are formed which are interpreted as 'generalized' Mach cones in the bi-ion plasma flow. The related wave modes are discussed. The results are also = relevant for unmagnetized planets (Venus, Mars) where the solar wind directly interacts with the planetary exosphere/ionosphere.

Abstract P-3-30

DETECTION OF SOFT X-RAY EMISSION FROM COMET C/1995 O1 (HALE-BOPP)

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We report the detection of soft X-rays from the direction of comet Hale-Bopp by the Low Energy Concentrator Spectrometer (LECS) on-board the X-ray satellite, BeppoSAX. The observations took place on 1996 September 10 and 11, approximately 1 day a large dust outburst (Schulz et al., this conference). After correcting for the comets motion, a 7 sigma enhancement was found (2.1 +/- 1.3) x 10^5 km from the position of the nucleus in the general solar direction. The total X-ray luminosity in the 0.1 - 2.0 keV energy band is 5 x 10^16 erg s-1, which at least a factor of 3 greater than that measured by EUVE 4 days later and suggests that the bulk of emission measured by the LECS is related to the dust outburst. The extracted spectrum is well fit by a thermal bremsstrahlung model of kT = (0.29 ± 0.06) keV - consistent with that observed in other comets (e.g., see Lisse et al. 1996, Science 274, 205). We find no evidence of fluorescent carbon or oxygen emission and place 95x 10^{15} ergs s-1 for narrow line emission at 282 and 523 eV, respectively.

Abstract P-3-31

THE SPATIAL SODIUM DISTRIBUTION IN THE COMA OF COMET HALE-BOPP (C/1995 O1)

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Long-slit spectra of sodium D-line emission in the coma of comet Hale-Bopp (C/1995 O1) have been obtained on 14 March and 16 April 1997 from the observatory Haute-de-Provence, France, and the William Herschel Telescope on La Palma, Spain. The spectra show Na spatial profiles within $\approx 2.5\ 10^5$ km from the nucleus along and perpendicular to the sun-comet line. In both observing periods secondary maxima are present, indicating spatial structures in the coma sodium distribution. A comparison with the structures seen in the cometary dust continuum is made and a sodium production rate for the March observing period derived.

Abstract P-3-32

SPECTROSCOPIC OBSERVATIONS OF SODIUM IN THE COMA OF COMET HALE-BOPP (C/1995 O1)

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Spectra of sodium D-lines in the coma of comet Hale-Bopp (C/1995 O1) were obtained at high and medium resolutions from the Observatory of Haute-Provence in March and April 1997. The velocity of sodium atoms at several points within $2\,10^5$ km from the nucleus has been measured. Evidence for a distributed source of Na in the coma is found from the relatively high anti-sunward velocity on the sunward side of the coma, in addition to the large sunward extent of sodium emission in April. The intriguing observed D_2/D_1 ratios can probably be explained by the combination of the Swings effect and the absorption by telluric features.

Abstract P-3-31

SULFUR CHEMISTRY AT MILLIMETER WAVELENGTHS IN C/HALE-BOPP

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The recent availability of bright comets has given us an excellent opportunity to study cometary chemistry. Comet Hale-Bopp (1995 O1) gave us the particularly rare opportunity to study a bright and active comet for almost two years.

Our program concentrated on millimeter-wave observations of sulfur- bearing molecules in an effort to understand the total sulfur budget of the comet. Using the National Radio Astronomy Observatory 12-m telescope on Kitt Peak we monitored both the long and short-term variations in H_2S, CS, and OCS, as well as observing H_2CS and SO. This was the first observation of H_2CS in any comet. Additionally, we mapped CS with the BIMA interferometer.

C/Hale-Bopp is the first comet in which so many sulfur species have been observed. Analysis of the abundances of these species in comparison to the total atomic sulfur observed should reveal whether or not we can now account for all of the primary sulfur sources in comets. Perhaps the most interesting question that these observations leave unanswered is why C/Hale-Bopp appears to contain so much more SO and SO_2 (as observed by others) than any other comet.