Possibility of ion acceleration by the local convection electric field: Venus Express observations

Kei Masunaga[1]; Yoshifumi Futaana[2]; Masatoshi Yamauchi[3]; Stas Barabash[2]; Andrei Fedorov[4]; Naoki Terada[5]; Shoichi Okano[6]
[1] Planet. Plasma Atmos. Res. Cent., Tohoku Univ.
; [2] IRF; [3] IRF-Kiruna; [4] CESR, Toulouse, France.; [5] Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.; [6] PPARC, Tohoku Univ.

http://pparc.geophys.tohoku.ac.jp/

Venus has no intrinsic magnetic field, so its upper atmosphere is directly exposed to the solar wind creating direct interactions between them. As a result of the interaction, ionospheric ions are removed from Venus mainly as O+. It is thought that the escaping oxygen from the atmosphere has played an important role in the atmospheric evolution on Venus. Pioneer Venus Orbiter and Venus Express have investigated the plasma environment of Venus. Many authors reported that high energy planetary oxygen ions were observed in the hemisphere to which a global convection electric field (**Esw** = -**Vsw** x **Bsw**) directs [e.g. *Intriligator*, 1989, *Slavin et al*., 1989; *Barabash et al*., 2007]. Thus, the convection electric field has been considered as a possible mechanism for the acceleration of planetary ions.

However, recently *Masunaga et al*., in press reported that a spatial distribution of outflowing O+ ions is strongly controlled by the IMF directions. By investigating two cases, IMF directs nearly perpendicular to the Venus-Sun line (perpendicular IMF case) and IMF directs nearly parallel to it (parallel IMF case), they indicated that the O+ ion acceleration mechanisms would be different. In the perpendicular IMF case, O+ fluxes are observed near the magnetic poles and x-component of the magnetic field reverses once per orbit. Sometimes the O+ flux is associated with the Bx reversal. Energy of those fluxes depends on the global convection electric field, which is consistent with previous studies [e.g. *Intriligator*, 1989; *Slavin et al*., 1989; *Barabash et al*., 2007]. These results can be understood by draping of the IMF around the Venus ionosphere followed by forming a single plasma sheet, and thus most of O+ ions are accelerated by the convection electric field and outflow through the plasma sheet. On the other hand in the parallel IMF case, a spatial distribution of O+ is different from that of the perpendicular IMF case. O+ fluxes are observed regardless of the convection electric field direction and Bx reverses multiple times per orbit. The fluxes are sometimes associated with the Bx reversal. Energy of the fluxes does not depend on the direction of the global magnetic field. This indicates that IMF drapes around the ionosphere more complicatedly and forms multiple outflow channels around the terminator. The independency of the outflow channel and the convection electric field direction indicates that O+ ions are not accelerated by the convection electric field but by local effects, such as a **j** x **B** force [*Dubinin et al*., 1993], viscous force [*Perez-de-Tejada*, 1997] or local convection electric field ($\mathbf{E}_L$ = -$\mathbf{V}_L$ x $\mathbf{B}_L$; where $\mathbf{V}_L$ and $\mathbf{B}_L$ is the local velocity vector and the local magnetic field).

In this study we concentrate on the effect of the local convection electric field and discuss whether or not the local electric field can explain the O+ acceleration observed by Venus Express. We show several examples to investigate dependence of oxygen ions' flow direction on the local convection electric field's direction by comparing with the global convection electric field's direction. The dependence between the O+ velocity vector and the local convection electric field is clearer than that on the global convection electric field in both cases. This may imply that planetary O+ ions could be accelerated by the local convection electric field.

References

Barabash et al., [2007], Nature, 450, 650-653, doi:10.1038/nature06434.
Dubinin et al., [1993], JGR, 98, A3, 3991-3997
Intriligator, [1989], GRL, 16, 2, 167-170
Masunaga et al., in press, JGR, doi:10.1029/2011JA016705
Perez-de-Tejada, JGR, 106, A1, 211-219, 2001
Slavin et al., [1989], JGR, 94, A3, 2383-2398