

ELECTRIC FIELD INDUCED IN THE MAGNETOSPHERE DURING STRENGTHENING OF THE SOLAR WIND PRESSURE

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Fast jump in the solar wind pressure known as a sudden impulse (SI) produces the induction electric field in the magnetosphere. In a two-dipole model the field is

$$\mathbf{E} = -[\mathbf{v}_1 \times \mathbf{B}_1] - \nabla \varphi \quad (1)$$

where \mathbf{v}_1 and \mathbf{B}_1 are the velocity and magnetic field of the imaginary dipole respectively, φ is the electric potential which may be calculated with help of the high conductivity condition

$$(\mathbf{E} \cdot \mathbf{B}) = 0 \quad (2)$$

where $\mathbf{B} = \mathbf{B}_E + \mathbf{B}_1$ is the total magnetic field, \mathbf{B}_E is the field of the earth dipole. Substituting (1) to (2) and considering the earth to be small, we get

$$\varphi = \int_0^r \frac{(\mathbf{v}_1 \cdot [\mathbf{B}_E \times \mathbf{B}_1])}{B^2} (\mathbf{B} d\mathbf{r}) \quad (3)$$

where \mathbf{r} is the distance from the earth dipole.

Assuming, as the first approximation, $B_1 \ll B_E$, $r \ll a$, where a is the distance to the imaginary dipole, we obtain in the equatorial plane $\varphi = v_1 B_{1zo} y (1 + 3x/2a)$, where $B_{1zo} = B_{1z}(\mathbf{r} = 0)$. Substitution of φ into (1) yields the radial and azimuthal electric field components (the λ -axis is directed eastward)

$$E_\rho = 0, \quad E_\lambda = -\frac{\rho}{2} \frac{\partial B_{1zo}}{\partial t} \quad (4)$$

The azimuthal electric field drives the magnetospheric plasma drift with the radial velocity $v_\rho = E_\lambda / B_z$. Magnetic field in the frame of a frozen-in plasma varies as follows

$$\frac{dB_z}{dt} = \frac{\partial B_z}{\partial t} + v_\rho \frac{\partial B_z}{\partial \rho} \quad (5)$$

Substituting v_ρ and (4) into (5), and accounting for $\delta B_z / \delta \rho = -3B_z / \rho$, we get

$$\frac{dB_z}{dt} = \frac{5}{2} \frac{\partial B_z}{\partial t} \quad (6)$$

Thus, the betatron acceleration of the frozen-in plasma is 2.5 times stronger if the induction electric field is taken into consideration.