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Grant **Submillimeter Continuum Observations of Comets**

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PI David Jewitt

Institution Institute for Astronomy
University of Hawaii
2680 Woodlawn Drive
Honolulu HI 96822

Tel 808-956-6664

E-mail jewitt@ifa.hawaii.edu

Summary of Findings

The aim of this proposal was to study the submillimeter continuum emission from comets. The study was based mainly on the exploitation of the world's leading submillimeter telescope, the JCMT (James Clerk Maxwell Telescope) on Mauna Kea. Submillimeter wavelengths provide a unique view of cometary physics for one main reason. The cometary size distribution is such that the scattering cross-section is dominated by small dust grains, while the mass is dominated by the largest particles. Submillimeter continuum radiation samples cometary particles much larger than those sampled by more common observations at shorter (optical and infrared) wavelengths and therefore provides a nearly direct measure of the cometary dust mass.

Major findings under this grant include

- Submillimeter continuum was detected from comets P/Swift-Tuttle and C/Hyakutake. In both cases, the strength of the emission was sufficient to demonstrate that the ratio of dust to gas outgassing in these comets exceeds unity. This supports a growing body of evidence to the effect that the bulk of the mass loss from comets is in dust, and argues for strong dust loading of the near-nucleus gas flow.

- We obtained the first measurement of the spectral index of the submillimeter continuum of a comet. The index, $\beta = 0.89 \pm 0.10$, is very flat and indicates the dominance of large particles (sizes $\geq$ 1 mm). Similarly small values of β are measured in the circumstellar dust disks of T Tauri stars. The coincidence should not be surprising: the cometary dust represents a frozen aggregate of dust particles agglomerated in the sun's own circumstellar disk.

- In the early phases of this work, we employed the single-pixel bolomeer UKT-14. In order to find our comets, we sometimes tried "search" observations utilizing the bright rotational transitions of the carbon monoxide (CO) molecule. We discovered and monitored CO [3-2] and CO [2-1] emission from comet Schwassmann-Wachmann 1 at 6 AU, and proved that outgassing from this comet is driven by CO. This solves a decades-old puzzle regarding the origin of SW1's persistent (and sometimes explosive) activity. The measured outgassing, at rates near 1000 to 2000 kg s^{-1}, has persisted in JCMT observations taken in each year of the grant, implying great longevity of the source. A high CO fraction is consistent with the Centaur-like nature of this body. SW1 is most likely an escaped Kuiper Belt Object scattered by the gas giant planets and on the verge of a strong interaction with Jupiter that will either inject it to the inner solar system (where it will become a spectacular short-period comet) or eject it from the planetary system.

- We surveyed 5 short-period comets for CO emission, finding either no measurable line (indicating production rates < 500 kg s^{-1}) or very weak CO emission incapable of driving the coma. This observation shows that near-surface CO is depleted in short-period comets, a likely consequence of prolonged solar heating. The mass loss from short-period comets is controlled by the sublimation of water ice. These results formed part of the PhD Thesis (University of Hawaii) of Matthew Senay.

Publications

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D. Jewitt and H. E. Matthews (1997). "Submillimeter Continuum Observations of Comet Hyakutake (1996B2)", Astron. J., **113**, 1145-1151.

M. Senay (1997). "The Source of Activity in Distant Comets". Ph D Thesis, University of Hawaii.