Comparative study of lobe/mantle O+ beams with precipitating O+ onto dayside polar ionosphere: FAST and GEOTAIL observations

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One of candidates of supply mechanisms of O+ beams in the distant lobe/mantle regions of geomagnetotail is circulation of trapped ions in the dayside magnetosphere caused by the dayside reconnection. In order to examine validity of this mechanism, the phase space density (PSD) of locally mirroring O+ at low altitudes (400-4200 km) is compared with the peak PSD of O+ beams in the lobe/mantle according to the Liouville's theorem. The results show that the high-energy O+ ions in the dayside magnetosphere are adequate in quantity to supply O+ beams in the distant lobe/mantle.

Observations of tailward cold O+ beams (COBs) in the distant lobe/mantle is shedding a new light upon plasma supply mechanisms to the magnetotail, since their location up to a tailward distance of ~210 Re is not explicable with a conventional view of the magnetospheric dynamics. Since the COBs exist primarily in the mantle-like regions which correspond to the transport route of magnetic flux tubes reconnected at the dayside magnetopause, it has been suggested that these high-energy COBs in the distant lobe/mantle have originated from trapped O+ ions in the dayside magnetosphere. In order to examine validity of this mechanism, quantitative properties of the COBs observed by the GEOTAIL spacecraft in the lobe/mantle are compared with those of precipitating O+ ions onto the dayside ionosphere observed by the FAST satellite at low altitudes (400-4200 km). For the comparison of these two different regions, the phase space density (PSD) of locally mirroring O+ at FAST is compared with the peak PSD of COBs at GEOTAIL according to the Liouville's theorem. A case study shows that the PSD of high-energy precipitations in closed field line regions is comparable to that of the COBs. It is also shown that there are regions where the magnetosheath and dayside plasma sheet/ring current components coexist and are precipitating together, and in these coexistence regions, the O+ PSD is typically smaller than, but sometimes comparable to that of the COBs. These observations indicate that the high-energy O+ ions in the dayside magnetosphere are a promising candidate for the source of COBs in the lobe/mantle. Statistical comparison also supports this conclusion for high-energy COBs above 1 keV, while the PSDs of O+ precipitation at energies less than 1 keV are typically less than that of COBs. These results suggest that the trapped O+ ions in the dayside magnetosphere is one of major sources of COBs at energies above 1 keV and as for COBs below 1 keV, polar O+ outflows from the cusp/cleft regions seem to be the most probable source. The ion dynamics on reconnected flux tubes needs to be examined further for more quantitative discussions.