18.14

SUBMILLIMETER PHOTOMETRY OF COMETS

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We describe submillimeter radio-continuum observations of comets obtained using the 15-m diameter James Clerk Maxwell Telescope on Mauna Kea. Broadband observations are presented for periodic comets Borresen-Metcalf, Schwassmann-Wachmann 3 and Honda-Mrkos-Pajdusakova and for the dynamically new comets Okazaki-Levy-Rudenko and Austin.

We interpret the submillimeter radio-continuum as thermal emission from cometary dust. The submillimeter emission supplies unique information on the nature and abundance of large (mm-sized and larger) particles emitted from comets, although particles small compared to a wavelength also contribute significantly to the measured signals. We will discuss the uncertainties in the interpretation of the submillimeter data. The possible relation between the submillimeter cometary emission and the particles in pre-main sequence circumstellar disks will be discussed.

18.15

Dust production of comet P/Halley at the Giotto encounter.

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Observations of the inner coma of comet Halley by the Halley Multicolour Camera during the night of March 13 1986 show that the intensity seen along the line of sight through the point of closest approach of Giotto to the cometary nucleus is 2.4 times greater than the average intensity around a circle at the same cometocentric distance (596 km). The result implies that in situ measurements of dust when combined with assumptions of isotropy will over-estimate the cometary mass loss. The single scattering albedo of the dust grains is derived using the mass distribution of the in situ observations. The dust to gas mass ratio is re-evaluated. This ratio depends upon the dust size distribution, particle terminal velocities and the three-dimensional distribution of the dust. Large particles in the 10 to 50 mg range were observed by the Halley Multicolour Camera by analysis of attitude and spin rate changes of the spacecraft. Our observations suggest that the in situ measurements may have studied points in the coma where the flux of large particles was relatively high. Images taken onboard the spacecraft are compared to ground-based observations and show good agreement.

18.16

Color Gradients in Comets

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Spatial color variations in cometary dust comae are mapped using narrow and broadband CCD images obtained at Mauna Kea and Kitt Peak Observatories. Broadband BVR filters were used to take color images of comets with no gas (as determined from spectra), while those with gas were studied through narrowband continuum filters centered at 4845 Å and 6840 Å. Color maps computed from the images generally show a coma which is centrally reddened, with radial color gradients of order 0.01 mag/arcsec or less. These observations lend themselves to a variety of physical interpretations of the nature of cometary dust. In general, the spatial scale of the color gradients is too large to permit an explanation in terms of the sublimation of water ice grains. The color gradients may instead indicate particle size sorting by solar radiation pressure, or possibly the sublimation of organic grains.

18.17

Gas and Dust Production by Comet P/Halley (1910 II)

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Selected long-slit spectrograms of Comet P/Halley, photographed during the post-perihelion period between 16 April and 3 June 1910 by V. M. Slipher of Lowell Observatory, have been quantitatively analyzed for comparison with the 1985/86 apparition. Using the Fe-V-Na spark spectrum which Slipher employed for his wavelength calibration, we have determined characteristic curves for these plates and applied flux calibrations based on contemporaneous broadband photometric measurements. We computed Haer model production rates for CO and values AFs for each of the nights selected and compared them with the photometric observations obtained by Schleicher et al. (1989) during the comparable post-perihelion period of the 1985/86 apparition. As found by them for the 1985/86 apparition, the gas and dust production in 1910 varied in phase, but the rates of production were higher than observed in 1986 by a small but statistically significant amount. Using the post-perihelion heliocentric dependence derived by Schleicher et al., we deduced a value of log(Q) = 27.54 ± 0.02 for C2 at 1 AU, which is larger by 0.44 than the equivalent measurement in 1986. The gas-to-dust ratio was independent of heliocentric distance in the range of the 1910 observations, yielding a mean value of log(Q) - log(AFs) = 22.32 ± 0.12.

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18.18

Cometary and asteroidal delivery of prebiotic organics vs. in situ production on the early Earth

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Miller and Urey [Science 130, 245 (1959)] assessed the comparative importance of various energy sources for the production of prebiotic organic molecules on the early Earth. After 30 years, this work may be substantially updated—to include better estimates of energy sources for in situ synthesis, and to take into account a variety of extraterrestrial sources of organics. The latter include comets and asteroids that impact the Earth's surface or interstellar dust. In addition, impacts will shock-synthesize organics, both in the atmosphere and in the post-impact vapor plume. Such considerations should also be relevant to Mars and other worlds.

In order to bracket the possible range of prebiotic organic production, we consider two candidate atmospheres as probable end-members of the continuum of possible oxidation states of the early terrestrial atmosphere, and then tabulate organic production from each potential source. In a ~1 bar reducing atmosphere with ~10^-4 H2O, organics are primarily produced by long-wavelength UV at ~10^2 - 10^4 g yr^-1. At the other extreme, in a 10 bar CO2 atmosphere with negligible CH4 and CO, organics are primarily supplied by post-impact quench synthesis and airbursting comets and carbonaceous asteroids, at ~10^5 - 10^6 g yr^-1. Were products soluble in early oceans of present depth, and were they to survive for ~10^6 yr, the primitive terrestrial ocean would have been, respectively, a 1-10% or a 0.01-0.1% solution of organic matter.