Degenerate induced magnetospheres: from Venus and Mars to exoplanets

Stas Barabash (Swedish Institute of Space Physics, Kiruna, Sweden)
Mats Holmström, Futaana Yoshifumi, Qi Zhang, Robin Ramstad

Induced magnetospheres of non-magnetized atmospheric planets like Mars and Venus are formed by magnetic fields of ionospheric currents induced by the convective electric field E = - V x B/c of the solar wind. When the interplanetary magnetic field is mostly radial (the cone angle is close to 0°), the convective electric field E ≈ 0, and the induced magnetosphere becomes degenerate. The structure and domains of degenerate induced magnetospheres even of Mars and Venus are still not fully understood. A solar wind void is observed but how it is maintained and whether or not a magnetic barrier forms is unclear. The degenerate induced magnetospheres are “open”, with quasi-parallel bow shock over almost the entire interaction region. The magnetic field in the magnetosheath is highly variable, typically 10s second period. This configuration results in the strong coupling between the induced magnetosphere and the solar wind and in significant energy transfer to the system. Degenerate induced magnetospheres present a specific and unique case of the interaction between a planet with ambient plasma. This type of interaction, though rare, has been observed at Venus and Mars. In total, 17 cases with the cone angle < 10° observed at Mars by Mars Express for the period 2014-2019, and 12 cases at Venus were recorded by Venus Express for the period 2006-2014. For the majority of the discovered exoplanets (hot Jupiters) orbiting the parent stars on distances 0.01 – 0.1 au the cone angle is ~4° (assuming the solar conditions). If the hot Jupiters do not have intrinsic field, they form degenerate induced magnetospheres. In this report we introduce degenerate induced magnetospheres as a new type of interaction and review the current works on the subject. We also show examples of observations at Mars and Venus and numerical simulations, describe the main properties and basic physics of such configurations, and how these results can be applied to exoplanets.