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Fragment size-ejection speed correlation in impactor-ejecta processes

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Abstract

Ejecta created in high velocity impacts ($v > 10\,\frac{\mathrm{km}}{\mathrm{s}}$) of micro-meteoroids on atmosphereless cosmic bodies is an efficient source for interplanetary dust. The impact erodes the target surface and releases material into space. The ejecta are typically micron-sized and populate a dust cloud whose number density decreases with increasing distance from the target. Unbound particles escape and add to the planetary dust environment. However, even mesoscopic particles ($R > 100\,\mu\mathrm{m}$) can severely damage manmade space hardware as they have high kinetic energies when they encounter spacecraft with high relative velocities. Here we investigate the influence of a correlation between the fragment size R and the ejection speed u in the form

$$\bar{u}\,(R) \sim \int_{u_{\min}}^{u_{\max}} u\,g\,(R,u)\;\mathrm{d}u \sim R^{-\beta} \quad \beta > 0 \qquad (1)$$

stating that larger fragments are (in average) launched with slower speeds as suggested by theoretical considerations and impact experiments (Melosh, 1984; Miljković et al., 2012).

We found that such a correlation constitutes a dynamical filter which removes large ejecta from high altitudes. For large moons they are always bound and restricted to regions close to the target surface. The effect is stronger for bigger ejecta and for more massive target bodies. Our results show that the risk to encounter dangerous particles during close flybys around large moons is lower than expected from the uncorrelated model of Krivov et al. (2003). Further changes due to strong planetary magnetic fields at the other end of the size range are discussed.

References

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