An induced global magnetic field looping around the magnetotail of Venus

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Venus serves as the prototype of solar wind interaction with unmagnetized planetary bodies with atmospheres. It has no intrinsic dipole or crustal magnetic field; the only magnetic field is believed to be formed by the draped interplanetary magnetic field (IMF). However, the large-scale magnetic field observed over the north polar region of Venus has a bias in the dawnward direction and seemingly unresponsive to the IMF's direction. Here we show that besides the draped field, there is a second type of induced global magnetic field at Venus and the dawnward field is only a part of it. This global field has a distribution in a cylindrical shell around the magnetotail and a counterclockwise direction looking from the planetary tail toward the Sun, which demonstrates that there are two currents flowing out and in of the planet along the inner and outer boundaries of the looping field, respectively. [JGR, 2016, doi:10.1002/2015JA021904]

It has been well established that the draped IMFs (green curves in left figure) form the induced magnetosphere and magnetotail [Saunders and Russell, 1986]. However, after the launch of VEX, dawnward large-scale magnetic fields have been frequently observed over north polar region at its periaxis. The dawnward field seems unresponsive to the IMF’s direction (red arrow in left figure, an observation example in right figure).

Are the mysterious large-scale dawnward fields local phenomena?

The average fields in the northern hemisphere observed by VEX (top) and on the nightside of Venus observed by VEX (middle) and PVO (bottom) are calculated by integrating the data along the +Z axis and the -X axis, respectively. Here the Venus-Solar-Orbiter (VSO) coordinates systems is used, in which X is antiparallel to the solar wind and 5-degree aberration being removed. Y is parallel to the transverse IMF, and Z is parallel to the solar wind convection electrical field (E = -Vx × Ba). The loop current fields (red) distributions observed by PVO in 1978-1988 and VEX in 2006-2014.

Venus is the subject to two types of looping fields, one is the draped IMF, the other is induced field, which has been identified by VEX and VSO instruments, respectively. Here we show that this induced field is not a local phenomenon, but is globally formed by an IMF-normal flow, and the field is probably of planetary scale. Thus the induced field is global and not a local phenomenon. Proof?

**Average magnetic fields around Venus**

**Large-scale downward magnetic field over north pole**

**Large-scale northward magnetic field over dusk equator**

**Global looping magnetic field at Venus**

**Global looping magnetic fields at Mars and Titan**

Schematic illustration of the looping field (red cycles) and its current system (green arrows), and the magnetic field lines.