COORDINATE TRANSFORMATIONS OF LOW BETA REGIONS IN THE NIGHTSIDE VENUS IONOSPHERE. H. N. Williamson[1] and J. M. Grebowsky[2], [1]Department of Physics, Randolph-Macon College, [2]NASA Goddard Spaceflight Center.

Introduction: Pioneer Venus Orbiter (PVO) detected large regions of low plasma pressure and high magnetic pressure in the nightside ionospheric region of Venus, i.e. low beta regions. These regions frequently, but do not always, occur in pairs and are typically located near midnight local time. While many attempts have been made in the past to determine the origin of these regions, these regions are still not fully understood. Since Venus has no detectable magnetic field, any magnetic field lines present in the ionosphere must be solar in origin. However, there were no detailed attempts to look at the locations of the regions in a solar coordinate system, based on the interplanetary magnetic field. This new method is able to shed some light on the possible origin of these low beta regions.

Additionally, previous papers ([1], [2]) had said these magnetic field lines were typically oriented in a radial or sunward direction relative to the planet. However, this is not statistically the case. As a result, it is useful to examine the curl of the magnetic fields in the regions to determine the cause of these irregular orientations.

Methods: The orientation of the interplanetary magnetic field (IMF) at Venus is described by two angles: the clock angle and the cone angle. The clock angle is the angle in the north-south plane of the planet. The cone angle is the angle from the Sun-Venus line. The archived data coordinates for the low beta regions were in a Cartesian coordinate system, with the z-axis being north-south, the y-axis being east-west, and the x-axis being the radial axis. A magnetic coordinate system was then employed in which coordinates for each low beta region region were rotated once around the x-axis by the clock angle of the IMF, and then rotated again around the y-axis by the IMF cone angle measured on the same orbit. In doing so, we created a coordinate system where the orientation of the IMF is constant.

This produces the following three-dimensional plot, where each line represents a crossing through a beta low beta region. There is no obvious pattern to the distribution of the regions. However, there appears to be a bias towards the northern hemisphere, although it is unclear why this occurs. The locations of the regions, while still appearing random, are different than in the original coordinate system given by the spacecraft.

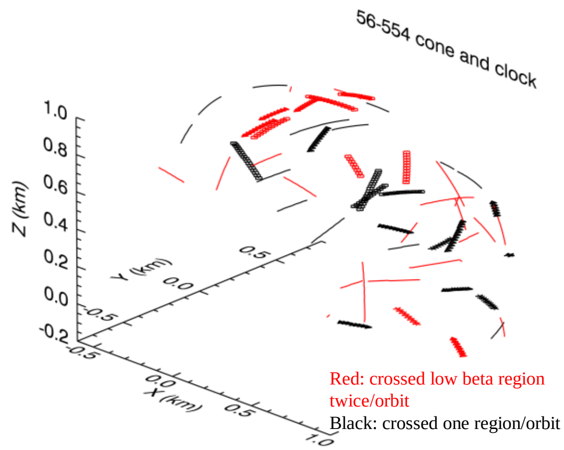

Figure 1: Axes are in terms of Venus radii and X, Y, and Z remain the same directions as in the Cartesian coordinate system.

In order to examine the electrical fields inside these regions, we then took the curl of the magnetic field to produce a plot of the currents for each region, using ephemeris data in addition to magnetometer data. The following example plot shows the curl in a region that did not have the predicted dominantly radial field. Figure 2 shows the magnetic field for a region in PVO orbit 520, while Figure 3 shows the curl of the field.

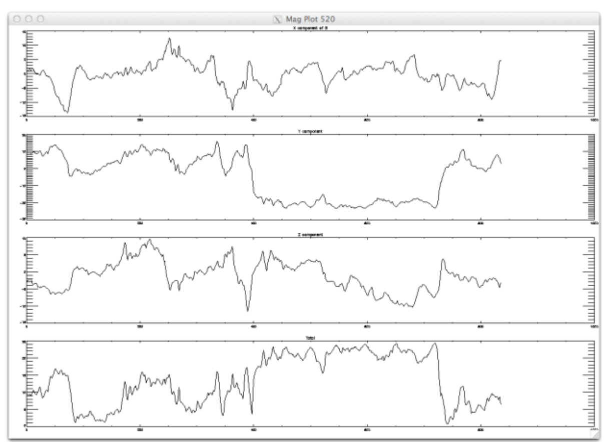

Figure 2: The magnetic field in a low beta region. The panels are from top to bottom: radial, east-west, north-south, and total field magnitude. Note that the field is strongest in the east-west direction (second panel). The rise in magnetic field near the center is the low beta region.

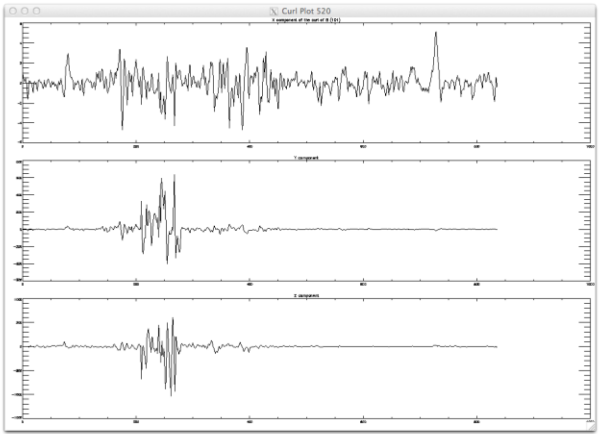

Figure 3: Each panel represents current direction—from top to bottom: radial, east-west, and north-south (X, Y, and Z).

Results: Despite using the new coordinate system, the locations of the low beta regions still appear to be random. This does not make sense, since the presence of a magnetic field should be related to the orientation of the IMF. However, the curl plots of the magnetic fields in the regions help to solve this issue. Since the magnetic fields are frequently oriented in a direction that does not correspond with the direction of the IMF, there are currents in the ionosphere that are contributing significantly to the magnetic fields in the regions. This is seen in the plots of the magnetic field curl.

It can be concluded, then, that the development of the radially directed electrical current seen in the curl plots creates a magnetic field component perpendicular to it, i.e. in the north-south or east-west direction. Since the magnetic field is not simply a result of the IMF, creating a coordinate system dependent on the direction of the IMF does not remove all variability from the locations of the low beta regions.

However, it is not clear how these radial currents are developed, as the data set is not complete enough to discover their origin. Despite this, it is possible to create a theory for their presence. As the IMF drapes around the planet and streams into the wake of the planet, it will create a radial magnetic field on the nightside of the planet. It is likely that the moving plasma of the ionosphere due to cross-terminator flow [3] is pulled out along this field line. Due to the mass differences of the ions and electrons present in the ionospheric plasma, they could become separated, creating a radial current such as is seen in the curl plots.

Thus, the idea of ion and electron separation could provide an explanation for the radial currents seen in these low beta regions. These radial currents in turn explain the variability in location of the regions despite the new, IMF based coordinate system. However, while the coordinate system does not remove the spread in location of the regions, the coordinates are both more useful and more intuitive as a way to map the locations of the regions in the nightside ionosphere.

References:

[1] Marubashi et al. (1985) *JGR, 90*, 1385-1398. [2] Brace, L. H. et al. (1982) *JGR, 87*, 199-211. [3] Hartle, R. E. and Grebowsky, J. M. (1993) *JGR, 98*, 7437-7445.