The Magnetic Field and Magnetosphere of Mercury

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The most naive picture of planetary magnetism is that a planet is hottest at initial accretion, the iron sinks to the center, if there is sufficient energy a magnetic field is generated, and when the planet cools the dynamo stops. In this picture, the large rocky planets, such as the Earth, should have active dynamos and the small rocky planets such as Mercury should not. In fact Mercury does appear to have an active dynamo while larger bodies such as Mars and Venus do not. The dynamos in the cores of these two planets either ceased or in the case of Venus perhaps never began. Thus the story of the generation of a planetary magnetic field is more complicated than the naive picture and includes the effect of the crust and mantle in allowing the core to cool so that a solid inner core can condense and provide the energy for the dynamo.

We can learn about the interior of Mercury from its gravitational and magnetic fields but from the Mariner 10 flybys these have been but poorly constrained. In the case of the magnetic field the solution for the quadrupole moment is almost totally unconstrained. Orbiter measurements such as planned on the Messenger and Bepi Columbo missions are essential to determine the high order magnetic field.

The solar wind plasma confines Mercury's magnetic field to a teardrop-shaped region with a long tail in the antisolar direction. The solar wind is so strong at Mercury's orbit and the planetary magnetic moment so weak that the standoff distance of the solar wind flow at the subsolar point is very close to the planet's surface. Thus relative to the size of Mercury, already the smallest of the terrestrial planets, its magnetosphere is small. There is not much room for a radiation belt as we have on Earth. Nevertheless, the magnetosphere of Mercury is of great interest to magnetospheric physicists because of something else Mercury lacks, a significant atmosphere. In the terrestrial magnetosphere the magnetic field is rooted in a highly electrically conducting ionosphere caused by the ionization of the Earth's ionosphere. This ionosphere enables the coupling of the solar wind momentum with the atmosphere through the generation of current systems that close in the ionosphere. Since this coupling is not expected at Mercury, the nature of the solar wind magnetosphere interaction might be quite different at Mercury than at Earth. These differences in turn can provide insights into how the various magnetospheric processes work. Thus, one of the overall objectives of the Messenger and Bepi Columbo missions is to examine these magnetospheric processes. The sparse data obtained from the Mariner 10 missions in 1974 and 1975 indicates that analogues of terrestrial processes do occur at Mercury but that there are important differences in the ways in which these processes work.