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Cold ions in magnetotail reconnection and waves in the ion diffusion region: Particle-in-Cell simulations

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Magnetic reconnection is an explosive plasma process which is responsible for conversion of magnetic energy into heat and bulk plasma flows. In collisionless environments (in particular, in the Earth's magnetotail), the process develops a multi-scale structure with the electron diffusion region (EDR) embedded into that of heavier species (protons, heavy ions). Recent observational and simulation studies reveal a substantial population of very cold ions (10 eV) of ionospheric origin which spreads in the Earth's magnetosphere without significant heating. Such a population co-exists with hot magnetospheric ion component (5-10 KeV), thus influencing kinetic properties of magnetic reconnection at the magnetopause and in the tail. Motivated by these observational findings, we present results of 2D Particle-in-cell (PIC) simulations of collisionless reconnection in a plasma composed of hot electrons, hot and cold ions. We vary density of hot component from 0 to 100% in different runs to investigate in detail the effect of cold component. We report a new instability, which is excited inside the IDR due to unmagnetized cold ion beams accelerated by polarization electric field perpendicular to the B field. The sub-ion scale instability is of lower hybrid range (unmagnetized ions, magnetized electrons). The mode partially relaxes electron nongyrotropies existing in the EDR, leading to shortening of the unmagnetized electron jet. In a simulation where cold ion component is the only population (no hot ions), the diffusion region and separatrices appear to be turbulent with no electron jet emanating from the EDR, which is of potential importance for detection of EDR crossings in data. We suggest that the presence of cold ion component can slightly increase the reconnection rate.