# Astronaut Charging on an Asteroid

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## Introduction

An asteroid is an obstacle to the flowing solar wind plasma, and any object placed in this electrical environment will develop a potential relative to both the asteroid and the local plasma. It has been shown in recent simulations [Zimmerman et al., *2014]* that the solar wind plasma environment at a small exposed body is very complex, especially when considering effects of photoemission, topography, and formation of a plasma wake. We consider an astronaut moving along the surface of an asteroid, in periodic contact with the surface under widely varying solar wind and photoelectric particle fluxes.

**Objective** – to determine how an exploration craft/astronaut accumulates charge about a small asteroid while considering safe locations and grounding configurations for exploration contact .

**Considerations** – location (i.e. terminator, shadowed or dayside), the effects of being tethered to a spacecraft such as the Orion Multi Purpose Crew Vehicle (MPCV).

## Regions of Interest

Similar to the moon, a trailing wake is formed behind the asteroid due to solar wind obstruction.

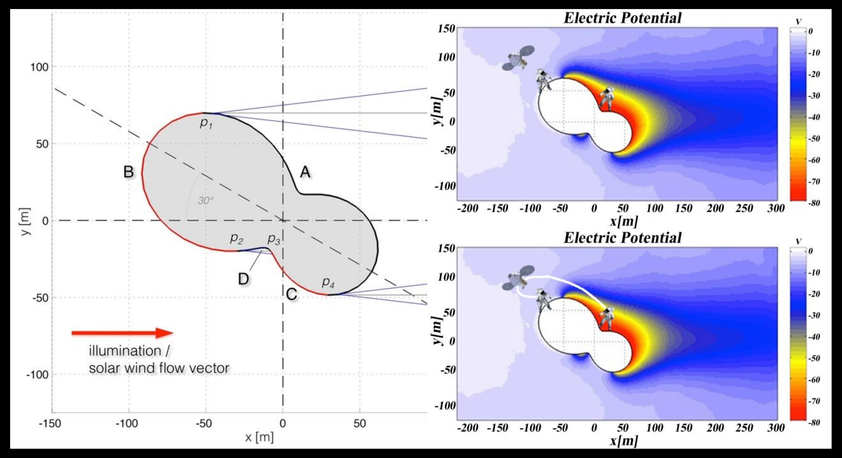
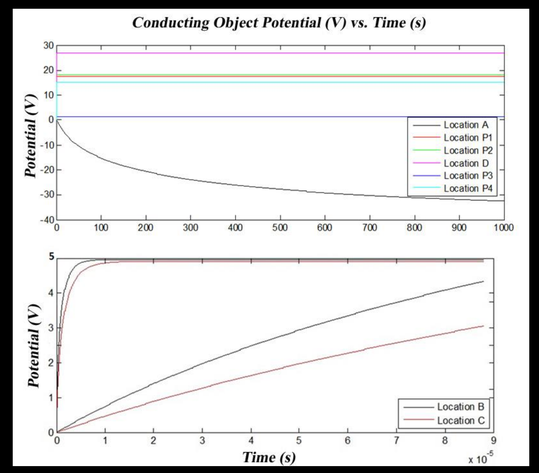



Figure 1: A and D are selected shadowed/nightside locations in the asteroid created plasma wake. B and C are dayside locations immersed in the dense photoelectron sheath. P1 – P4 are terminator regions [Zimmerman et al., *2014*]. *Astronaut and spacecraft are not to scale. Top panel shows isolation while bottom panel shows tether to illuminated spacecraft. The surface potential in the shadowed regions is very negative, becoming more positive as one crosses the terminators into the dayside regions.

## Object Charging

Stationary objects reach an equilibrium potential. The time to reach this potential is longest at the larger shadowed region A.

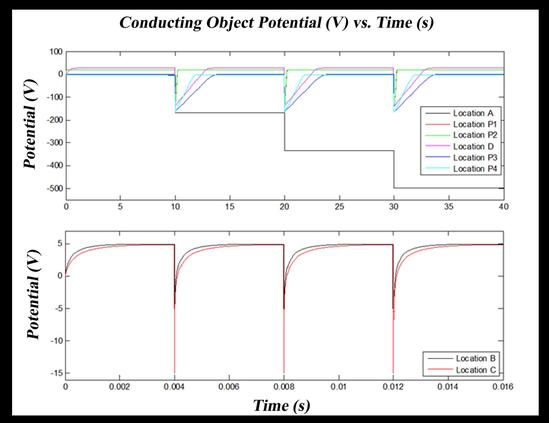


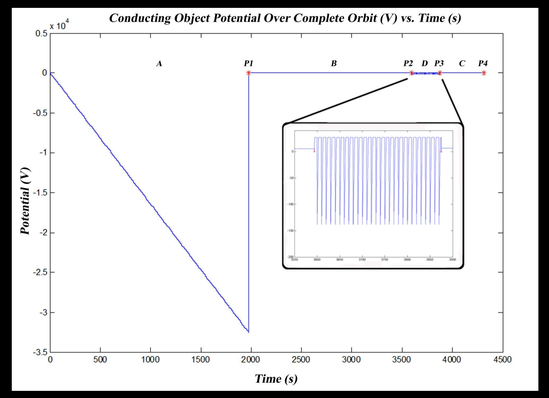

Although the Orion spacecraft is larger than the astronaut suit, both conducting objects will reach the same equilibrium value at each location. The top panel shows only the stationary astronaut at night and terminator regions. The bottom panel shows the slower charging astronaut against the faster charging spacecraft in illuminated regions.

## Tribocharging

A roving astronaut can be modeled as a capacitor, initially connected to a triboelectric current source. As the astronaut roves, he/she will come in contact with the surface to tribocharge, which charges up the capacitor. The ground of the asteroid is assumed to be a poor conductor, leaving the plasma currents as the dominant path for remediating charge buildup. Since tribo-charging is dynamic, the potential of the tribo-charging astronaut is found by solving a charging equation (Jackson et al. 2011). We use $\phi_o$=-Q/C as the potential collected at each astronaut/surface contact (every 10s).

## Results




## Conclusion

- Charging and dissipation times are reduced with larger current collecting areas.
- Dayside charge is remediated almost instantaneously.
- Charging to > -1000's of volts is possible in the trailing plasma wake/void region.
- Increasing speed causes more vigorous charging in shadowed regions.
- After significant tribocharging in shadowed regions, charge should be dissipated before venturing across the terminator and into dayside regions .
- Resulting buildup of significant negative charge could eventually initiate other "currents of last resort" i.e. dust transport, field emission from the astronaut.
- Having the astronaut tethered to the illuminated MPCV could potentially reduce the drastic charge accumulation while roving in shadow by giving the astronaut access to photoelectric currents.