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Geophysical Exploration of Binary Asteroids using Surface Packages: The BASiX Mission

Scheeres, D.J., University of Colorado;
Lognonne, P., IPGP;
Chesley, S., JPL; Anderson, R., JPL; The BASiX Science Team

The BASiX mission has been proposed to NASA's Discovery Mission call for proposals. The mission visits a primitive binary asteroid to explore the unique evolutionary pathways that rubble piles are subject to, and to understand the geophysics of rubble pile bodies. This talk will focus on the innovative approach to geophysical exploration taken by the BASiX mission, and will discuss how this approach can be easily generalized to small bodies in general.

The BASiX geophysics experiment consists of deploying two different types of spherical pods on the surface of a rubble pile body, GeoPods (GPods) and BlastPods (BPods). GPods carry geophones to enable the measurement of seismic waves as they traverse through a rubble pile body. BPods contain about 5 kg of high explosives, providing approximately 20 MJ of energy that will create a crater on the surface that is at least 2 meters across, and likely much larger.

At least two or more GPods are deployed to the small body surface. After deployment they record and subsequently transmit up to 8 hours of data, enabling the natural seismic signature of a rubble pile to be documented. In addition to thermal induced noise within the body, micrometeorite impacts may also provide seismic sources that would enable multiple GPods to perform cross correlation measurements of the seismic signal, enabling constraints to be placed on the body interior. To ensure that a measurable seismic signal is available for measurement, the BPod is deployed to the surface later, and its detonation provides a seismic source for the GPods to measure. Given the long recording time of the GPods, even if they are lofted from the surface they will land while the interior ringing is still predicted to be active. In addition to enabling the seismic sounding of the asteroid interior, the size of the crater also provides a precise measurement of the cohesive strength of the asteroid regolith.

The BASiX proposal has addressed several potential challenges associated with this approach to geophysical exploration. First is the deployment of the Pods to the asteroid surface. The BASiX mission plan uses controlled flybys at relatively low altitudes as staging points for the deployment of the Pods using a spring mechanism. By choosing a binary system to explore, the total mass of the system is known, enabling the necessary spring release speeds to be specified now. The range of expected surface motion of a Pod has been studied using simulation and laboratory experiments to develop constraints on the total motion and and interaction with the surface, enabling design insight into how this can be controlled. Ample power is provided by internal batteries sized to the extreme thermal environments expected. Cost is controlled by only using COTS power, UHF communication systems and field tested geophones and high explosives for the Pod payloads.