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A Retrospective Look at the Collected Results on the Large Scale Ionospheric Magnetic Fields at Venus

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Abstract

We revisit the collected large scale ionospheric magnetic field results obtained by the Pioneer Venus Orbiter (PVO) and Venus Express (VEX) missions to ask how much we really understand about that field's global structure. To assist in this assessment we make use of several previously described MHD simulations of the solar wind interaction that reproduce its other observed features. These comparisons help to support our conceptual pictures in some cases, and to raise questions in others.

1.Introduction

The PVO mission provided the first look at the ionospheric magnetic fields of Venus, including their spatial patterns and their changes with external conditions (e.g. see the review in [1] and references therein). PVO sampled the fields near its ~150 km periapsis centered around 15 deg. N latitudes, primarily during the active period of the solar cycle. The availability of many orbits of low altitude observations (~600) made it possible to develop a conceptual picture of those fields. The VEX mission made its deepest measurements (to ~130 km) around its near-north-polar periapsis, during the recent pre-end-of-mission aerobraking phase. These VEX measurements were also obtained around solar maximum, with the difference that the present cycle has been weaker in terms of both its solar EUV flux and solar mass flux/interplanetary field strengths. Both sets of measurements show the apparent penetration of nearly horizontal large scale magnetic fields from the magnetosheath/magnetic barrier into the ionosphere, whose nominal boundary ranges from ~250 km to ~800 km, depending on solar wind pressure and ionospheric pressure [1,2].

It is not likely that the Venus ionospheric field will be observed again for some time, making an overall revisit of this topic timely –especially in light of broader interest in induced magnetospheric interactions and weakly magnetized planetary bodies. We also have the results of several global MHD simulations of the Venus-solar wind interaction that have been run using the BATS-R-US code in both single fluid, multispecies, and multifluid forms [3]. We use these as inspiration for investigating features found in the combined, orbitally biased, data sets, as well as for determining the extent to which the model assumptions capture the physics of this part of the solar wind interaction. Among the features re-examined are field structures in the nightside and their magnetic connection to the dayside draped fields, and the extent to which the penetrated magnetic barrier field can truly be regarded as a 'belt' [4,5].

2. Approach

We manipulate the observations in a statistical sense, in the VSO coordinate system and its spherical counterpart. We eliminate difficulties of not having an upstream solar wind monitor and associated statistics reductions inherent in organizing the data by interplanetary field orientation by working with the complete data set as measured. This allows us to look for patterns such as statistical relationships between vector components, drawing out behaviors associated with the average (toward and away Parker Spiral) interplanetary magnetic field directions, and solar wind and ionospheric pressures. We make graphical comparisons of key components of the field with their model counterparts, examining specific features such as the severity of field draping and the large scale field altitude profiles at the poles compared to lower latitudes. We ask whether there are counterparts of the nightside ionospheric holes in the model and their relationship to the large scale dayside field. These and other such comparisons provide a worthwhile test of our real understanding.

References

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