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The dust coma of comet 9P/Tempel 1 from Stardust NExT: Further evidence for grain fragmentation.

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Abstract

On 14 February 2011, the Stardust spacecraft performed its second cometary flyby, following the successful completion of primary mission to return coma samples from comet 81P/Wild 2. Stardust NExT passed within 200 km of the nucleus of comet 9P/Tempel 1, first visited by the Deep Impact spacecraft in 2005, providing an opportunity to make in-situ measurements of a second cometary coma with the same dust detection instruments. We present new results from the Dust Flux Monitor Instrument at the Tempel 1 flyby which detected bursts of impacts consistent with measurements at Wild 2, interpreted as the fragmentation of larger aggregates of material emitted from the nucleus into smaller particles within the coma.

1. Dust Flux Monitor Instrument

The Dust Flux Monitor Instrument (DFMI) measures particle impacts using two kinds of sensors–one based on polyvinylidene fluoride (PVDF) thin films, the other on acoustic detectors [7]. The PVDF sensors comprise two circular films of 20 cm^2 and 200 cm^2, with 4 different mass thresholds each. The two acoustic sensors, with two mass thresholds each, are mounted on the front and second protective shields (with sensitive area up to 0.3 m^2 and 0.7 m^2 respectively). Particles reaching the second shield have to penetrate the front shield. At the higher encounter speed of 10.9 km s^{-1} compared to the 6.1 km s^{-1} at Wild 2, the mass sensitivity of DFMI sensors increased by approximately a factor of two (acoustic) to four (PVDF), covering the range from ~$3x10^{-15}$ to $>10^{-6}$ kg. The PVDF sensors accumulated impact counts in 0.1 s time bins with impact rate capability of 10^4 counts s^{-1} without appreciable dead time. The derivation of impact counts from the acoustic sensor signals is more complex, with time bins between 0.1 and 1 s [4,7].

2. Wild 2 flyby

The Dust Flux Monitor Instrument (DFMI) made direct measurements of the dust environment in the mass range $10^{-14} < m < 10^{-5}$ kg at comet 81P/Wild 2 during the Stardust flyby on 2 January 2004. Dust fluxes measured by the Dust Flux Monitor Instrument (DFMI) revealed a highly non-uniform spatial distribution, centred round closest approach, characterised by short duration "bursts" of impacts implying localized spatial density changes of several orders of magnitude on scales of less than a km [4,6]. These bursts were clustered in "swarms", of duration ~ seconds, consistent with passage through narrow jets imaged by the Navigation Camera. In addition, a second period of high activity ~4000 km from the nucleus where almost 80% of the detected impacts occurred.

The overall mass distribution in the inner coma was dominated by the largest grains, with an average cumulative mass distribution index of α=0.75±0.05 (where the number of particles of mass *m* or larger, $N(m)\propto m^{-\alpha}$). The mass distribution was highly variable during the flyby, and during the second period of high activity, small grains dominated, with α=1.13±0.2.

The enormous variations in dust spatial density over distances of a few hundred metres, have been interpreted as the result of jets and distributed particle fragmentation [2,4,6], with the second period of high activity resulting from outgassing and/or fragmentation of a large (10s of metres diameter) boulder [5].

3. Tempel 1 flyby

DFMI was powered on 22 minutes (~14,000 km) before closest approach. The first particle detection occurred at 4300 km and 90% of the particle events were observed within 300 km of the nucleus. As at Wild 2 the dust detections were highly non-uniform, with bursts of detections separated by quiet periods. We will present the latest results from the DFMI instrument at Tempel 1 and compare the fluxes and mass distributions with those from Wild 2.

As was the case for Wild 2, it appears that at Tempel 1 the steady emission of small particles from active areas is of secondary importance compared to the emission of aggregates. Data from other comets indicate that the same processes may have occurred and therefore may be common in comets in general [2,3]. Additional evidence for emission of aggregates has recently been obtained from images of 103P/Hartley-2 from the EPOXI mission, which show a cloud of dm-sized clusters of micron sized icy grains surrounding the nucleus [1].

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