The Phenomenon of Particle Ejections from Asteroid Bennu

*Coralie Dominique Adam[1], Dante S Loretta[2], Carl W Hergenrother[2], Steven R Chesley[3]

1. KinetX Inc., Space Navigation and Flight Dynamics Practice, Simi Valley, CA, USA, 2. Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA, 3. Jet Propulsion Laboratory, Pasadena, CA, USA

The OSIRIS-REx spacecraft has been operating in proximity to near-Earth asteroid (101955) Bennu since December 2018. Particle ejections off the surface of the asteroid were first discovered[i] in images from 6 January 2019, 1 week after the spacecraft entered orbit and 4 days before Bennu perihelion. This phenomenon was serendipitously captured in the NavCam 1[ii] optical navigation images, intended to image background stars while maintaining Bennu in the field of view. Prior to arrival at Bennu, an extensive natural satellite imaging campaign conducted to search for orbiting objects greater than 10 cm yielded null results.

The first optically observed particle ejection event on 6 January 2019 shows more than 200 star- like point-source objects and trailed (higher-velocity) objects located off the limb of Bennu. A second image minutes later shows objects in common with the earlier image that have moved away from Bennu, implying the movement of discrete particles. The included figure[i] shows (A) a composite image of two exposures taken by the NavCam on 6 January 2019 in immediate succession: a short-exposure image (1.4 ms), showing the asteroid, and a long-exposure image (5 s), showing the particles; and (B) two long-exposure images (5 s, spaced 7.27 min apart) registered on the center of Bennu and differenced to highlight any moving particles. Particles moving at high velocity appear as streaks in a single image (red), and paths of particles moving more slowly (yellow) are identified from individual particles detected in the earlier image that also are present in the later image, farther from Bennu’ s limb.

This first observation triggered an immediate mission risk assessment, which concluded that the size and velocity of these particles (0.07–3.3 m/s, <1 to ~10 cm)[i] did not pose risks to keeping the spacecraft in its 1.6 x 2.0 km frozen orbit. The operations teams quickly worked to build new observation campaigns to improve the frequency and data quality in observing the active asteroid activity. In the subsequent year of operations, the team has detected multiple large ejection events, more than a dozen small events (<20 observed particles), as well as a persistent background level of particles in the Bennu environment. A pipeline was established which automates the detection of potential particles, identifies object pairs between images, reconstructs the event location and timing, and solves for various dynamical and physical properties of each particle.

A forthcoming special collection in the *Journal of Geophysical Research: Planets* will characterize this phenomenon, from reconstruction of the event dynamics to proposed mechanisms for particle release.

This work is supported by NASA under Contracts NNM10AA11C, NNG12FD66C, and NNG13FC02C. OSIRIS-REx is the third mission in NASA’ s New Frontiers Program. Dante Lauretta of the University of Arizona, Tucson, is the principal investigator, and the University of Arizona also leads the science team and the science observation planning and data processing. Lockheed Martin Space Systems in Denver built the spacecraft and is providing flight operations. Goddard Space Flight Center and KinetX Aerospace are responsible for navigating the OSIRIS-REx spacecraft.

[i] D.S. Lauretta, et al., “Episodes of particle ejection from the surface of the active asteroid (101955)

Bennu," Science, Vol. 366, No. 6470, 2019.

[ii] B. Bos, M. Ravine, M. Caplinger, J. Schaffner, J. Ladewig, R. Olds, C. Norman, D. Huish, M. Hughes, S. Anderson, et al., "Touch and Go Camera System (TAGCAMS) for the OSIRIS-REx asteroid sample return mission," Space Science Reviews, Vol. 214, No. 1, article id 37, 2018

Keywords: Bennu, OSIRIS-REx, Particles, Active, Asteroid, NASA