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On the origin of low-energy downward electrons in the polar cap ionosphere

Yugo Kitanoya[1*], Takumi Abe[2], Toshifumi Mukai[2]

[1]Tokyo University, [2]ISAS/JAXA

It is known that the thermal ions are accelerated by ambipolar electric field due to ambipolar diffusion caused by plasma pressure gradient along field lines in the polar cap where the geomagnetic field lines are basically open.

There is an idea that the strong potential difference may be generated to keep current continuity between the magnetosphere and the ionosphere approximately above 2 Re altitude in the polar cap. Upward moving ions are further accelerated by such a potential difference because such a potential difference is upwardly directed. This idea may suggest that the potential difference plays an important role in transporting ions from the ionosphere to the magnetosphere. On the other hand, since this potential difference can accelerate electrons downwardly, it is possible that low energy component of upward photoelectrons with energy of about 10-50 eV originated from the ionosphere is reflected by the potential gap. Therefore it is possible that a part of low energy (about 10-50[eV]) downward electrons observed in the polar cap ionosphere is attributed to the potential difference above 2 Re altitude. In fact, such low energy downward electrons are observed by Low Energy Particle (LEP) instrument on Akebono satellite below 2 Re altitude in the polar cap. Thus, we believe that such a potential difference actually exists and plays a role in reflecting upward photoelectrons above 2 Re altitude.

A statistical analysis of long-term observations of the photoelectron flux with the LEP on Akebono in the polar cap region suggests that even when the upward photoelectron flux is in the same level the downward flux of electrons with the same energy changes. Such downward electrons may be originated from the deep magnetosphere. However, a fact the energy spectra are similar between upward and downward electrons implies that the downward electrons are originated from the ionosphere and reflected by the upward electric fields. The observational result of variable downward flux may indicate that the flux is controlled by the magnitude of the potential difference existing in the high altitude polar cap. The purpose of our study is to elucidate what the dominant process or condition is for determining the size of the potential difference. It is suggested from our statistical analysis that the potential difference is about 30 V on the average but the actual magnitude changes from 10 to 50 V in some cases.

In this presentation, we show the detailed result of our analysis and discuss the dependence of the potential difference in the high-altitude polar cap on the solar activity, the geomagnetic activity, and the ionospheric plasma condition.

Keywords: polar cap, polar wind, photoelectron