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Penetration of cold solar wind plasmas deep into the magnetosphere

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Under Northward IMF conditions, plasma sheet becomes cold and dense globally and plasmas entering the plasma sheet are believed to be primarily of solar wind origin. Cold dense plasma sheet has been detected deep inside the magnetosphere and it often consists of the mixture of cold magnetosheath and hot magnetospheric plasmas. Many candidates such as slow diffusive transport and double lobe reconnection have been suggested for the formation of cold dense plasma sheet. However, whether they are actually operating for the penetration of cold magnetoheath plasmas deep into the magnetosphere and their relative importance for the formation of cold dense plasma sheet are still unknown.

We discussed the transportation mechanism of solar wind cold plasmas deep into the magnetosphere by investigating in detail the observed mixed states of magnetosheath and magnetospheric plasmas, which posses the memory of mixing and heating processes they experienced. We found that the observed velocity distributions with the mixed cold and hot ions can be classified into two different types in regards to electron distributions. One type is characterized by both ion and electron distributions consisting of cold and hot components. Bi-directional ion beams and large temperature of cold electrons compared to the magnetosheath electrons support the double lobe reconnection scenario. The other type is characterized by the mixed cold and hot ions with the cold polar rain like electrons. Mixed electron distributions consisting of hot plasma sheet electrons and low energy field aligned electrons originated in the strahl component of solar wind electrons are observed prior to the emergence the cold ions. These observed distributions indicate usually closed magnetic field lines of the midnight near-Earth plasma sheet had somehow direct access to the solar wind magnetic field resulting in the direct entry of cold solar wind ions and electrons and the depletion of hot electrons due to their large thermal velocities.