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Gradual and sudden energization of outflowing oxygen ions near the high-latitude magnetopause

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Among the oxygen ions originating from the ionospheric cusp, those with relatively higher energies can access the high-altitude cusp (above several Earth radii) and subsequently escape into the high-latitude magnetosheath along open field lines. Although escaping oxygen ions into the magnetosheath have been reported in many observations, their dynamics near the high-latitude magnetopause remain poorly understood. Using data from the Cluster Ion Spectrometry, we analyzed more than 40 events in which field-aligned beams of oxygen ions were observed near the high-latitude boundaries. In most events, the beam energy is several hundred eV in the lobe/mantle region and increases to several keV, sometimes exceeding 20 keV at the boundary. We identified two types of energy change in the energy-time spectrograms: gradual increases and sudden increases. The gradual increase may be attributed to cyclotron resonance and the centrifugal acceleration, which operate over timescales much longer than a gyroperiod, whereas the sudden increase may be caused by non-adiabatic acceleration due to sharp spatial gradients in the convection electric field, which operates on timescales comparable to a gyroperiod, possibly associated with dayside magnetopause reconnection. We present statistical results on the occurrence of these two types of energy change, and discuss their occurrence in relation to the background magnetic field structure and solar wind conditions.