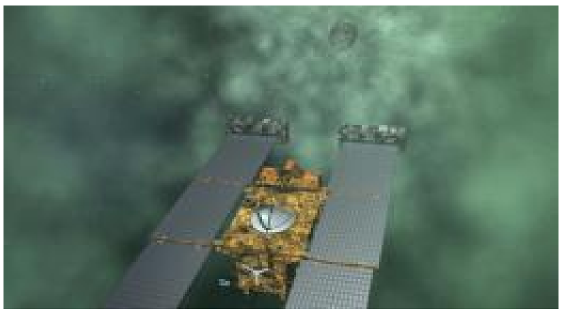
The two faces of Tempel 1

February 14 2011



Artist's concept of NASA's Stardust-NExT mission, which will fly by comet Tempel 1 on Feb. 14, 2011. Image credit: NASA/JPL-Caltech/LMSS

(PhysOrg.com) -- Just one year before its Feb. 14 encounter with comet Tempel 1, NASA's Stardust spacecraft performed the largest rocket burn of its extended life. With the spacecraft on the opposite side of the solar system and beyond the orbit of Mars, the comet hunter's rockets fired for 22 minutes and 53 seconds, changing the spacecraft's speed by 24 meters per second (54 mph). The burn was a result of an international effort to determine something that could very well be indeterminate -- which face of Tempel 1 will be facing the sun when Stardust hurtles by tonight, Feb. 14, the evening of Valentine's Day in the United States.

"Our goal is to re-visit a comet to look for changes that occurred since NASA's Deep Impact mission took a look five-and-a-half years ago," said Tim Larson, Stardust-NExT project manager from NASA's Jet Propulsion Laboratory in Pasadena, Calif. "We may also see the crater that Deep Impact created in 2005, but because of Tempel 1's rotation, there is no guarantee. At the end of the day, whatever we see there should provide some great new science."

While comets have been observed and postulated on for centuries, cometary science acquired literally "on the fly" is a relatively new field. Since 1984, there have been spacecraft flybys of six comets. Of these, none involved the ability to look for changes that may have occurred as a result of the comet's orbit around the sun. That is, until Stardust-NExT and Tempel 1 meet tonight.

"You could argue that comet Tempel 1 is the most unique icy dirtball in our solar system," said Joe Veverka, Stardust-NExT principal investigator from Cornell University, Ithaca, N.Y. "Not only does it have many intriguing physical characteristics that fascinate the scientific community, it also has been analyzed and scrutinized time and again from the ground and space."

In January 2007, NASA chose Veverka's plan to revisit comet Tempel 1 with NASA's already in-flight Stardust spacecraft. Stardust had just completed the mission it was designed for – flying to comet Wild 2, collecting samples of the coma as it hurtled by, and then flying back to Earth to drop off a sample return capsule so scientists could study pieces of comet in their labs.

Ask any spacecraft project manager -- re-tasking a spacecraft designed for a completely different mission is a challenge. To be in the right place at the right time to see changes in surface features on a small celestial body that seemingly changes its rotation rate on a whim and is out of view from observers for most of its five-and-a-half-year orbit about the sun -- that's something else entirely. But that was the assignment given to Stardust-NExT team members Mike Belton, Steve Chesley and Karen Meech.

"As comets sweep though the inner solar system, they come alive," said Belton, a Stardust-NExT co-investigator from Belton Space Initiatives in Tucson, Ariz. "They belch gas and dust, and this outgassing can not only change their orbits, it can also change their rotation rate."

Determining the comet's rotation rate and which side will be illuminated when is tricky, because the comet had only been seen up close for a short time in July 2005 during the Deep Impact encounter. From then on, the comet nucleus, about 6 kilometers (3.7 miles) wide, appeared to observers to be little more than a point of light in the sky for even the best telescopes -- including NASA's Hubble Space Telescope. (Tempel 1's orbit takes it as far out as Jupiter's orbit and almost as close as Mars' orbit.) But even points of light can bear scientific fruit for astronomers and space scientists. The flattened, oblong Tempel 1 nucleus was no exception.

"Its shape is central to what we could learn about its rotation," said Belton. "A comet reflects the sun's light. When one of its two broad regions is facing us, it gives off more light. When one of its skinnier sides is pointed toward the telescope, it gives off less light. So we felt we could develop an accurate model for the comet's rotation."

The plan was for Belton and Chesley to generate comet rotation models independently. What both needed was data (and a lot of it) on the amount of sunlight Tempel reflected and when. Both knew the source for that information: fellow Stardust-NExT co-investigator Karen Meech. Meech, an astronomer from the University of Hawaii, reached out to her network of fellow astronomers around the world.

"They came through (in spades)," said Meech. "In total, 25 telescopes at 14 observatories around the world allocated about 450 whole or partial nights to this project. With telescope time at a premium, it was a massive effort on their parts."

With the Tempel 1 light curve data acquired by Meech in hand, Belton and Chesley independently worked on determining the rotation rate for Tempel 1. As it turned out, the data revealed it was not so easy.

"The comet doesn't just rotate at a specific rate -- it speeds up and slows down its rotation depending on what part of its surface is heated by the sun," said Steve Chesley, Stardust-NExT co-investigator from JPL. "Overall, the comet’s spin is speeding up over time. We expect its average rotation rate to go up progressively as it continues its orbits around the sun, but it is hard to define just how much."

In January 2010, after almost a year of analysis, Belton and Chesley compared notes. Their two independently generated rotational models for Tempel 1 were remarkably similar. But were they right?

"NASA looked at the data and decided that they were actionable," said Tim Larson. "Our Feb. 17 burn last year set us up for a flyby when the comet rotation model suggests the face of Tempel 1 that contains the Deep Impact crater is facing the sun."

If that is the case, Stardust's camera should be able to see the crater.

"When Stardust completed its prime mission in 2006, it was in an orbit that could possibly reach only two comet targets in the future," said Veverka. "One of those two was Tempel 1. I chose it because it is a fascinating place. If we see the Deep Impact crater, that's great. If we see the other face of the comet, we will provide science with the most complete picture of any comet surface to date. Either way, we win."

The wait to find out which face Tempel 1 decides to put forward is almost over. Tonight, Feb. 14, at 8:40 p.m. PST (11:40 p.m. EST), the Stardust spacecraft is expected to fly within 200 kilometers (124 miles) of comet Tempel 1. During the encounter, the spacecraft's navigation camera will take 72 images. The first one should be down on the ground soon after midnight at JPL.

"Some people have asked me where I will be when those first images come down," said Chesley. "I know exactly where I will be. I'll be on the edge of my seat."

Stardust-NExT is a low-cost mission that will expand the investigation of comet Tempel 1 initiated by NASA's Deep Impact spacecraft. JPL, a division of the California Institute of Technology in Pasadena, manages Stardust-NExT for the NASA Science Mission Directorate, Washington, D.C. Joe Veverka of Cornell University is the mission's principal investigator. Lockheed Martin Space Systems, Denver, built the spacecraft and manages day-to-day mission operations.

Provided by JPL/NASA

Citation: The two faces of Tempel 1 (2011, February 14) retrieved 19 April 2024 from https://phys.org/news/2011-02-tempel.html