Stardust—Searching for Contemporary Interstellar Dust

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In 2006, the Stardust Mission returned the first samples from a primitive solar system body. This NASA discovery class mission, along with the Apollo and Genesis missions, represents NASA's third sample return from a celestial body. The Stardust spacecraft made a close encounter—at 6 kilometers per second (km/s)—with comet Wild-2, and successfully captured thousands of dust grains ejected from the comet's coma. The collector was an array of silica aerogel and aluminum foils arranged in the approximate size and shape of a tennis racket.

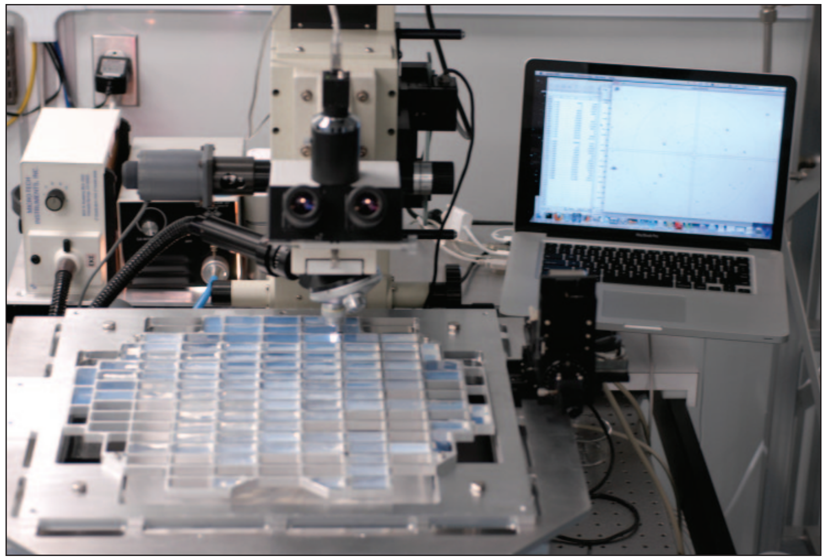

Fig. 1*. The Stardust aerogel scanning system at Johnson Space Center with the interstellar collector mounted for automated scanning.*

Although the primary (and successfully completed) objective of the mission was to capture these Wild-2 comet samples, a second similar collector was flown on the same payload and exposed to the stream of "contemporary interstellar dust": particles that originate from other stars, planetary systems, and nebulae. This very low flux of micrometer (µm) and sub-µm-sized dust grains pass through our solar system at speeds in excess of 20 km/s as the sun revolves around the center of the Milky Way Galaxy. While thousands of particles in the size range of a few µm up to approximately 150 µm were collected from comet Wild-2, it is expected that only perhaps a few dozen dust grains approximately a few µm *and less* were captured from the interstellar medium. The extremely low particle flux and tiny grain size make locating these particles a colossal challenge. To overcome this "needle in a haystack" search, the team conducts automated scanning of the aerogel at high resolution using an optical compound microscope equipped with a live video feed and computer-controlled stage. To date, the team has scanned almost one half of the collector and created roughly one quarter of a million "focus movies," each of which represents a field of view of 0.24 mm squared. These movies are distributed for inspection to volunteers around the world via the web-based Stardust@home project. With more than 29,000 volunteers, it is the largest ever collaboration in planetary science.

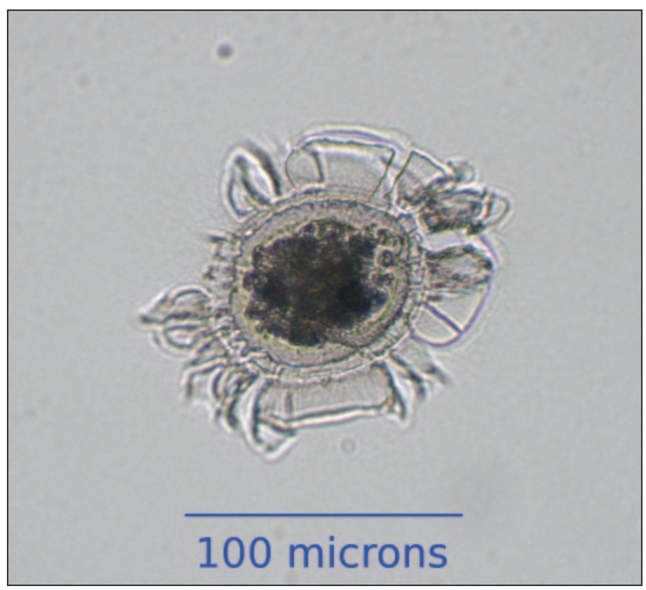

Fig. 2. *A cavity seen through the aerogel scanning system, possibly created by the hypervelocity impact of an interstellar dust grain.*

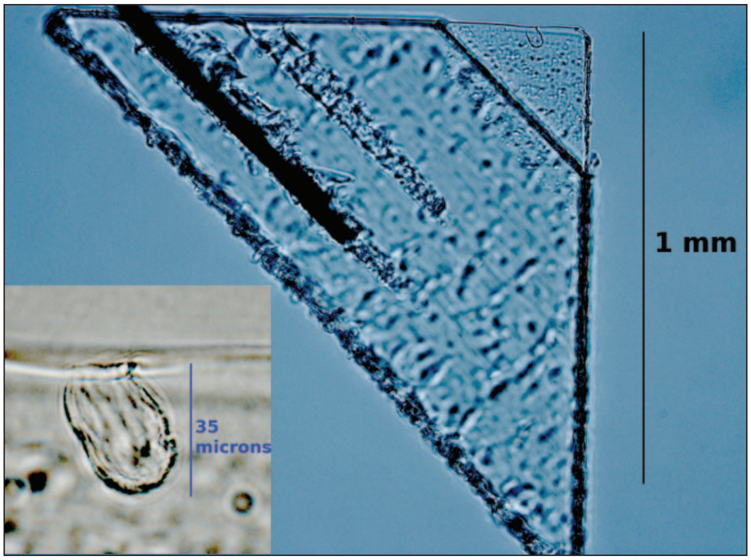

Fig. 3. *An aerogel wedge cut and mounted to a silicon "micro-fork" containing a microscopic particle impact that may be one of the first identified contemporary interstellar dust samples.*

Potential features identified by Stardust@home are closely examined. Real particle impacts are extracted from the collector in tiny wedges of aerogel less than 0.5 mm thick, using glass needles formed to a µm-sized tip. The needles are programmed to repeatedly poke into the aerogel via computer-controlled micromanipulators, eventually creating a series of precise "cuts" in the aerogel. These samples are extracted and prepared for investigators around the globe. The Stardust Laboratory at Johnson Space Center is one of two laboratories in the world with this specialized capability (figure 1).

External scientists analyze the compositions of candidate interstellar grains using synchrotron-based, x-ray spectroscopy, and attempt to determine which particles are real interstellar dust and which originate from the spacecraft, other contaminants, or from within our own solar system. At the March 2011 Lunar and Planetary Science Conference, the Stardust Interstellar Preliminary Analysis Teams reported that four of these identified, extracted, and analyzed particles may be the first of the rare and elusive interstellar dust grains (figures 2 and 3).

The team will continue to conduct automated scanning and particle extraction to identify and analyze impacts by interstellar dust.
These samples will complement the highly successful and dramatic collection of Wild-2 comet dust. Taken together, they will increase our understanding of our own solar system and its early history, how it compares to other planetary systems and galactic materials, and the astrophysical environment of interstellar space in between.