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Initial Orbit Determination and Event Reconstruction from Estimation of Particle Trajectories about Bennu

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Abstract

The OSIRIS-REx spacecraft began its first orbital campaign around near-Earth asteroid (101955) Bennu on December 31, 2018. After a week of nominal operations, optical navigation images revealed particles emanating from the surface of Bennu with significant velocities. The observation cadence and imager settings were modified to better detect possible future events. Multiple ejection events have since been monitored, with several particles being ejected on hyperbolic or ballistic trajectories from the surface of Bennu, some particles entering long-lived orbits. This talk will present current results pertaining to the identification of particle tracks, an evaluation of the estimated orbits and the excess velocity necessary to induce the particle ejection from the surface, and the uncertainty quantification of the ejection location.

1. Introduction

Current best estimates of particle trajectories and their velocities spanning multiple ejection events will be presented based on observed particles detected in the navigation camera during the first two months of the OSIRIS-REx spacecraft orbital campaign. This talk will summarize the techniques used to determine particle tracklets, how the trajectories were able to be estimated and the assumptions pertaining to that analysis, and an uncertainty quantification of the particle event locations and their respective excess body-fixed velocities that were induced on the particles to release them from the surface.

2. Initial Results

Three ejection events with greater than 20 detected particle tracks were identified on January 6, January 19, and February 11. The minimum number of observations per particle track necessary to constrain the orbit solution is two. The January 6 event contains the least amount of image data for which tracklets of particles can be determined, whereas the January 19 and February 11 events contain tracklets with 2 – 5 observations providing a detailed data set to determine the energy necessary to create a particle release event. Figure 1 shows preliminary results of the required excess velocity induced on the particles that were freed from the surface on January 19. Individual particle trajectories have been estimated for each of the events, and the results of those trajectories, including the location and potential sizes, will be discussed.

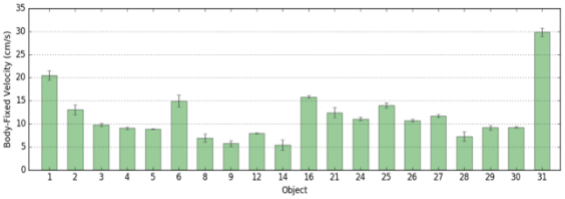

Figure 1: January 19 excess body-fixed particle velocities

3. Uncertainty Analysis

A key component of this analysis is the reliance on the estimated uncertainty in the system to provide a search region on the surface of Bennu. The primary objective of the trajectory estimation process for the particle ejection events is identification of ejection and impact locations. This talk will review the results from a Markov-Chain Monte-Carlo for each of the ejection events to obtain a more realistic sampling of the *a posteriori* uncertainty associate with the event location on the surface as well as the local solar time at which the event occurred. Detailed analysis of these ejection sites can provide further insight into the mechanical process producing these particle events.

Acknowledgments

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