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The firehose instability during multiple reconnection in the Earth's magnetotail

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We found unique events in the Cluster spacecraft observations of the Earth's magnetotail which correspond to the case of multiple reconnection sites. The ion temperature anisotropy of more energized ions in the direction parallel to the magnetic field, rather than in the perpendicular direction, is observed in the region of dynamical interaction between two active X-lines. The magnetic field and plasma parameters associated with the anisotropy correspond to the firehose instability conditions. We discuss possible scenarios of development of the firehose instability in multiple reconnection by comparing the observations with numerical simulations.

Conventional Particle-in-Cell simulations of 2D magnetic reconnection starting from Harris equilibria are performed using implicit PIC code iPIC3D [Markidis, 2010]. At earlier stages the evolution creates fronts which push the weakly magnetized current sheet plasma away from the X-line. Fronts accelerate and reflect particles, producing parallel ion beams and increasing parallel ion temperature ahead of the front. If multiple X-lines are present, then the counterstreaming ion beams appear inside the original current sheet between colliding reconnection jet fronts. For large enough parallel ion pressure anisotropy, the firehose-like mode is excited inside the original current sheet with a flapping-like appearance along the X GSM direction but not Y GSM (current) direction.

One should note that our simulations do not include the Bz magnetic field component (normal to the current sheet), hence ion beams cannot escape into the lobes and the whole region between two colliding fronts is unstable to firehose-like instability. In the Earth's magnetotail such configuration likely occurs when two active X-lines are close enough to each other, similar to a few cases we found in the Cluster observations.