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A Double-Disturbed Lunar Plasma Wake

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Under nominal solar wind conditions, a low density wake region forms downstream of the nightside lunar surface. However, the lunar plasma environment undergoes a transformation as the Moon passes through the Earth's magnetotail, with the warm plasma typically not having a strong flow, and thus the wake structure disappears. However, while in the tail, there can be a sudden intense change due to solar-driven events such as coronal mass ejections. With a new planned human presence on the Moon, it is important to understand the near-surface plasma environment's response to these extreme conditions. We investigate the response of the lunar wake to a passing coronal mass ejection on 2012 March 8 while crossing the Earth's magnetotail using both a large-scale MHD model of the Earth's global magnetosphere and smaller-scale 3-D hybrid-PIC simulations.

The CME plasma shock was detected by the Wind spacecraft around 10:30 UT and in the Earth's magnetotail around 11:20 UT by the ARTEMIS spacecraft in lunar orbit. Wind observations are used as time-dependent up-stream conditions for a 24-hour global magnetosphere MHD simulation run through NASA's Community Coordinated Modeling Center using the OpenGGCM model. Extracted plasma parameters from the ARTEMIS spacecraft following the plasma shock are used as upstream static boundary conditions for hybrid-PIC simulations using the AMITIS code.

Results for the hybrid-PIC lunar wake simulations performed during a momentary jump in magnetotail plasma velocity and density show a short misaligned plasma void relative to nominal SW conditions. MHD results indicate that changes near the Moon appear as a result of a warped magnetopause boundary moving inward after 11:00 UT, causing the Moon to enter the magnetosheath. These results also show a number of plasmoids developing and propagating down the tail, including one seen at 11:20 UT that corresponds temporarily with plasmoid-like features in the ARTEMIS magnetic field profiles.