Leaping lunar dust

March 18 2013, by Nancy Neal-Jones & Bill Steigerwald

This is a view from NASA's Lunar Reconnaissance Orbiter spacecraft across the north rim of Cabeus crater. The leaping dust behavior may be observed on the moon in places like this where sunlit areas are close to shaded regions. Credit: NASA/GSFC/Arizona State University

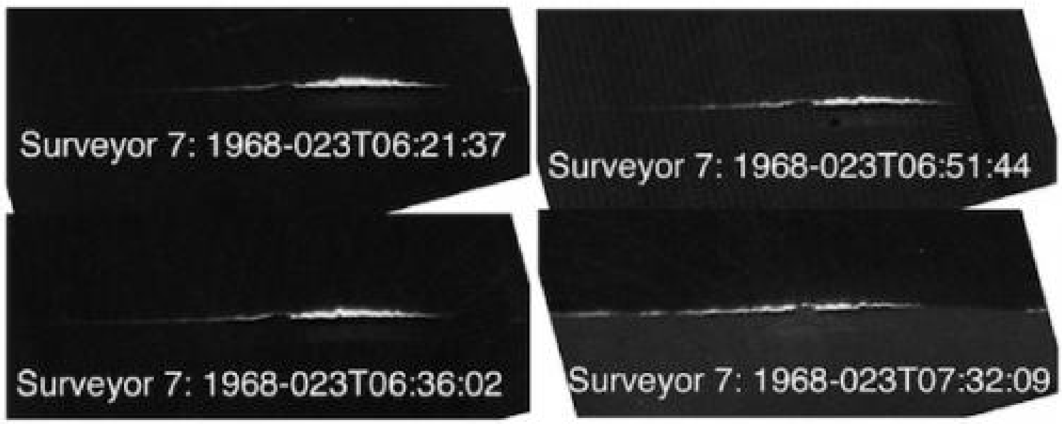
(Phys.org) —Electrically charged lunar dust near shadowed craters can get lofted above the surface and jump over the shadowed region, bouncing back and forth between sunlit areas on opposite sides, according to new calculations by NASA scientists.

The research is being led by Michael Collier at NASA's Goddard Space Flight Center, Greenbelt, Md., as part of the Dynamic Response of the Environment At the Moon (DREAM) team in partnership with the NASA Lunar Science Institute (NLSI), managed at NASA's Ames Research Center, Moffett Field, Calif.

"The motion of an individual dust particle is like a pendulum or a swing," says Collier. "We predict dust can swarm like bees around a hive over partially shaded regions on the moon and other airless objects in the solar system, such as asteroids. We found that this is a new class of dust motion. It does not escape to space or bounce long distances as predicted by others, but instead stays locally trapped, executing oscillations over a shaded region of 1 to 10 meters (yards) in size. These other trajectories are possible, but we now show a third new motion that is possible." Collier is lead author of a paper on this research published October 2012 in Advances in Space Research.

This effect should be especially prominent during dusk and dawn, according to the team, as regions become partially illuminated while features like mountains and crater rims cast long shadows.

"The dust is an indicator of unusual surface electric fields," says William Farrell of NASA Goddard, a co-author on the paper and lead of the NLSI DREAM team. "In these shaded regions, the surface is negatively charged compared to the sunlit regions. This creates a locally complex, larger electric field with separate positively and negatively charged regions, called a dipole field, over the shaded region. The dust performed its swinging motion under the influence of this dipole. Such a surface process occurring on the moon at the line where night transitions to day, called the terminator, might also occur at small bodies like asteroids. It might be a fundamental process occurring at airless rocky bodies."



These are photos of low-level Lunar Horizon Glow observed by Surveyor 7; white streaks are glows observed at different times. Credit: NASA

There is evidence that dust actually moves this way over the lunar surface. "There are hints for this type of dust swarm in Surveyor images. A twilight was observed over the landed platforms during dusk and dawn. This was surprising at first because the moon does not have a dense enough atmosphere to scatter light when the sun is below the horizon. It was long considered to be light scattered from lifted dust. This model suggests the dust is really leaping or swarming overtop a large number of shaded regions that would exist along the lunar dusk/dawn line, called the lunar terminator. It's a natural fit. Charged lunar dust transport is also believed responsible for the Apollo 17 Lunar Ejecta and Meteorites (LEAM) experiment's observation of highly charged dust near the terminator," adds Collier.

To our eyes, the moon has no apparent activity and seems dead. However, because it has almost no atmosphere, the moon is exposed to the solar wind, a thin stream of electrically conducting gas called plasma blown off the surface of the sun at around a million miles per hour. The effects of sunlight and the solar wind generate a bustle of unseen commotion at the moon. On the day-lit side, sunlight knocks negatively charged electrons off the surface, giving it a positive charge. On the night side or in shadow, electrons from the solar wind rush in, giving the surface a negative charge.

The exact mechanism for launching lunar dust is not uniquely known. Micro-meteoroid impacts can transfer energy to the surface to launch particulates. Also, a rough surface has small, localized concentrations of electric fields that could lift dust electrostatically from the surface. The pendulum motion then happens because sunlit areas on the moon tend to get positively charged, while shaded areas become negatively charged. Since like charges repel each other, a positively charged dust grain in a sunlit area gets pushed away from the positively charged surface. If there were no negatively charged area nearby, the dust grain would rise straight up. However, since opposite charges attract, the positively charged dust gets pulled toward the negatively charged crater floor, bending its path over the crater. Dust launched from the sunlit area with just the right speed will pass over the shaded floor of the crater to the sunlit area on the other side, where the positively charged surface there will reflect it back over the crater again. When many particles do this, the model predicts there should be a swarm or canopy of dust over the crater.

If there were no complications, the particle could continue to bounce between sunlit areas on opposite sides of the crater indefinitely. However, in reality, things like differences in crater rim height, roughness on the crater floor, and interference from the solar wind that weakens the electric field produced by the surface charges can alter the particle's path. These perturbations cause the dust to eventually either fall into the crater or be launched away. "This model provides a natural explanation for the observation of dust ponds inside craters on the asteroid Eros," says Collier.

"Calculating how these complications will affect the path of a dust particle on the moon and around asteroids are good areas for future research," says Collier. "Additionally, we're not sure how many particles get charged and move like this – is it something like one in a thousand, one in a million, or one in a billion? We'd like to do more studies to see how likely it is that a particle will behave this way. Since most of the lunar surface is covered in dust, even one in a billion would still be significant." The team is also planning on examining Apollo-era images to evaluate possible evidence for dust canopies over shadowed craters.

More information: For more information about the DREAM team visit: ssed.gsfc.nasa.gov/dream/

Provided by NASA

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