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Strong ion energization by electromagnetic fluctuations in plasmoid-like magnetic structures.

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Numerous studies based on data from many magnetospheric missions reported the observations of energetic ions with energies of hundreds of keV in the Earth magnetotail. The acceleration of charged particles to energies exceeding the potential drop across the tail can be produced by strong inductive electric fields generated in the course of transient processes related to changes of the magnetic field topology: e.g., magnetic reconnection, dipolarization, magnetic turbulence, and so on. The observations of energetic ion flows by Cluster/RAPID instruments in the near-Earth tail show the increase of H+, He+, and O+ fluxes in the energy range $\geq$130 keV during the periods of the tailward flows. The hardening of ion spectra is observed inside the plasmoid-like magnetic structures propagating tailward through the Cluster spacecraft. Simultaneously, the low-frequency electromagnetic fluctuations were observed in such structures. The analysis of 37 events demonstrated that the following factors are favorable for the ion energization: (1) the spatial scale of a plasmoid should exceed the thermal gyroradius of a given ion component in the plasmoid neutral plane; (2) the Power Spectral Density (PSD) of the magnetic fluctuations near the gyrofrequency of a particular ion component should exceed $\sim$ 50.0 nT2/Hz for oxygen ions; while the energization of He+ and H+ takes place for much lower values of the PSD. The kinetic analysis of ion dynamics in the plasmoid-like magnetic configurations with the superimposed electromagnetic fluctuations similar to the observed ones confirms the importance of ion resonant interactions with the low-frequency electromagnetic fluctuations for ion energization inside plasmoids. The analysis also show that to be strongly accelerated ions do not need to pass a large distance in the duskward direction and the effective energization can be reached even at the localized source. Thus, ion acceleration by the electromagnetic fluctuations may smear the dawn-dusk asymmetry in the spatial distribution of energetic ion fluxes. This may explain the statistical results showing the absence of a pronounced dawn-dusk asymmetry in the distribution of energetic ions in the magnetotail plasma sheet for some periods.