Comet Hyakutake

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COMET observers have been busy during the past two years, observing the famous split comet Shoemaker–Levy 9 during 1993–94 and making preparations for the forthcoming visit of the comet Hale–Bopp which is going to be a bright object during early 1997. The discovery of yet another comet C/1996 B2 (Hyakutake) on January 31 by Japanese amateur astronomer Yuji Hyakutake and prediction of its imminent brightening led to another surge of activity. Improved orbital elements of this comet by Marsden[1] confirmed that it is not a new comet, the last perihelion passage having occurred some 9000 years ago. It was closest to the sun at a distance of about 34 million kilometers on May 1. On March 25 it made a close encounter with the earth at about 15 million kilometers over the north pole. Such close approaches are not very common. Only 16 comets have been confirmed to have come close to earth to a distance of 2.25 to 15 million kilometers during the last 300 years. The comet was a bright naked eye object with a spectacular tail extending to several degrees on the sky even much before the perihelion.

The approach of this comet to the earth within a distance of 15 million kilometers offered possibilities of its observations at high spatial resolutions. In fact it was the best opportunity, second only to the observations from the space probes. Weaver[2] on behalf of the Hubble Space Telescope (HST) team reported that, the inner coma was reminiscent of the coma of comet Halley during Giotto fly-by, with multiple jets in the sunward hemisphere. The HST team further reports that they cannot yet say anything definite regarding the size of the nucleus. Sunward jets of gas and dust have been reported by several ground-based observers. The main jets crossed the nucleus-sun line each day at the same hour. Lecacheux *et al.*[3] estimate that the synodic period of rotation of the nucleus was 6 h, a sub-multiple of 24 h. A period of 8 h was also not excluded by them. Narrow band CCD imaging by Schleicher, Millis and Wasserman[4] using the Hall telescope on March 23, 24 and 25 noticed a distinct morphological structure varying on a time scale of well less than 1 h. Their preliminary analysis indicates that the morphology repeated with a period between 6.0 and 6.4 h. Based on their imaging and light curve results, they propose that the comet has a rotation period of about 6.25 h and that a single active region controls the photometric variations.

Polarimetric observations of the comet were made by Ganesh *et al.*[5] at narrow band continuum wavelengths 365–368 nm, 484.5–486.5 nm and 684–689 nm on Mar. 13.97 and Mar. 18.88 using the PRL 1.2 m telescope at Gurushikhar.

Thermal emission from the nucleus and large dust grains falls mainly in the radio region. The amount of radio continuum emission from a cloud of particles is strongly dependent upon their compositions. Radio continuum observations from submillimeter to centimeter wavelengths are therefore important. Matthews *et al.*[6], using the James Clerk Maxwell Telescope on Mauna Kea on March 23 and 24 detected strongest continuum radiations ever achieved in a comet. Preliminary estimates of the flux density at 350 and 800 μm of 6.8 ± 1.3 Jy and 0.55 ± 0.04 Jy respectively have been reported by this group. They estimate that the total mass of the dust in the 19 arcsec (1700 km) diameter beam is of order 10^8 kg and by assuming a dust out flow velocity of 10 m/s, arrive at a dust production rate of 1200 kg/s.

Mumma *et al.*[7] detected various parent molecules, viz. H_2O, HDO, CO, CH_4, CH_3OH, C_2H_6 and OCS on March 23 and March 24 using a cryogenic infrared spectrometer at the NASA Infrared Telescope Facility on Mauna Kea. One of the interesting results of IR spectroscopy of the comet Hyakutake is the detection of the unstable species HNC by Matthews *et al.*[8] at 363 GHz (J (4–3)) with an abundance ratio HNC/HCN = 0.07. This ratio for the interstellar medium ranges from 0.004 to 1. The detection of HNC by this group would therefore have strong cosmogonical implications.

Determination of D/H value in various astronomical objects including comets, is one of the important goals since almost the entire deuterium inventory was most likely synthesized in the early universe. Lis *et al.*[9] detected the 110–000 rotational line of HDO at 464.9 GHz at the Caltech Submillimeter Observatory. Using the OH measurements with IUE by Festou *et al.*[10], they obtain a preliminary value for the D/H ratio of 1.4×10^{-4} which is very close to the standard mean ocean water value of 1.6×10^{-4}.

Lisse *et al.*[11] observed for the first time X-rays from this comet with ROSAT during March 26–28. The X-ray images were diffused, crescent-shaped and were offset sunward by about 6 arcmin from the nucleus at a projected distance of about 30,000 km. A probable mechanism for the observed radiation suggested by these authors is scattering of solar X-rays by matter in the comet's coma. They also suggest the possibility that the radiation is derived from energy deposition by the solar wind.

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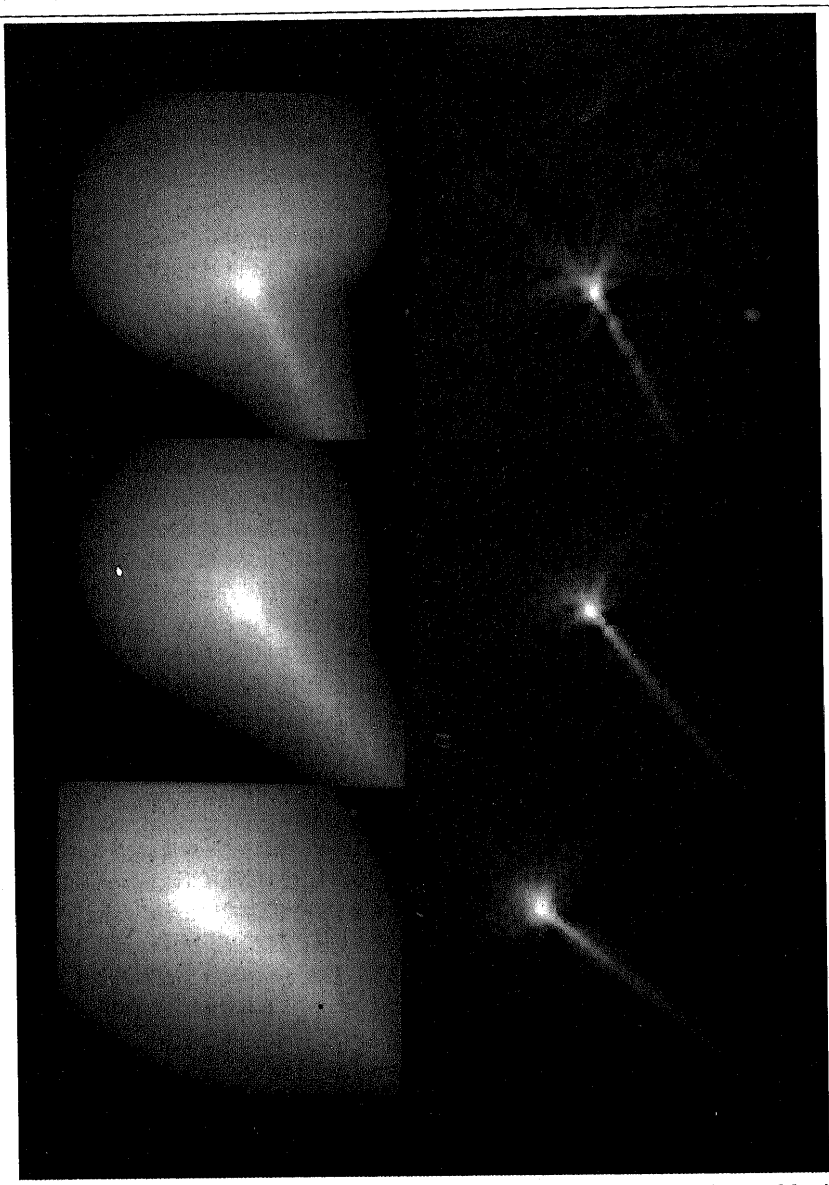

Figure 1. *Left panel*: False colour photographs of images of the comet obtained on March 23.79 UT (lower), March 24.84 UT (middle) and March 25.88 UT using the 1024 × 1024 pixels CCD camera at the 2.34 m telescope. *Right panel*: The corresponding median filtered images with the same scale. Jets of matter coming out from the nucleus are readily seen. Top is North and East to the left.

The scientists at the Indian Institute of Astrophysics have been monitoring the comet Hyakutake using the telescopes at the Vainu Bappu Observatory (VBO). The observational programmes include obtaining images of the comet through different filters and spectra of the different regions of comet. The wide angle picture (see cover picture) was obtained on 24th March. It shows a condensed coma and interesting tail structures of both gas and dust extending to several degrees along the south-west.

Images of the comet obtained using a CCD camera at the 2.34 m telescope show details of the inner coma at better resolutions. The left panel of Figure 1 shows images of the comet on March 23.79 UT (lower), March 24.84 UT (middle) and March 25.88 UT. The first image was through a broad band standard blue filter and the other two were through standard red filters. The images span an angular size of 4.0 × 3.5 square arcmin. At the distance of the comet on these days, the linear size corresponds to about 18,000 × 16,000 km^2. The shape of the coma and part of the tail structure changed over the two days because of the change in the viewing geometry. The solar phase angle (earth–comet–sun angle) changed from 46.0 deg on 24.0 March to 70.7 deg on 26.0 March. The images shown in the right panel of Figure 1 were processed using a median filtering technique to look for fine features embedded in the bright cometary background. Jets of matter coming out from the nucleus in the sunward direction are readily seen. A plot indicating the iso-intensity contours of the image of the comet taken on 25th is shown in Figure 2. The projected direction of the sun is indicated by the arrow. The

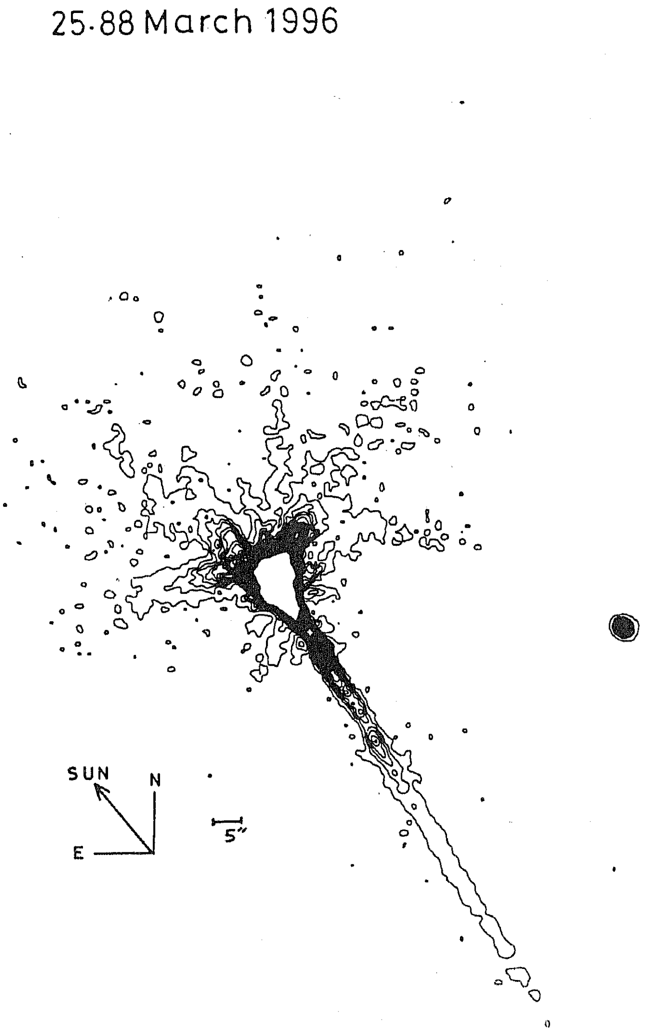

Figure 2. Iso-intensity map of the median filtered image of March 25.88 UT. shown in Figure 1.

jets are formed on the sun-ward side due to the directional out-flow of sublimed gas dragging along with it, fine grains of dust from certain vents on the nucleus which is believed to resemble a snow ball with dust mixed in. Results of Giotto spacecraft fly-by missions to comet Halley in 1986 indicated, at least for Comet Halley, that the sublimations from certain active vents were the primary sources of gas and dust. In the post-Halley era, studies of these jets have gained increased importance. The period of rotation of the comets can be inferred from the rotation of the jets. In case of comet Hyakutake, the position of identifiable jets in the two images taken very nearly at the same time of the night of 24 and 25 March appears similar. The series of images from VBO are being analysed to derive the period of rotation of the comet and to locate the position of the active region on the nucleus.

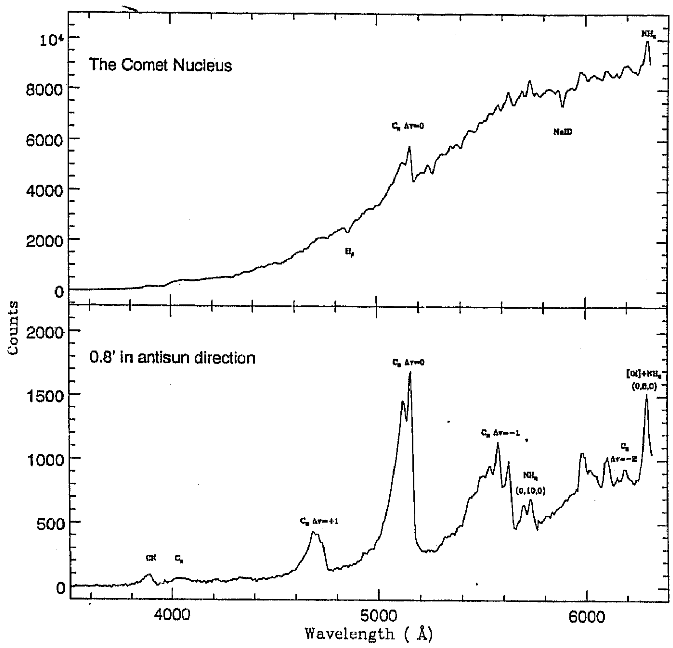

Figure 3. Spectra of comet Hyakutake at the inner coma and at the tail at a distance of 0.8 arcmin (7200 km) obtained using the 102 cm telescope at VBO. The spectrum of the central region is mostly scattered sunlight. The molecular emissions of C_2, CN and NH_2 dominate in the tail.

Spectra of comet Hyakutake were obtained using the 102 cm telescope at the VBO at a resolution of 5 Å per pixel on the CCD detector. The spectrum at the nucleus and at the tail at a distance of 0.8 arcmin (7200 km) are shown Figure 3. The spectrum of the central region is mostly scattered sunlight. The central region of comet Hyakutake therefore appears to be very dusty. The molecular emissions of C_2, CN and NH_2 dominate in the tail. The production rates of the dissociated molecules like C_2, CN, and NH_2 will be estimated from their resonance fluorescence spectral signatures at various distances along the tail.

The present apparition of the comet Hyakutake thus offered a valuable unique opportunity to study in detail, a comet in wavelength bands ranging from X-rays to submillimeter waves. A detailed analysis of the data by the various groups will lead to a better understanding of the composition of the comets. Although all Solar System objects formed from the interstellar medium, most material within the inner Solar System has been thoroughly processed and preserves no record of the conditions in the protoplanetary nebula. Comets, however, may still preserve a chemical record of their formation, since it is believed that that they are relatively unprocessed bodies. The study of cometary compositions will ultimately lead to a better understanding of cometary formation conditions in the early solar system and to conclusions of how well cometary dust represents unprocessed interstellar medium.

The observing team at the Indian Institute of Astrophysics consists of M. Appakutty, Pavan Chakraborty, G. Ganeshan, Alok Gupta, K. Jayakumar, V. Moorthy, S. Perumal and G. Selvakumar at the 2.34 m telescope. The spectra at the 102 cm telescope were obtained by Pavan Chakraborty and B. S. Shylaja of the Jawaharlal Nehru Planetarium. The author is responsible for the overall coordination of the project.

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ACKNOWLEDGEMENTS. The group is thankful to Prof. N. Kameswara Rao for several extremely helpful discussions. The members of the group are grateful to the observers at the 2.34 m Vainu Bappu Telescope for generously permitting the use of part of their telescope time for comet observations.

Infectious diseases in a changing world*

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I present in this article a perspective on infectious diseases – newly-emerging diseases, resurgent diseases and simmering diseases that have a proclivity to break out in epidemic form from time to time, and view them in the context of rapidly changing life conditions in India and elsewhere. We live in truly remarkable times.

India and infectious diseases

India's health history is a mixed one, of successes and failures, and on the whole the balance of evidence suggests that India could have done far better in the health field than she did. There have been, of course, many successes and these have largely been on the infectious diseases front. But India's *problem is sustainability of those successes and overcoming the inertia and complacency following initial successes.* Once conquered diseases had lulled the country into dangerous complacency. DDT and chloroquine, ureastibamine and pentavalent antimony, multidrug treatment of tuberculosis and leprosy, diethylcarbamazine (DEC) against filariasis and now ivermectin, penicillin, streptomycin and the whole array of later-day antibiotics had enabled much progress to be made in the control of infectious diseases. Predictions that infectious diseases would soon be a thing of the past were made in the fifties and sixties of this century; a euphoria of the possible conquest of Tropical Diseases pervaded. Vaccination against childhood diseases in the form of the Expanded Programme of Immunization (EPI) is now increasing child survival enhancing optimism. All this had led to decline of mortality in the earlier age groups, increased longevity and the demographic transition (Figure 1).

And yet, the infectious diseases front is *a restless tide, rapidly changing and extremely worrisome*, unless society foresees the dangers and takes preparatory action. The fact is that infectious diseases continue to be leading causes of mortality in the world as a whole and in developing countries in particular and will be so well into the 21st century (Figure 2). We are in the midst of a rapidly-changing scene with regard to infectious diseases which consists of a mixture of newly emerging

*One of the Frontier Lecture Series given at the Indian Institute of Science, Bangalore, on 15 March 1996.

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