Comet Dust and Activity in the SEPPCoN Survey

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Introduction: A Survey of Ensemble Physical Properties of Cometary Nuclei (SEPPCoN) is underway to characterize the nuclei of 100 Jupiter-family comets (JFCs). The survey combines both visible and mid-infrared observations to measure this dynamical family's size and albedo distributions. We observed comets between 3.4 and 6.5 AU from the sun, when some JFCs have little or no activity. However, we detected many comets with dust comae, tails, and/or trails—34 out of 85 in our *Spitzer* observations, and 14 out of 51 in our ground-based optical observations. We present our analysis of the dust and activity of these comets.

Detecting Dust in the Survey: Dust tails and comae are observed as extended surface brightness enhancements surrounding a point source (the nucleus); meanwhile, dust *trails* are found along a comet's projected velocity vector. Trails are composed of larger dust grains than tails and comae (≥ 100 μm versus $\lesssim 10$ μm), and therefore weakly respond to both gas outflow from the nucleus and radiation pressure from sunlight. Dust trails trace activity on long timescales (several months to years), comae provide evidence for activity concurrent with the observation, and tails are an intermediate case.

Due to limitations in detector sensitivity and spatial resolution, dust comae may manifest itself as a point source. When available, multi-color photometry helps discern whether an observed point source includes a contribution from dust. The majority of our targets were observed with both the 16 μm and 22 μm arrays of the *Spitzer*/Infrared Spectrograph (IRS) images. At these wavelengths, dust will have a cooler color-temperature than a nucleus in instantaneous equilibrium with sunlight (the "slowly rotating" case).

Comet Activity at Moderate Heliocentric Distances: Out of 79 *Spitzer* comets analyzed, 20% appear to be active at the time of observation. We find two significant trends in our data set: 1) JFCs are more likely to be active post-perihelion (13 out of 43; mean $r_h = 4.6$ AU) than pre-perihelion (3 out of 36; mean $r_h = 4.6$ AU); and 2) none of the 15 JFCs with small perihelion distances ($q < 1.5$ AU) in our sample were active in our *Spitzer* images (Fig. 1). We discuss the significance and implications of these trends.

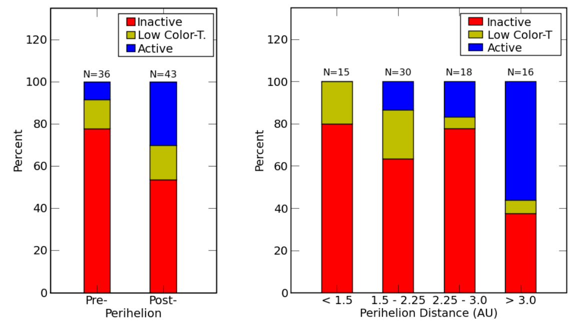

Figure 1: *Left*—Comet activity binned according to whether the comet was observed before or after perihelion. The "Low Color-T" label corresponds to point sources with color-temperatures cooler than expected for a slowly-rotating nucleus, which may indicate an unresolved coma. The number of comets in each bin (N) is listed. *Right*—Comet activity binned according to the comet's perihelion distance.

Dust Color-Temperature: We fit each off-nucleus dust feature in our *Spitzer*/IRS images with a scaled Planck function to derive dust color-temperatures. The ensemble color-temperatures are best-fit by $T = 280 r_h^{-1/2}$ K, similar to thermal emission dominated by 1–10 micron sized grains composed of amorphous carbon and/or silicates. The apparent dust trail detections of 22P/Kopff, 121P/Shoemaker-Holt, and 171P/Spahr have higher than average color-temperatures. These grains may have surface temperature gradients, which increase their observed color-temperatures, consistent with our observations and the *IRAS* results of Sykes & Walker [1].

References:

[1] Sykes, M. V., & Walker, R. G. 1992, Icarus, 95, 180

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