Ultra-low frequency solar wind foreshock waves: comparison of Mercury, Venus and Mars in a global hybrid simulation

R. Jarvinen(1),(2)
(1) Department of Electronics and Nanoengineering, School of Electrical Engineering, Aalto University, Espoo, Finland
(2) Finnish Meteorological Institute, Helsinki, Finland

We analyze the solar wind interactions of Mercury, Venus and Mars in a three-dimensional global hybrid model. In the model, ions of solar wind and planetary origin are treated as macroscopic particle clouds moving under the Lorentz force, while electrons form a charge-neutralizing fluid. Ion velocity distributions evolve self-consistently according to the model calculation coupled with the evolution of the magnetic field by Faraday's law. Here we concentrate on the formation of large-scale, ultra-low frequency (ULF) waves in planetary ion foreshocks and their dependence on solar wind and interplanetary magnetic field conditions in the inner solar system. The ion foreshock forms in the upstream region ahead of the quasi-parallel bow shock, where the angle between the shock normal and the magnetic field is small enough. The magnetic connection to the bow shock allows the backstreaming of solar wind ions leading to the formation of the ion foreshock. This kind of beam-plasma configuration is a source of free energy for the excitation of plasma waves. The foreshock ULF waves convect downstream with the solar wind flow and encounter bow shock and transmit in the downstream region. The analyzed model runs use more than two hundred simulation particles per cell on average to allow fine enough velocity space resolution for resolving the foreshocks and waves self-consistently. The properties of the ULF waves and foreshocks differ significantly between these three planets. We discuss their causes including the upstream conditions and the size of the magnetosphere and the bow shock.

References

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