Abstract IT-2a-1

ESTIMATING THE SIZE OF HALE-BOPP'S NUCLEUS

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A variety of independent methods have been used to estimate the size of the nucleus of comet Hale-Bopp. Several groups have analyzed optical and infrared images of the comet and claim to detect the signature of the nucleus, despite the presence of a strong coma. A detection of the nucleus was also claimed during mm-wave interferometry of Hale-Bopp shortly before perihelion. A team of observers attempted to detect the occultation of a star by the nucleus of Hale-Bopp in October 1996. The maximum observed gas production rate of the comet near perihelion can be used to place a lower limit on the size of the nucleus. This paper will critically review the many different methods used to constrain the size of Hale-Bopp's nucleus. All of the techniques are affected by systematic errors that can be difficult to quantify precisely. Nevertheless, the available evidence strongly suggests that the nucleus of Hale-Bopp has an effective diameter of at least 40 km and may be as large as 70 km. Thus, the prodigious gas and production rates from this comet might be naturally explained by its unusually large size.

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Abstract CT-2a-1

DETECTION OF A SATELLITE ORBITING THE NUCLEUS OF COMET HALE-BOPP (C/1995 O1)

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This paper reports the detection of a satellite around the primary nucleus of comet Hale-Bopp. Overlapping jet activity from the comet pair could more easily explain the exceptionally complex morphology of the dust coma. The detection was made on images taken with the Hubble Space Telescope's Wide Field Planetary Camera 2 in the planetary mode on five days in May–October 1996. An average satellite-to-primary signal ratio is 0.21 ± 0.03, suggesting that the satellite's diameter is $\sim$30 km, if the main nucleus is $\sim$70 km across. To avoid collision, the separation distance must exceed 50–60 km or more at all times. The satellite's projected distances derived from the images vary from 160 to 210 km, or 0.06 to 0.10 arcsec. The satellite was not detected in October 1995, presumably because of its subpixel separation from the primary. The radius of the gravitational sphere of action of the main nucleus of the assumed size is 370–540 km at perihelion, increasing linearly with the Sun's distance: the satellite appears to be in a stable orbit. Its orbital period at $\sim$180 km is expected to be $\sim$2–3 days, much shorter than the intervals between the HST observations. If the main nucleus should not be more than 42 km across, Weaver et al.'s upper limit, the satellite's orbit should become unstable and the object would drift away from the main nucleus after perihelion, contrary to observation. In fact, ground-based detections of massive multiple comets are altogether unlikely. Efforts to determine the satellite's orbit and the total mass of the system are expected to get underway shortly.

Abstract CT-2a-2

PHYSICAL PROPERTIES OF THE NUCLEUS OF COMET HALE-BOPP

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We present results from our multiwavelength campaign to study the nucleus of comet Hale-Bopp, using data collected from the optical, mid-infrared, and microwave regimes. We have used a coma-fitting technique to separate the comatic and the nuclear emission in our optical *HST* and infrared IRTF and ESO imaging, allowing us to constrain the nuclear radius and albedo. We also have the first detection at VLA of a comet's continuum emission, which constrains the nuclear size and the nucleus' thermal characteristics. The rotation period has been inferred from the infrared imaging of periodic morphological changes in the inner coma.

Abstract IT-2a-2

THE NUCLEUS SPIN STATE

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It has long been recognised that cometary nuclei spin, and that nuclear rotation may influence the photometric and morphological properties of the inner coma. It is also suspected that torques due to non-central outgassing may act to change the nucleus spin vector, leading to both spin-up and precession. In this invited review, I will discuss the observational constraints pertaining to the spin vector of the nucleus of comet Hale-Bopp. Foremost among these are optical images of inner-coma jets, which changed with time from a distinctive straight-armed ("starfish") pattern to a more conventional spiral. Secondary evidence comes from photometric variations of the inner coma. To set the nucleus of Hale-Bopp in proper context, I will also try to relate the current evidence for nuclear spin, spin-up and related physical phenomena in other comets.

Abstract CT-2a-3

THE SPIN AXIS POSITION OF COMET 1995 O1 (HALE-BOPP)

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A northern fan structure (NFS) was observed on 78 nights between March 26 and Nov 13, 1996, by broad-band CCD imaging with the 82cm. IAC-80 telescope, and the 51cm. Univ. of Mons telescope at Teide Observatory (Instituto de Astrofísica de Canarias). From the position angle of the NFS, and the sense of rotation observed in April 1997, we have determined the position of the comet's North Pole (Long.= 275, Lat.= -50). A periodic oscilation of the observed PA of the NFS around the computed one is also detected, and related to the precession of the nucleus spin axis. These results and the method we used to obtain them are presented.

Abstract CT-2a-4

THE SPIN AXIS OF COMET 1995/O1 HALE-BOPP

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We present results from computer simulations of the coma of Comet Hale-Bopp. The simulations are compared to approximately 100 images taken by various groups of observers between September 1996 and May 1997, in order to constrain the rotational properties of the comet. The direction of the spin axis, as well as the positions of the active regions on the nucleus are adjusted to optimize the fit between the simulations and the data. We have assumed a constant set of active sources to account both for the relatively structureless coma of Hale-Bopp in late 1996, and for the spiraling shells in the coma observed from February until May, 1997.

We obtained a set of plausible solutions for the direction of the rotation axis and for the approximate locations of the active sources on the nucleus.

Abstract CT-2a-5

AN ANALYSIS OF THE STRUCTURE AND EVOLUTION OF COMA MORPHOLOGY OF COMET HALE-BOPP

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We have obtained CN (3871 Å) and continuum (4449 Å) narrowband images of comet C/1995 O1 Hale-Bopp from the WIYN telescope on 13 days spread over a two month period when the comet was near perihelion. In addition, we have also observed the comet using wideband continuum filters up to a heliocentric distance of 4 AU both pre and post perihelion.

We will present the results constraining the rotational state of the nucleus of Hale-Bopp based on these observations and other published literature. Results based on Monte Carlo simulations aimed at explaining the coma structures and differences among them will also be discussed.

Abstract CT-2a-6

THE ROTATION PERIOD OF COMET HALE-BOPP (1995 O1)

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Hale-Bopp was a very active comet that produced dust at a rate greater than has been measured in any other comet at any distance in the past 20 years. As early as the Fall of 1995, Hale-Bopp was exhibiting dust features that changed with time. Our own images were obtained on 49 nights between June 1996 and May 1997 at the 42" Hall telescope at Lowell Observatory.

The comet was monitored each night using the red continuum filters from the IHW and the new Hale-Bopp filter set (6840 Å and 7128 Å, respectively) to isolate scattered light from the dust particles near the nucleus. Images were also obtained with other filters in each set to isolate gas and ion emission bands and to measure the continuum at other wavelengths. The comet changed very slowly during 1996, when it was at large heliocentric distances and the dust structure was primarily radial. In early 1997, spiral shaped arcs became visible and outward motion started to become apparent from night to night. Closer to perihelion, arcs were the dominant features near the nucleus and small changes could be measured during a single night's observations.

We used the motions of the dust arcs from 25 March through 1 April to measure a rotation period of 11.33±0.05 hours for Hale-Bopp. Lecacheux *et al.* (IAUC 6560, 6583) found a period which oscillated between 11.20 and 11.65 hours over a 22 day period. These two conclusions are inconsistent, however, because the Lecacheux results predict that the period should be near 11.6 hours at the end of March. In order to resolve the discrepancies between these two results and determine if there is evidence for complex rotation, we are currently analyzing our imaging data from other time frames to look for variations in the rotation period as a function of time. The results of this analysis and its implications on the overall rotation state of the nucleus will be presented

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Abstract CT-2a-7

THE ROTATION PERIOD OF COMET 1995 O1 (HALE-BOPP) AT PERIHELION

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Narrowband near infrared images of Comet 1995 O1 (Hale-Bopp) were obtained in day–time during April 1997, using the 1.5m Carlos Sanchez Telescope, at Teide Observatory (Instituto de Astrofísica de Canarias), by the Hale Bopp European Team. The comet was observed on 16 days, and for several hours on five of thess days (up to 12 h.), which let us obtain a complete map of the comet's rotation, and evolution of the structures observed in the coma. A rotation period of 11.35 h. is determined using two different methods, and possible variations due to preccesion have been investigated, but not detected in our data. Results about the rotation period, and the method we used are presented.