EGU2020-5971
https://doi.org/10.5194/egusphere-egu2020-5971
EGU General Assembly 2020

Interaction of Interplanetary Shocks with the Moon

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In this presentation, we use data from THEMIS-ARTEMIS spacecraft and electromagnetic hybrid (kinetic ions, fluid electrons) simulations to describe the nature of the interaction between interplanetary shocks and the Moon. In the absence of a global magnetic field and an ionosphere at the Moon, solar wind interaction is controlled by (1) absorption of the core solar wind protons on the dayside; (2) access of supra-thermal and energetic ions in the solar wind to the lunar tail; (3) penetration and passage of the IMF through the lunar body. This results in a lunar tail populated by energetic ions and enhanced magnetic field in the central tail region. In general, ARTEMIS observations show a clear jump in the magnetic field strength associated with the passage of the interplanetary shock regardless of the position in the tail. Compared to the shock front observed in the solar wind, the magnetic field strength in the tail is stronger both upstream and downstream of the shock which is consistent with the expectations of larger field strengths in the tail. In addition, the transition from upstream to downstream magnetic field strength takes longer time as compared to the solar wind, indicating the broadening in space of the shock transition region. In contrast, plasma observations show that depending on the position of the spacecraft in the tail, a density enhancement in association with the shock front may or may not be observed. Using the observed solar wind conditions, we have used hybrid simulations to examine the interaction of interplanetary shocks with the Moon. The results indicate that by virtue of IMF passage through the lunar body, the magnetic field shock front also passes through the Moon and as such a jump in the magnetic field strength is observed throughout the lunar tail in association with the passage of the shock. As expected, the field strength in the upstream and downstream regions in the tail are larger than the corresponding values in the solar wind. In addition, the passage of the shock through the lunar tail is associated with the broadening of the shock front. The absorption of the core solar wind protons on the dayside introduces a density hole in the shock front as it passes through the Moon and the lunar tail and, as such, the shock front as a whole is disrupted. This hole is gradually filled with the ambient plasma while it travels further down the tail until eventually the shock front is fully restored a few lunar radii away from the Moon. The simulation results are found to be consistent with ARTEMIS observations. Here we also discuss the impacts of shock Mach number on the interaction. These results depict the lunar environment under transient solar wind conditions, which provide helpful information for the NASA's plan to return humans to the Moon.