EPSC Abstracts
Vol. 13, EPSC-DPS2019-852-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

(101955) Bennu is an Active Asteroid

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Abstract

The OSIRIS-REx sample return mission [6] has observed its target asteroid (101955) Bennu to be an active asteroid. The activity of Bennu manifests as the release of particles from multiple locations on the surface [4]. This talk will present an overview of completed search observations, plans to monitor particle activity, and our current understanding of the particle ejection events and resulting short-lived orbiting particles.

1. Introduction

A group of main belt asteroids, called 'active asteroids', has been observed to display mass loss [5]. Some active asteroids exhibit mass loss due to mechanisms common to all small bodies, such as impacts, and YORP-induced rotational instability. Other mechanisms are object-specific, including sublimation of volatiles, electrostatic levitation, dehydration, and thermal fracturing or disintegration.

One of the criteria used to select Bennu as the OSIRIS-REx mission target was its B-type spectral classification. A number of active asteroids in the Main Belt or on near-Earth orbits originating from the Main Belt are classified as B-types, including (3200) Phaethon, 107P/Wilson-Harrington, and 133P/Elst-Pizzarro [5].

2. Observations

2.1 Pre-Discovery Observations

The possibility of mass loss activity led the OSIRIS-REx program to plan observations to search the environment of Bennu for dust, particles, and long-lived satellites during the mission's Approach phase [4]. These observations utilized the OSIRIS-REx Camera Suite (OCAMS) PolyCam and MapCam imagers [7]. Searches for comae, tails, and dust along Bennu's orbit and the anti-solar vector in September 2018 at a range of ~10^6 km detected no evidence of mass loss. A satellite search conducted over ten dates in October and November found no satellites larger than a diameter of 8 cm (for an albedo of 0.03, corresponding to the darkest material seen on the surface of Bennu) and 2 cm (for albedo of 0.15, corresponding to the brightest surface material) [3].

While no dedicated particle search observations were planned after the satellite searches in September 2018, observations taken during the Preliminary Survey and Orbital A phases were sensitive to particles within a few kilometers of Bennu. A number of off-body returns from the OSIRIS-Rex Laser Altimeter

(OLA) instrument [2] during the Preliminary Survey may constitute the first evidence of particle ejection activity, although this remains to be confirmed.

2.2 Particle Observations

The first particles to be discovered were part of an ejection event on 6 January 2019 during the Orbital A mission phase (orbit ranging between 1.5 and 2.1 km from Bennu center of mass). The discovery was the result of a visual inspection of Touch And Go Camera System (TAGCAMS) NavCam1 [1] optical navigation images and noted as an enhancement of the stellar background off the limb of Bennu [4]. The event had the visual appearance of a large open star cluster with stellar magnitudes down to ~7. A gradient filter was used to remove stray light from Bennu, enhancing the view of the event and allowing the identification of ~150 particles with inferred sizes of centimeters to decimeters and ejection velocities up to meters per second.

After the identification of the 6 January event, the mission team formed a task force to identify the nature of the event and ruled out instrument and spacecraft artifacts, and non-Bennu related natural phenomena. At discovery, optical navigation images were taken once every ~2 hours for 16 hours per date. After discovery, the cadence was increased to as frequent as every ~20 minutes. This cadence continued through late February. During the months of January and February, a number of particle ejections events consisting of between 1 and 150+ particles were detected. Several ejected particles completed multiple circuits about Bennu before impacting back onto the asteroid's surface.

2.3 Future Observations

As the mission proceeds through its scheduled observations, observing geometries may not be as conducive for particle observation due to greater ranges and phase angles. Future observing campaigns are being added to focus on monitoring and characterizing the ejection events and the behavior of the resulting particles. In the immediate term, these include 2 weeks of dedicated monitoring in late June from the Orbital B altitude (circular near-terminator orbit of ~0.93 km from Bennu center of mass), 4 weeks in August and September near the time of Bennu's aphelion, and a possible 3-month campaign around the time of Bennu's next perihelion in early 2020. The August and early 2020 campaigns will be conducted at the Orbital A altitude, allowing a direct comparison with perihelic activity observed in January and February 2019.

3. Results

Our understanding of the particle phenomenon is rapidly evolving as new data are produced. By the time of this presentation, nearly a year of particle monitoring data will have been collected, including at the times of Bennu's perihelion and aphelion. Results will consist of heliocentric distance trends of particle frequency and energy of events; photometric analysis including phase functions; particle brightness, size, and mass distributions; and source regions on the surface of Bennu.

Acknowledgements

The National Aeronautics and Space Administration supported this work under Contract NNM10AA11C issued through the New Frontiers Program. Part of this research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

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