火星の残留磁化下流で観測される磁気フラックスロープの統計解析研究

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Statistical study of flux ropes observed downstream from the Martian crustal magnetic field

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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 terrestrial magnetosphere. 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 intrinsic magnetic field. *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 the Mars Global Surveyor (MGS) measurements. They suggested that the magnetic flux rope could intermittently detached from Mars, and remove significant amounts of atmosphere away from Mars. On the other hands, *Beharrell and Wild* [2012] pointed out that the magnetic flux ropes observed around the southern polar region of Mars might be rather stationary and attached to the upstream crustal magnetic fields. We thus have no crucial conclusion in terms of the effect of the magnetic flux ropes to the atmospheric escape from Mars, because there is somewhat ambiguous to estimate the spatial structure of them from the single spacecraft data.

We here conduct the statistical survey of the magnetic flux ropes observed by MGS around the southern polar region of Mars, which corresponds to the downstream of the strong crustal magnetic field. This statistical survey showed that MGS had frequently detected the magnetic field enhancement associated with the magnetic flux ropes around the region. We could obtain 1171 magnetic flux rope candidates from the MGS magnetic field data between April 1999 and November 2006. The observational possibility of identified magnetic flux ropes depends on the upstream solar wind dynamic pressure, while it has no clear dependence in terms of the upstream IMF sector polarity. We estimated the axis orientation and the spatial structure of these candidates by applying the Grad-Shafranov (GS) reconstruction technique. This technique is capable of recovering the two-dimensional spatial configuration of the magnetic flux ropes from single spacecraft data, and allows us to provide a reliable observational restriction on the spatial scales of magnetic flux ropes. The results of the GS reconstruction technique indicated that the estimated magnetic flux rope axes are orientating horizontally relative to the Martian surface in most cases. We also confirmed that almost all the identified large-scale magnetic flux ropes are located downstream from the strong crustal magnetic fields with respect to the solar wind flow. In this presentation, we will discuss why those magnetic flux ropes are frequently observed around the southern polar region of Mars based on the results of the GS reconstruction technique.

References:
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