E137-029 **Room: 201B** **Time: May 15 11:00-11:15**

Origin of the storm-time electric field in the inner magnetosphere

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Recent satellite observations have revealed that the strong ambient electric field from 5 mV/m to 47 mV/m appears in the inner magnetosphere during geomagnetic storms [Wygant et al., 1998; Shinbori et al., 2005]. It has been revealed that most enhanced electric fields from 1.5 to 4.0 mV/m appear in the dawn and dusk regions from 2 to 8 earth radii [Nishimura et al.; Shinbori et al., SGEPSS fall meeting, 2005]. Since the convection electric field only reaches up to 2 mV/m in this region [Maynard and Chen, 1975], another electric field source needs to be considered. In the present study, based on the distribution of the electric field in the inner magnetosphere, origins of the electric field are investigated.

The co-rotation electric field and the electric field deduced from the solar quiet (Sq) current system are projected from the ionosphere to the geomagnetic equatorial region of the magnetosphere. The convection electric field, which is represented by the difference of the polar-cap potential, is also mapped onto the geomagnetic equatorial plane.

The Sq electric field is calculated based on the method by Maeda [1956]. It is mapped onto the geomagnetic equatorial plane by assuming equipotentials along the magnetic field line. As a result, the Sq electric field has the amplitude of 1 mV/m from the midnight to the morning sectors within 4 earth radii, and this feature well coincides with the observation. Therefore, the quiet time electric field can be represented by the co-rotation electric field, the weak convection electric field with the amplitude of 0.5 mV/m, and the Sq electric field.

On the other hand, the storm-time electric field cannot be fully explained by these electric fields. In order to generate the electric field localized in the dawn and dusk sectors, some kind of localized source has to be taken into account. In this study, we have adopted a condenser-type charge distribution. The Poisson equation has solved numerically under the condenser-type charge distribution along the sun-earth line apart from about 2 earth radii with the charge density of 6*10^{-8} Re/cc.

As the result of the simulation, the localized dawn-dusk electric field up to 1.8 mV/m is achieved by this charge distribution, and the shielding electric field is also generated within 3 earth radii. These electric field distributions well coincide with the observed electric field.

These electric fields can be produced by the charge separation of the ring current particles injected from the geomagnetic tail region during geomagnetic storms. If an energetic proton and electron with different energies are injected from the geomagnetic tail regions, these particles drift on different L-shells due to the difference of drift speeds. As a result, the condenser-type charge distribution is produced. Although some part of charges is shielded by ambient plasma, only a minor part of the ring current particles can generate the observed electric field. Therefore, the charge separation of energetic particles may significantly contribute to the ambient electric fields during geomagnetic storms. It is concluded that the storm-time electric field is composed of the co-rotation electric field, the convection electric field, and the electric field produced by the charge separation of the ring current particles.