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Anks. Ion Beam Sputtering of Secondary Objects in Space : from debris removal to surface composition measurements

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Abstract

Controlling the interaction between an ion beam and a secondary object can serve various mission purposes such as debris orbit modification or asteroids surface composition measurements. By secondary object, we mean any object other than the primary spacecraft from which the ion beam is emitted, e.g. another spacecraft, a piece of debris or a natural object such as an asteroid. The ion beams are emitted usually from an electric propulsion device, or as part of a potential control device.

1 Orbit modification missions

Researchers have recently considered the concept of 'ion beam shepherd' [1]. In this concept, an ion beam is deliberately directed at an asteroid or a piece of debris in order to impart a delta-V and cause a trajectory change. For efficiency reasons such technique requires the firing spacecraft to be located sufficiently close to the target, in order for the beam to be fully intercepted.

In such configuration we have estimated the amount of sputtered products with trajectories intercepting the firing spacecraft, resulting in a potential source of contamination for optically sensitive surfaces (e.g. solar cells). We have carried out such estimation considering both types of target compositions, representative of debris on the one hand and of asteroids on the other hand.

Based on simplifying assumptions on the sticking probability between sputtered products and the spacecraft surfaces, we have obtained potentially significant deposition rates, such as 6nm per day in the typical debris case and between 0.5nm and 8nm per day in the asteroid case, indicating the existence of a potentially critical source of contamination of sensitive surfaces during such mission. We describe here the simulations that we have carried out as well as the results obtained. Most importantly, we discuss our assumptions and propose way forward to refine the results of such simulations.

2 Surface composition measurements

Probing of tenuous asteroid exospheres using sate of the art space based mass spectrometers is limited by spacecraft outgassing levels, as demonstrated during ROSETTA Stein and Lutetia flybys [2]. In contrast, directed ions beams can be generated from a spacecraft and sputter surface materials in sufficient amount to be detected by an associated mass spectrometer. Such technique, known as Secondary Ion Mass Spectrometry, would provide a detailed analysis of the first layers or bulk composition of the surface, depending on operating modes. It has been implemented for instance onboard ROSETTA spacecraft with the COSIMA instrument which will analyze the composition of dust grains ejected from comet 67P/Chuyruymov-Gerasimenko nucleus [3].

In this context we estimate putative sputtered fluxes of (positive / negative ions, and neutrals) species resulting from either Solar Wind ions impact, 1keV / Xe+ ions (ion thruster like) impact, or 10keV In+ impact on the surfaces of a number of small objects. We also discuss detectability thresholds as a function of distance from the object according to existing technologies, and inherent drawbacks of such technique.

References

[1] C.Bombardelli and J.Peláez, 'Ion Beam Shepherd for Asteroid Deflection', JOURNAL OF GUIDANCE,

CONTROL, AND DYNAMICS, Vol. 34, No. 4, July–August 2011

[2] Altwegg, K. et al, In situ mass spectrometry during the Lutetia flyby, Planetary and Space Science 66 (2012).

[3] Kissel, J. et al, COSIMA: A High Resolution Time-of-Flight Secondary Ion Mass Spectrometer for Cometary Dust Particles on Its Way to Comet 67P/Churyumov-GerasimenkovCOSIMA: A High Resolution Time-of-Flight Secondary Ion Mass Spectrometer for Cometary Dust Particles on Its Way to Comet 67P/Churyumov-Gerasimenkov, Proceedings of Dust In Planetary Systems, LPI contr. 1280, 2005