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CORRELATION BETWEEN Pi 2 AT NIGHTSIDE GEOSYNCHRONOUS ORBIT AND AURORAL MODULATION (EXTENDED ABSTRACT)

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It has been widely accepted that substorm expansion phase onset is accompanied by an onset of ground Pi 2 pulsations, and at the onset of ground Pi 2 oscillations at dip-equator the energetic-particle and magnetic field changes at nightside geosynchronous orbit are often detected. To clarify these behaviors, we have utilized the high-time resolution data from Huancayo, Peru (dip-equator, 75° W) and the geosynchronous satellites GOES5,GOES6 and 1984-129. It is found that both the fluctuations of particle flux (electron,30–300 keV; proton,145–560 keV) and oscillations of the field line signature at nightside geosynchronous orbit are similar to the oscillations of the corresponding ground Pi 2. Furthermore, SAKA *et al.* (1997) found that an increase of the energetic-particle flux is correlated to increases of the H component of ground Pi 2 oscillations.

There is another noteworthy observation, to which we must pay attention. WATANABE *et al.* (1996) studied the correlation between auroral modulation and ground Pi 2 oscillations during substorm event, and they found that an increase of auroral luminosity (namely, particle precipitation) was correlated with increases of the H component of the ground Pi 2 oscillations, too.

The field disturbances occurred in the midnight sector of the magnetosphere are associated with ULF waves excited at substorm onset. Therefore, it is suggested that the observed fluctuations of the particle flux at the geosynchronous orbit can be explained by the field-aligned plasma motion, and the periodicity of these fluctuations is associated with field line oscillations generated by ULF waves. Based on this observational evidence, the following equation was obtained from the field-aligned components of momentum equation and continuity equation.

$$\left\langle \tilde{V}_Z \frac{\partial \tilde{V}_Z}{\partial z} \right\rangle = \frac{{C_A}^2}{\left(1-\frac{{C_S}^2}{{V_Z}^2}\right){B_0}^2} \Big\{ (\delta \mathbf{b}_\perp \cdot \nabla_\perp B_0) + \frac{\mu_0}{B_0}(\delta P_Z - \delta P_\perp)\nabla_Z B_0 + \frac{\mu_0}{B_0}(P_{0Z}-P_{0\perp})\nabla_Z \delta\mathbf{b} \Big\}. \tag{1}$$

Here, V is the flow velocity, C_A is the Alfvén speed, C_S is the speed of sound, B_0 is the ambient magnetic field, $\delta\mathbf{b}$ is the field perturbation, μ_0 is the magnetic permeability of free space, δP is the plasma pressure perturbation and P_0 is the ambient plasma pressure. And the suffix 'z' and '$\perp$' stand for the component 'parallel' and 'perpen-

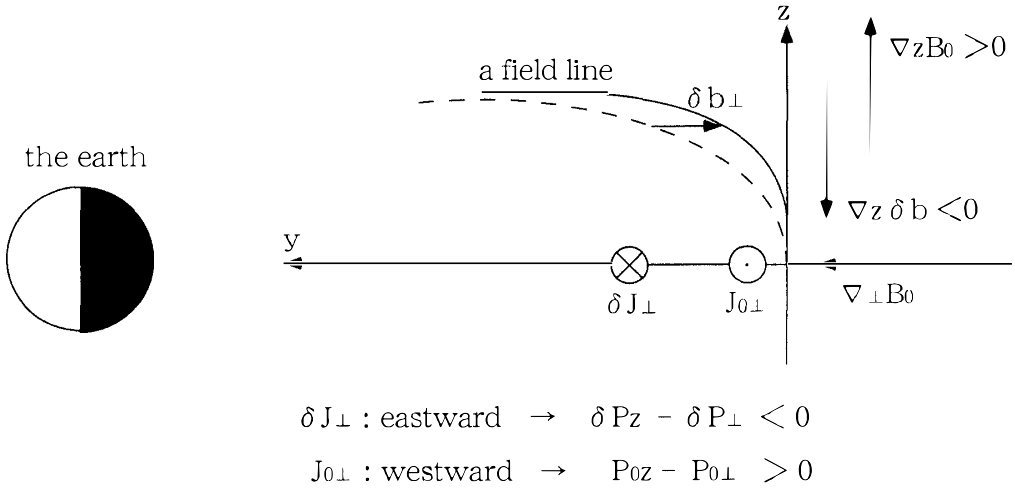

Fig. 1. This figure shows reconfiguration of the magnetic field line at the nightside geosynchronous orbit at substorm onset. $J_{0\perp}$ is the ambient westward cross-tail current at the growth phase, then we may say that P_{0Z} is larger than $P_{0\perp}$. $\delta J_\perp$ is the eastward cross-tail current perturbation at substorm onset, then we may say that $\delta P_\perp$ is larger than δP_Z. And $\delta J_\perp$ generates the field line oscillations ($\delta \boldsymbol{b}_\perp$).

dicular' to B_0 at the equatorial plane in the magnetosphere, respectively. The direction of the field-aligned plasma motion is decided by the sign of the l.h.s., thus, it is important whether the sign of the r.h.s. is plus or minus.

In the present paper, we shall confine our attention to the substorm onset. The relative orientations of some vectors ($\delta J_\perp$: the cross-tail current perturbation which is eastward at substorm onset, $J_{0\perp}$: the ambient cross-tail current which is westward at substorm onset because the cross-tail current is westward at the growth phase) are illustrated in Fig. 1. It follows from Fig. 1 that the numerator of the r.h.s. is of a negative value at substorm onset. Thus, a following result is obtained.

$$
\left.\begin{array}{ll}
\cdot\ V_Z \le C_S \rightarrow \left\langle \tilde{V}_Z \dfrac{\partial \tilde{V}_Z}{\partial_Z} \right\rangle \ge 0 & \left(\because\ 1 - \dfrac{C_S^2}{V_Z^2} \le 0 \right) \\
\cdot\ V_Z \ge C_S \rightarrow \left\langle \tilde{V}_Z \dfrac{\partial \tilde{V}_Z}{\partial_Z} \right\rangle \le 0 & \left(\because\ 1 - \dfrac{C_S^2}{V_Z^2} \ge 0 \right)
\end{array}\right| \tag{2}
$$

(at substorm onset)

It is important what this result represent, then, here is an interesting data that helps to understand it.

Figure 2 (ARNOLDY, 1986) indicates that at the geosynchronous orbit the low-energy particles (less than few keV) decreased, while the high-energy particles (several keV and greater) increased at substorm onset. If Fig. 2 is explained by eqs. (1) and (2), it can be summarized in the following scenario:

· $V_Z < C_S$ → The particles are accelerated along field lines.
(This can explain the decrease of low-energy particles in Fig. 2.)
· $V_Z > C_S$ → The particles are decelerated.
→ The particles are concentrated on the equatorial plane in the

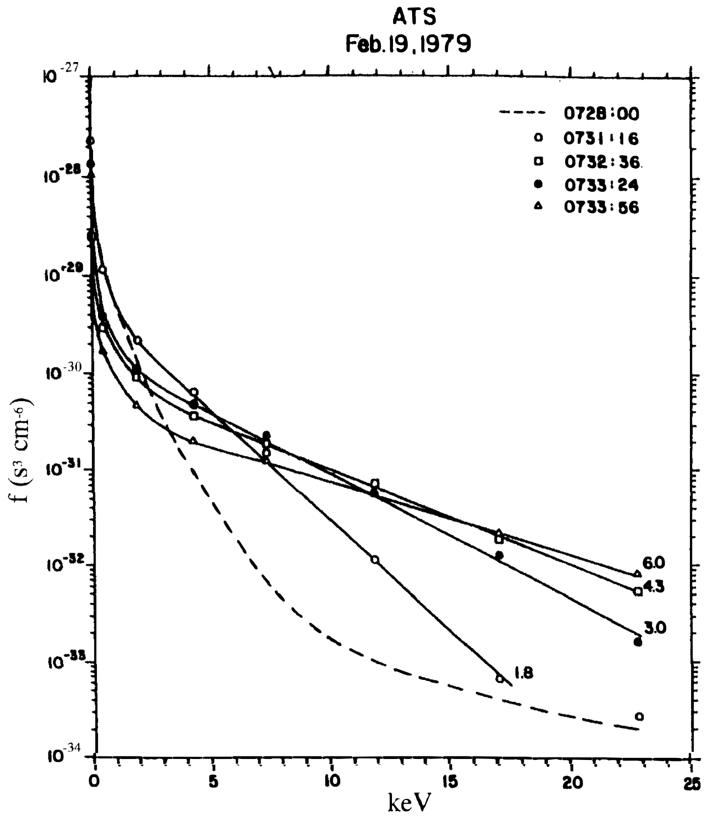

Fig. 2. Electron phase space density (f) versus energy at the nightside geosynchronous orbit at substorm onset. The dashed curve is for a time before the electron injection. From this figure, we see that low-energy particles (less than a few keV) decreased and high-energy particles (several keV and greater) increased (from ARNOLDY*, 1986).*

magnetosphere.
(This can explain the increase of high-energy particles in Fig. 2, and the observed fact with the geosynchronous satellites 1984-129.)

From this scenario, it can be concluded that low-energy particles run away from the equatorial plane in the magnetosphere, while high-energy particles are concentrated on the equatorial plane in the magnetosphere. We notice here that fluctuations of the particle flux at the geosynchronous orbit can be explained by $\delta \mathbf{b}_\perp$(namely, ULF waves) in eq. (1).

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