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Solar Wind Interaction with Mercury's Magnetosphere: a Simulation Study

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Three flybys of Mercury by Mariner 10, numerous terrestrial observations of Mercury's exosphere and MESSENGER observations during flybys and orbital operations have brought important information about the Hermean environment. Mercury's intrinsic magnetic field is principally dipolar and its interaction with the Solar Wind (SW) creates a small and very dynamic magnetosphere. Mercury's exosphere is a highly variable and complex neutral environment made of several species: H, He, O, Na, K, Ca, and Mg have already been detected. MESSENGER is in orbit around Mercury, since March 2011, with a polar trajectory and a periapsis located near the north geographic pole. MESSENGER observations lead to a new description of the source of the intrinsic magnetic field : a northward shifted dipole of 500 km seems to better fit the magnetic field observations at northern latitudes higher than 30°, than former models (Anderson et al, 2011). However the lack of low altitude observations above the southern hemisphere does not allow definitive conclusions about the topology of the planetary magnetic field at high southern latitudes. Global simulations can provide complementary information of Mercury's magnetic field structure and its global interaction with the solar wind.

This study presents simulation results from a 3-dimensional parallel multi-species hybrid model of Mercury's magnetosphere interaction with the SW. The SW in this model is representative of conditions at Mercury's aphelion (0.47AU) and is composed of 95% protons and 5% alpha particles. The simulated IMF is oriented accordingly to observations during the orbit of MESSENGER on April 23rd of 2011 without component in the north/south direction and a cone angle of about 60°. In addition a neutral corona of sodium is included in this model and is partly ionized by solar photons. Planetary and SW plasmas are treated separately and the dynamic of each ion species can be investigated separately. Simulations have been performed on a grid of $186\times400\times400$ cells with a spatial resolution of $\Delta x\sim120$km. Two models of the source of the internal magnetic field are tested: 1/ a northward shifted dipole, according to Anderson et al, 2011, 2/ a combination of a centered dipole and quadrupole fitted to the shifted dipole in order to comply with MESSENGER observations above 50°N latitudes.

We emphasize differences between the two southern magnetospheres resulting from the two different models of the internal field.