Abstract P-4-1

NEAR-INFRARED POLARIMETRIC IMAGING OBSERVATIONS OF COMET HALE-BOPP

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Near-infrared polarimetric imaging observations of comet Hale-Bopp (1995O1) using KONIC (Kiso Observatory Near-Infrared Camera) are reported. Observations are carried out on March 18 UT and April 26 UT 1997, the heliocentric distances of the comet for these dates were 0.94 and 1.02 AU, the phase angles were 48.5 and 32.9 degrees respectively. We obtained linear polarization degrees of near nucleus region of 16.0, 18.8, and 15.1 percent on Mar 18, and 7.1, 8.9, and 6.9 percent on Apr 26 for J, H, and K' bands respectively. These values are higher than those of observed from P/Halley. The maximum polarization was found at H band from both dates. Polarimetric images showed higher polarization tail toward anti-solar direction in J and H bands. K' band images did not show such a tail. No distinct correlation between the high polarization tails and intensity maps was found.

Abstract P-4-2

OPTICAL IMAGING POLARIMETRY FOR THE INNER COMA OF COMET HALE-BOPP (C/1995 O1)

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The optical imaging polarimetric observations of Comet Hale-Bopp (C/1995O1) have been performed from 10 Febrary to 5 May, 1997, using Okayama Optical Polarimeter and Spectrometer system (OOPS) mounted on 91-cm reflector at Okayama Astrophysical Observatory. We used four narrow band filters (two for C_2 and H_2O^+ gas emission bands and two for those near-by continuum bands), as well as a broad band filter (I-band).

Results were obtained for a range of phase angle between 30° and 48°. Our results of polarization become higher than the previous results observed at the same phase angle for P/Halley or some other comets compiled in Levasseur-Regourd et al. (1996, A&A 313, 327). The resulting polarization map of the dust continuum in March indicates the existence of (1)higher polarization region in the anti-solar direction of the dust tail, and (2)higher polarization region shifted to the anti-solar direction similar to the 'arc' structure found in the brightness map. Furthermore, the maps taken in Febrary are different from those in May, although the phase angles on Febrary and May were approximately the same. The dust jet may have caused those differences.

Finally we propose the dust model to explain the higher polarization degree region in the maps based on the numerical calculations.

Abstract P-4-3

CCD POLARIMETRY OF COMET HALE-BOPP

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The Comet Hale-Bopp was imaged around the perihelion phase through the 1-meter astrometric telescope of the Osservatorio Astronomico di Torino. The CCD camera was equipped with a rotating polarizer in order to investigate the polarization properties of the coma. The results indicate that the two-dimensional distribution of polarization intensity is highly inhomogeneous and correlated to the system of jets and shells close to the nuclear condensation. The various problems related to the method of observation are also discussed.

Abstract P-4-4

CCD-POLARIMETRIC IMAGING OF COMET C/1995 O1

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The scattered light by dust in comet 1995 O1 has been observed at Pic du Midi observatory (France) with the 2 m telescope on June and September 1996, and at Haute-Provence observatory with the 80 cm telescope on April 1997. The phase angle is in 7 to 48 deg. range. The polarization maps show significant variations between the circumnucleus region and the "jets" or shells of dust: from -4 percent in the circumnucleus region to 1 percent in the "jets" near 8 deg. phase angle, from 5 percent in the "jets" to 1 percent in the outer coma (the circumnucleus region is hidden by the "jets") near 20 deg. phase angle and from 9 percent near the nucleus up to 18 percent in the dust shells for 48 deg. phase angle. For all the images a clear difference appears between the sunward and antisunward side. For the whole coma, the phase angle dependance is compared with 1P/Halley phase curve. The degree of polarization is high all along the phase curve. It could indicate the possibility of a new class of comets as compared to Levasseur-Regourd et al. classification (1996) or could be only considered as a fantastic comet in permanent outburst.

Abstract P-4-5

IMAGES OF POLARIZATION AND COLOUR IN THE INNER COMA

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From Feb. 28 to Apr. 1, 1997, photometry of Comet Hale-Bopp's dust was conducted with the two-channel focal reducer of the Max-Planck-Institute for Aeronomy attached to the 2m Telescope of Pik Terskol Observatory (Northern Caucasus). Interference filters at 642 nm and 443 nm selected red and blue narrow-band continuum windows. In addition, in the evenings of Mar. 31 and Apr. 1 imaging polarimetry was performed with the four-beam Wollaston polarimeter. The polarization maps at 642 nm cover an area of about 1.5 arcmin diameter around the nucleus. On Mar. 31 and Apr. 1 (phase angles 47.8° and 47.5°) the polarization averaged over a square window of 17000^2 km^2 centered at the nucleus amounted to 16.0% and 15.8%, respectively. In contrast to other observations the polarization angle was oriented normal to the scattering plane within ±1°. In our field of view the polarization increases along the sun-comet line from the solar to the antisolar side from ≈ 13% to 17%. The dust shells show up in the polarization images with an amplitude of about 1%. Colour maps, obtained shortly after the polarization measurements, show a decrease of the colour index C(443) - C(642) (the colour is bluer) at the location of the dust shells. The correlation between polarization and intensity is more obvious than the correlation between colour and intensity.

On Apr. 1, the map of the polarization angle displays features resembling the dust shells. The amplitude of the features, however, is about ±0.5°, i. e. close to the detection limit.

Abstract P-4-6

POLARIMETRY OF COMET HALE-BOPP: LINEAR AND CIRCULAR POLARIZATION, STELLAR OCCULTATION

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Comet Hale-Bopp was observed with the 2.6-m and 1.25-m telescopes of the Crimean Astrophysical Observatory on March 9-11, 1997. We determined the linear and circular polarization in the coma and observed the occultation of the eighth-magnitude star HD 211005 by the cometary coma. The following results were obtained:

- The linear polarization in the cometary dust coma varied from 7.8 % to 12.4 %. For all measured regions of the coma the polarization angle deviated by about 5.8° from the normal to the scattering plane.
- The degree of circular polarization in the coma did not exceed 0.3 % with an accuracy of ± 0.04 % on average. At the cometary nucleus it was less than 0.08 %. The circular polarization was always negative. The circular polarization varied up to 0.1 % without the changing its sign. The results are compared with those of Comet Halley and a combined phase dependence of circular polarization is derived.
- During the occultation the star weakened slightly and the value and angle of its linear polarization changed.

The measured linear and circular polarization of the comet, and the changes in the polarization parameters of the star during occultation indicates the presence of oriented nonspherical particles in the cometary coma.

Abstract P-4-7

NEW RESULTS ON UV PHOTOPOLARIMETRIC IMAGING OF COMET HALE-BOPP WITH THE WIDE-FIELD IMAGING SURVEY POLARIMETER (WISP)

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We report on the improved analysis of UV images of CI (1657A) and dust continuum at 2800A from comet Hale-Bopp taken with the WISP sounding rocket experiment on 8 April, 1997. This presentation includes the results of post calibration, improved image processing, estimates of red contamination, and a direct comparison of the WISP data with both wide field (1 degree) images of OH emission and narrow field spectra of CI (9850A) that were taken simultaneous with the WISP observations. The results of the observations suggest that the dust polarization was consistent with expectations base on visible measurements and expectations for the extrapolation of the scattering characteristics of comet dust to the UV. By contrast the carbon data are highly anomalous. There is no evidence of significant polarization from the CI 1657A multiplet despite theoretical evidence suggesting that the polarization for carbon atoms in fluorescence equilibrium should be 15/examine various possible explanations for this effect (including out of band pass contamination), and discuss what future measurements may be required to better understand the scattering mechanisms involved in the observed result.

Abstract P-4-8

LONG-SLIT SPECTROPOLARIMETRY OF COMET HALE-BOPP

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Long slit spectropolarimetry of comets yields information both on the wave length dependence of polarization as well as its variations in the spatial domain along the slit. We present here the results of spectropolarimetric observations of comet Hale-Bopp on 24^{th} April 1997 using a newly developed spectropolarimeter at the cassegrain focus of the $2.34m$ $(f/13)$ telescope at the Vainu Bappu Observatory. The wavelength coverage is from $5000\mathring{A}$ to $7500\mathring{A}$ with $4.9\mathring{A}/pixel$ resolution.

The Spectropolarimeter slit of length 8mm (= $48arcsec$) was positioned North-South with a slit-width of 800μ (= $4.8arcsec$). The comet centroid was placed at one end of the long-slit while the rest of the slit covered the southern section of the coma which included a prominent spiraling jet.

Lower polarization on the comet centroid (7% at $6000\mathring{A}$) compared to high polarization (38% at $6000\mathring{A}$) on the coma at $40arcsec$ south was observed. The solar phase angle on the date of observation was 49.1 deg. Hale-Bopp being an extremely dusty comet, a de-polarization in the inner coma due to multiple scattering may not be ruled out. The continuum polarization decreases from the red towards blue. These results are similar to the results reported by Harris, Wood and Fox (BAAS, 188, 62.10) for Comet Hyakutake C/1996B2. The prominent jet feature at $11arcsec$ south of comet centroid showed a polarization of 27% at $6000\mathring{A}$. The southern section of the comet during Feb-May was dominated by several overlapping shells from at least 2 active regions. We attempt to explain our observed results by considering the shell geometry.

Abstract P-4-9

NEAR-INFRARED IMAGING SPECTROPHOTOMETRY OF COMET C/1995 O1 (HALE-BOPP) NEAR PERIHELION

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The study of interstellar dust provides insight into astrophysical processes such as star and planet formation and interstellar chemistry. Comets are believed to represent the frozen reservoir of primitive solar nebula dust grains and ices. By studying the composition of cometary dust, we gain a glimpse into the species of organic and inorganic materials, which possibly originated in the ISM, and the processes they were exposed to in the early solar nebula. Infrared imaging and spectrophotometry allows us to examine the types of grains which occupy various features in the comet including dust tails, anti-tails, and jets, and how they behave in the solar radiation field after ablation from the nucleus (Woodward et al. 1996, ICARUS 124, 651).

We present 1- to 5-μm broadband and CVF images of comet Hale-Bopp taken 1997 February 10.3 UT, 49 days before perihelion. All the images exhibit a non-spherical coma with a bright “ridge” in the direction of the dust tail approximately 10 arcsec from the coma. The variation of the integrated surface brightness with radial distance from the coma (ρ) in all the images closely follows the "steady state" ρ^{-1} model for comet dust ablation (Gehrz and Ney 1992, ICARUS 100, 162). The near- infrared colors taken along the dust tail are not constant implying the dust grain properties vary with coma distance. We also examine 3.28μm CVF images to investigate the existence of possible solid state or gaseous emission from molecular species such as PAHs.

Abstract P-4-10

MID-INFRARED SPECTRA OF COMET HALE-BOPP: FIT OF THE OBSERVATIONS BY DUST MODELS

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Comet Hale-Bopp was observed with CAMIRAS, the Saclay mid-infrared camera, mounted on the Nordic Optical Telescope (Roque de los Muchachos, La Palma), from April the 14th to April the 25th. This observing run was part of the European campaign devoted to Hale-Bopp observations from Canary Islands (PI R. West). CAMIRAS spectro-imaging capabilities, achieved with Circular Variable Filters, were used to obtain spectra of the comet in the N atmospheric window (8-13 μm), where large infrared signatures of the silicates are present. Spectra (of resolution R$\approx$50) are available at the spatial resolution of $\sim$1 arcsec over the whole field of view of the instrument (52"X78"). Data were also obtained around 3.4 μm and at 5 μm. Dust models developed at Saclay in the framework of β-Pictoris dust disk studies were used to fit the observations. The results deduced from the fit will be presented at this conference.

Abstract P-4-11

SPECTROCAM-10 THERMAL INFRARED OBSERVATIONS OF THE DUST IN COMET HALE-BOPP

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We present 5 to 18 μm images with subarcsecond angular resolution and 8 to 13 μm, R $\sim$ 100 spectra of comet Hale-Bopp taken with SpectroCam-10 on the 5m Hale telescope during six runs between June 1996 and April 1997. Our data show the gradual warming of dust grains in the inner coma between June when the comet was 4.2 AU from the sun and late March when it was near perihelion. The 10 μm silicate emission feature was already prominent in June 1996 and steadily increased in strength as Hale-Bopp approached the sun, but spectral structure attributed to a crystalline olivine grain component remained relatively constant, indicating a variation in the ratio of small to large particles but little change in grain emission properties over a wide range of temperatures. Near perihelion we also made spatially resolved spectral maps of the inner coma which show variations in the silicate feature with position. We are attempting to correlate these variations with outbursts and jet activity which may account for changes in the grain size distribution.

Abstract P-4-12

ISOCAM OBSERVATIONS OF COMET 1995O1 HALE-BOPP

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Comet 1995O1 Hale-Bopp has been observed in early October 1996 with the high resolution mode of ISOCAM (IFOV of 1.5 arcsec) and several filters covering the 6-15 microns spectral domain. A sophisticated reduction procedure has been developed to correct the different spurrious effects crippling the detector. The temporal evolution of the signal in each pixel has been studied to determine its best estimate. First results will be presented on the detection of the nucleus and on the properties of the dust coma.

Abstract P-4-13

THERMAL IMAGING AND SPECTROSCOPY OF COMET HALE-BOPP: PRE & POST-PERIHELION

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We present results from our ongoing observational and modeling study of the coma particles and nucleus of comet Hale-Bopp. Thermal-infrared observations were obtained at a range of heliocentric distances both pre and post-perihelion.

Utilizing OSCIR [cf.http://www.astro.ufl.edu/ fisher/iral/oscir.html] at the IRTF we obtained the first reported thermal-infrared images of Hale-Bopp on UT May 19.7 1996 while the comet was at a heliocentric distance of 4.36 AU [IAUC 6403]. In October 1996, we obtained multi-aperture photometry from the IRTF using BOLO and the full silicate suite of filters (8-13 microns) as well as broadband N and Q3; in addition we obtained J,H,K, and L imaging using NSFCAM. These observations were near simultaneous with photometry and spectroscopy from the Infrared Space Observatory (ISO) [Peschke *et al.* 1997 BAAS 29, 1029-1030] and the Midcourse Sapce Experiment (MSX) [Walker *et al.* 1997 BAAS 29, 1015].

Using the UCSD mid-infrared camera at the 1.5 meter telescope on Mt Lemmon, we continuosly observed the comet for 11.5 hours at 8.7, 10.3, 11.7 and 12.5 microns on Mar 3.5-4.0 and Mar 5.5-6.0 UT 1997 [IAUC 6600]. These thermal wavelength observations showed an inner coma jet that rotates repeating approximately every 11.3 hours [Sarmecanic *et al.* 1997 BAAS 29, 1034]. Again in April, 1997 using the IAC's Carlos Sanchez telescope we made continuous daytime observations for intervals in excess of 9 hours providing exceptional sampling of the nuclear rotation effects in the inner coma (IAUC 6636). Thus, to date, we have obtained near and thermal-infrared images and spectra at three distinct intervals in accordance with the 'Hale-Bopp days' proposed by the NASA-NSF Hale-Bopp Steering Committee. In December 1997 we are scheduled to observe the comet, while at a heliocentric distance of 3.7 AU, continuously from sunset to sunrise from the southern hemisphere using OSCIR at the CTIO 4 meter telescope. Over the 10 night run 12-21 December 1997, we will obtain 2-D thermal-IR imaging in a full suite of filters from 5-20 microns, as well as 8-14 micron spectroscopy of Comet Hale-Bopp. Initial analysis of the December 1997 observations and comparison with the results from the other campaigns will be the focus of this presentation.

This work was supported by grants from NASA: NAG5-4036,NAG5-4204 and NSF: AST-9615613.

Abstract P-4-14

THE PRE- AND POST-PERIHELION INFRARED SPECTRAL ENERGY DISTRIBUTIONS OF COMET C/1995 O1 (HALE-BOPP) DURING 1997

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Dust grains may be a vehicle for the transportation of significant quantities of condensible elements from the circumstellar winds of evolved stars, novae, and supernovae into the parent clouds of young stellar and planetary systems. Whether grains that condense in stellar outflows ("stardust") survive supernova shocks in the interstellar medium and high temperature processing in the solar nebula to become the "seed" constituents of planetesimals remains uncertain. If some fraction of these grains survive intact, then analyses of the elemental abundances, mineralogy, and physical characteristics of early solar system grains may be expected to provide direct insight into stellar nucleosythesis and evolution. Comets, such as C/1995 O1 (Hale-Bopp), are particularly important to such studies because they are believed to be frozen reservoirs of the most primitive pre-solar dust grains and ices.

Here, we report $1 - 20$ μm IR spectrophotometric observations of comet C/1995 O1 (Hale-Bopp) obtained from 1997 February ($\approx$ 40 days prior to perhelion passage) to 1997 June ($\approx$ 70 days after perhelion passage). In particular, our measurement of the spectral energy distribution (SED) of Hale-Bopp prior to perhelion passage (1997 February) was dominated by scattering and thermal emission from sub-micron sized dust grains that were unusually small. Hale-Bopp's surprising brightness may have been largely a result of the properties of its coma grains rather than the size of its nucleus. The thermal emission continuum from the grains had a superheat of $S = T_{color}/T_{BB} \approx 1.84$, the peak of the 10 μm silicate emission feature was 1.81 magnitudes above the carbon grain continuum, and the albedo (reflectivity) of the grains was ≈ 0.41 at a scattering angle of $\theta \approx 144°$. These are the highest values for these empirical parameters ever observed in 20 years of optical/IR measurements of bright comets (cf., Williams et al. 1997, ApJ 489, L91).

Abstract P-4-15

INFRARED OBSERVATIONS OF COMET HALE-BOPP

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We present infrared imaging and photometry of the bright, giant comet C/1995 O1 (Hale-Bopp). The comet was observed in an extended infrared observing campaign using the ESO 3.6m telescope with the TIMMI camera in October and December 1996, using the NASA/IRTF telescope with the MIRAC2 and MIRLIN cameras in January and April 1997 (near perihelion), and again at ESO using the TIMMI camera in July 1997.

The infrared morphology of the comet was observed to change from the 6 to 8 jet "porcupine" structure in 1996 to the "pinwheel" structure seen in 1997; this has implications for the position of the rotational angular momentum vector. Long term lightcurves taken at 11.3 um indicate a dust production rate of $\sim 1/r$. Short term light curves taken at perihelion indicate a rotational periodicity of ~11.3 hours, and a dust outflow rate of ~0.4 km/sec. The spectral energy distribution of the dust in Autumn 1996 is well modeled by a mixture of 90% silcates and 10% carbonaceous material, with a small particle dominated size distribution like that seen for comet P/Halley by Lamy et al.(1987), and an overall dust production rate of ~7 x 10^4 kg/sec.

Abstract P-4-16

A COMPARISON BETWEEN NEAR-INFRARED AND VISIBLE IMAGING OF THE INNER COMA OF COMET HALE-BOPP AT PERIHELION

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CCD images of comet Hale-Bopp coma were obtained daily during March and April, 1997, using a V filter and an ST-6 CCD camera attached to the 51cm U. of Mons Telescope at Teide Observatory (Instituto de Astrofísica de Canarias), by the Hale-Bopp European Team. Over the nights of observations we cover a complete rotation of the nucleus. The rotation period of 11.35 reported by Licandro et al. at this conference, is supported. The resulting images are compared to the Near Infrared ones, obtained during April 1997, using the CAIN camera attached to the 1.52m Carlos Sanchez Telescope (OT, IAC). Three narrow-band filters were used: Br_γ (2.167 μm), CO (2.30 μm), and K continuum (2.23 μm). The morphology of the coma jets and shells is almost identical in the three infrared bands, and in the visual images, as a clear indication that they corresponds to dust structures. No evidence is seen of a warm dust component, nor of CO emission in the 2.30 micron line.

Abstract P-4-17

PHOTOGRAPHIC OBSERVATIONS OF COMET HALE-BOPP: THE PROPERTIES OF SHELL STRUCTURE

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Photographic observations taken with 26-inch Telescope of Pulkovo Observatory in March and April, 1997, have shown arm-spiral and shell structure inside the Comet head. On March, 5 the shells were placed at the distances 6".9, 15".8 and 27".9 from the nucleus. The final positions of the shells on April, 2 were 12".9, 28".1 and 44".0. The distances of the shells on March, 26 were $2 \cdot 10^4, 3 \cdot 10^4$ and $4 \cdot 10^4$ km, which correspond to positions of dust shells measured for Comet Halley by the Vega 2 outbound. Following to the Vega experiment we have estimated the mass range for dust particles as $3 \cdot 10^{-13}$ and $3 \cdot 10^{-14}$ g and the parameter $\frac{v^2}{\beta} = 3 \cdot 10^5 \; m^2/s^2$. For submicron particles, using the published numerical simulations, we have obtained $V_{dust} = 6 \cdot 10^2$ m/s and $\beta \sim 1$. It gives the value of cometary nucleus radius >30 km. The observed shell structure allowed us to evaluate the second rotation period of cometary activity as about 25 days (see IAUC No.6583). We have estimated angular extensions of the shells and their wavelength dependence.

Abstract P-4-18

SPATIAL DIFFERENCES IN THE VISIBLE/NEAR INFRARED CONTINUUM EMISSION OF COMET C/1995 O1 (HALE-BOPP)

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Imaging spectroscopy data in the 0.4-1 μm spectral region of comet Hale-Bopp have been analysed in order to study the spatial distribution and physical properties of the dust grains in the coma. The data presented cover a period of three days close to perihelion. The spectra have been processed by means of the principal component analysis in order to individuate coherent spatial units with different spectral properties. The study shows the presence of two regions on the sunward and antisunward sides of the nucleus exhibiting different continuum emissions. This fact is interpreted as due to the presence of dust grains of diverse compositions and/or sizes. In the latter hypothesis, the observations could be explained by size sorting due to solar radiation pressure.

Abstract P-4-19

CCD IMAGE ARCHIVE OF COMET C/1995 (O1) HALE-BOPP

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An optical archive of comet Hale-Bopp was obtained over 35 nights from June 1996 to May 1997. The CCD images were obtained with the 0.8-m University of Washington Manastash Ridge Observatory, the 0.25-m Pennsylvania State University at Erie portable observatory, and the 0.8-m Lowell Observatory. The reduced images clearly document the evolution of features of the coma including jets and arcs. We will present these images and our analyses of them pertaining to the heliocentric dependence of the observed features.

Abstract P-4-20

HB SHELL EXPANSION : A CCD STUDY

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Along a year (from May'96 to May'97) we devoted to Hale-Bopp comet more than thirty nights of observation, using the 33.5 cm Reflector ($f/4.8$) of S.A.S. Observatory, equipped with a filterless CCD camera (chip : Kodak KAF 400). Between 9 February and 1 May 1997, thanks to fine weather conditions, we took ten series of CCD images over many successive hours. Each single CCD image (4 sec exposure) was elaborated using the Larson-Sekanina and elipsoidal modellization algorithms. A computerised comparison was made of the position of the brightest shells at the beginning and at the end of each observation session, in order to calculate the shell-to-shell distance and the shell expansion velocity.
A number of interesting results were obtained.

1. Up to eight linear 'porcupine' jets were always visible, without any apparent angular rotation.
2. The CCD images taken between 10 and 31 March confirmed the interpretation of the shells as a single and apparently continuous spiral structure produced by the strong jet discovered in January 1997.
3. The shell-to-shell separation remained constant at about 17,000 Km troughout the 3-month observation period.
4. Surprisingly, the shell expansion velocity was not costant, varying from a maximum of about 1.4 km s^{-1} to a minimum of about 0.4 km s^{-1}. Even more surprisingly, the computerized interpolation of our data revealed the clearly periodic nature of the shell expansion velocity (with extimated period of 20-22 days).
5. We think this is a result of a regular change in the expansion velocity of the material ejected by the source jet, probably driven by some sort of seasonal effect : if we postulate a precession movement of the comet nucleus with period of 20-22 days, it is possible that a variable increase-decrease in solar heating over the source jet may lead to a rhythmic enhancement of the gas and dust emission velocity.

6. On the basis of our interpretation, the 0.4 km s^{-1} expansion velocity would be a situation of "strong precession winter" and the 1.4 km s^{-1} expansion velocity a "strong precession summer". Similar behaviour is obviously also possible in a situation of "real winter", and this probably happened when the comet was about 3 A.U. from the sun. On 9 September 1996, after a large burst observed near the most luminous porcupine jet, our computer elaborated CCD images showed a partial spiral structure emanating from the burst region at about 0.4 km s^{-1}. If we postulate that the same expansion velocity at 3 A.U. and during a "precession winter" at perielium is produced by a similar sun heating intensity, we can derive some useful information concerning the needed angle of the precession cone of the comet nucleus.

Abstract P-4-21

SILICATES IN HALE-BOPP: HINTS FROM LABORATORY STUDIES

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The recent passage of the Hale-Bopp comet has provided the first opportunity to analyze the spectral properties of a bright comet both from ground and by the Infrared Space Observatory. Previous works have already been dedicated to study the potential candidates to reproduce the cometary feature at 10 μm observed for different comets (Colangeli et al. 1996).

In the present work we have applied a similar approach to fit the Hale-Bopp spectra with our laboratory data. The best fit has been obtained by using a mixture of crystalline Mg-rich olivine (forsterite), amorphous olivine and amorphous carbon grains.

Some constraints on the possible cometary grain type derive from our simulation. In particular, fine aggregates of submicron particles, composed of amorphous and crystalline olivine and amorphous carbon materials look compatible with the cometary emission.

Abstract P-4-22

EVOLUTION OF DUST SHELLS AND JETS IN THE INNER COMA OF COMET C/1995 O1 (HALE-BOPP)

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Comet Hale-Bopp was observed with the 0.8-m reflector + CCD at the Haute-Provence observatory (OHP) and with the 0.62-m reflector + CCD at the Saint-Véran observatory (Queyras, France).

The very first appearance of several concentric dust shells was detected on Jan. 30, 1997 with the 0.80-m OHP telescope. The morphology of the shells was followed until their disappearance on May. 9, 1997. These shells spread from the nucleus region with a velocity in agreement with a nuclear rotation period of about 11.4 hours. We report also a short and bright dust ejection on May 8. to the north of the comet.

The circumnuclear structures have been followed at Saint-Véran from Apr. 5 to Apr. 11, 1997 with a high spatial resolution (200 km/pixel). We have followed the emergence of a recurrent linear polar jet. Measurements of its expansion show a constant acceleration of material with typical expansion velocity of 1 km/s. The CCD frames show the interconnection between spiral jets and the successive shells.

Abstract P-4-23

OBSERVATIONS OF THE DUST CLOUD OF COMET HALE-BOPP IN THE POST-PERIHELION PASSAGE

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We continuously observed comet Hale-Bopp (C/1995O1) from August 1995 to May 1997, using 50cm reflector at National Astronomical Observatory Japan (NAOJ). We noticed the comet had companion-like condensation in the images taken on 9 May, 1997 toward the north from the main nucleus. It seems that this phenomenon was caused by outburst. This secondary condensation was sweeping to nearly west (corresponding to anti-solar direction), in 10 and 11 May.

It was thought to be a dust swarm, of which motion is simulated by two-body problem in this paper.

And we researched some parameters decided by the characteristics of dust cloud, namely, the index of the power low size distribution, the dust ejection time, and the velocity depended on the size of particles.

Abstract P-4-24

MODELING DUST JETS AND SHELLS FROM COMET HALE-BOPP

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Persistent jet and shell structures of Comet Hale-Bopp from September 1996 to May 1997 are modeled. Gradual changes in the shapes and orientations of the features, with aspect angle and solar illumination geometry, indicate long lived active spots. A model to simulate the dust features has been applied to a series of observations.

The theoretical model calculates the loci of the dust grains from a given longitude and latitude on the rotating comet. The grains which are assumed to be ejected in the radial direction with a velocity v_{gr} move under the combined action of solar gravity and solar radiation pressure. The computed trajectories are compared with the observed jet and shell patterns.

Observations were made with a 60cm ($f/12.43$) telescope using a SBIG ST-6 CCD camera with a field of 3'x 4', at the observatory of the Naturwissenschaftlicher Verein Osnabrück on Oldendorfer Berg near Melle. The radial and rotational shift algorithm by Larson and Sekanina (ApJ. 89, 571, 1984) was applied to suppress the strong radial intensity gradient in the coma to enhance smaller fluctuations like the jets and the shells.

Most of the structures can be explained as arising due to ejections from persistent active regions at comet-o-centic latitudes near $+70$ deg, $+40$ deg, $+10$ deg, -35 deg and -70 deg. The best fitting pole positions vary between 210 ± 10 deg and 260 ± 10 deg in the right ascension and -10 ± 10 deg to -50 ± 10 deg in declination indicating complex rotational state of the nucleus. The radiation pressure parameter β was allowed to vary between .06 and 1.25 and the corresponding best fitting grain velocities v_{gr} were determined. Limits on the dust-to-gas mass production ratio at various epochs are estimated.

Abstract P-4-25

DUST MORPHOLOGY OF COMET HALE-BOPP (C/1995 O1) IN 1996: II. INTRODUCTION OF A WORKING MODEL

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A Monte Carlo computer code for the image simulation of dust features in comets is applied to comet Hale-Bopp to model the object's persisting porcupine-like appearance on high-resolution images taken between May 11 and November 2, 1996. A self-consistent model is offered by postulating four isolated sources of dust emission at various locations on both polar hemispheres of the rotating nucleus, whose spin axis suggests a complex motion in an inertial coordinate system. The observed jets and/or jet pairs represent boundaries of fan-shaped formations described by dust ejected from the sources during periods of time when the Sun was above the local horizon. The spin axis is found to travel through a field of 10° by 20° during the examined period of nearly six months. The results are insensitive to the rotation period, but the observed morphology can generally be expected to be more prominent for a rapidly rotating comet.

Abstract P-4-26

ON THE SYNCHRONIC BANDS IN COMET HALE-BOPP'S DUST TAIL

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Photographic observations of the dust tail of Comet Hale-Bopp were obtained with a double astrograph (400/2000) at the Main Astronomical Observatory of National Academy of Science (Kyiv,Ukraine). We detected several striae in the dust tail of the comet.The synchrone-syndyne analisis for these striae has been carried out. We find that the striae do not follow neither synchrone nor syndyne curves. Some assumptions on the nature of the striae are discussed.

Abstract P-4-27

SYNCHRONIC BANDS IN THE DUST TAIL OF COMET C/HALE-BOPP 1995 O1: FORMATION THEORY AND ITS APPLICATION

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In the dust tail of Comet C/Hale-Bopp 1995O1, many striae of degree scale were observed around the perihelion passage. We analyzed these striae on our wide-filed CCD images taken on early March, and concluded that these were synchronic bands(J. Watanabe et al. Pub. Astron. Soc. Japan, **49**, L35, 1997). These bands are thought to be made of dust grains originated through secondary process outer the coma or in the dust tail. We applied a modified theory of the synchronic bands formation proposed by Nishioka and Watanabe(Icarus, **87**, 403, 1990) to the observed structure, and derived the lifetime of the dust grains in these bands such as 10-30 days. This may suggest that the dust grains forming the synchronic bands have complicated structure such as core-mantle. Other characteristics derived in this analysis are also discussed.

Abstract P-4-28

DISTRIBUTION LAW FOR PARTICLE FRAGMENTATION TIMES IN A THEORY FOR STRIATED TAILS OF DUST COMETS: APPLICATION TO COMET HALE-BOPP (C/1995 O1)

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The original model for the striated dust tails of comets (Sekanina & Farrell 1980) describes the formation and evolution of the striae as a two-step fragmentation process that is characterized by the ejection time t_e of parent particles, by their radiation pressure acceleration β_p, and by their fragmentation time t_f. It is known that of these three, the time t_f is the weakest parameter in that a range of t_f offers nearly equally successful solutions. In this work we propose a truncated Gaussian function as a first-approximation distribution law for the particle fragmentation times. We apply this generalized model to the images of striae in comet Hale-Bopp, detected on March 12–15, 1997 and analyzed by Pittichová et al. (1998). It is found that in order to be consistent with the width of the striae, estimated at ~150,000 km on the observed images, the particle fragmentation times cannot be distributed over a period of more than approximately 2 days. A more profound relaxation of the fragmentation-time constraint would lead to the more rapid disappearance of the striae than suggested by the observations.

Abstract P-4-29

FINSON-PROBSTEIN ANALYSIS OF COMETARY DUST TAILS

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We present a method to obtain the parameters pertaining to the Finson-Probstein model on cometary dust tail analysis. The procedure is based on a downhill simplex method in multidimensions to derive the best-fitted rate of dust particles emitted from the nucleus, the size distribution of the particles, and the dust velocity distribution. An application of the method is made to the analysis of images of Comet C/1995 O1 Hale-Bopp obtained during various dates near perihelion from Sierra Nevada Observatory, Spain.