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Characteristics of the Martian magnetic flux ropes observed by the Mars Global Surveyor

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Mars is a unique planet because it locally possesses strong crustal magnetic fields mainly located in the southern hemisphere [e.g., *Acuna et al.*, 1999]. The Martian electromagnetic environment can thus become highly complicated and variable, since the interplanetary magnetic field (IMF) embedded in the solar wind interacts with the Martian crustal magnetic fields. Whereas it is known that the Martian upper atmosphere is escaping to the interplanetary space due to the interaction with the solar wind [e.g., *Lundin et al.*, 1989; *Barabash et al.*, 2007], the contribution of crustal magnetic fields to atmospheric escape from Mars has not yet been well understood.

Flux ropes are characteristic magnetic field structures seen throughout the solar system, e.g., at the Sun, in the interplanetary space, and at the Earth magnetosphere often in association with substorms. Flux ropes are also observed at planets such as at Venus and Mars [e.g., *Russell and Elphic*, 1979; *Vignes et al.*, 2004], which do not possess a global magnetic field. Recently, *Brain et al.* [2010] found a large-scale isolated magnetic flux rope filled with Martian atmospheric plasma located downstream from the crustal magnetic fields with respect to the solar wind flow based on their analyses of the magnetic field and suprathermal electron measurements from the Mars Global Surveyor (MGS) spacecraft. They suggested that the magnetic flux rope could intermittently carry significant amounts of atmosphere away from Mars by a bulk removal process such as magnetic reconnection between the IMF and the crustal magnetic fields. They proposed that this process might occur frequently and account for as much as 10 % of the total present-day ion escape from Mars.

We here investigate characteristics of the Martian magnetic flux ropes based on a reconstruction method using the MGS magnetic field data. This method is referred as the Grad-Shafranov (GS) reconstruction technique, which is capable of recovering the two-dimensional spatial configuration of the magnetic flux ropes from single spacecraft data. We assumed that it has a magnetohydrostatic, two-dimensional magnetic field structure [*Hu and Sonnerup*, 2002]. Since there is no ion detector onboard MGS, we assumed a typical density and temperature of the Martian ionosphere at the spacecraft altitude in order to calculate the input thermal pressure for the model. It is also assumed that the spacecraft velocity is the dominant component causing apparent movement of the magnetic flux rope relative to the MGS spacecraft. The resultant structure can provide a reliable observational restriction on the spatial scales of magnetic flux ropes. We applied the GS reconstruction technique to approximately 80 magnetic flux rope events observed by MGS. In the presentation, we will report not only the dependences of the flux rope orientation on the solar zenith angle and the crustal magnetic field, but also the relationship between the magnetic flux rope axis derived from the GS method and the typical plasma convection direction. We will also discuss the characteristics of the size of the magnetic flux rope depending on the observed geographic location.

References:

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