Energy transformation in the magnetotail: Reconnection onset, thin current sheets and plasma bubbles

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Abstract. Stretched magnetic field geometry characteristic of many astrophysical and laboratory plasmas, including the Earth's magnetotail, is provided by current sheets. Disruption of a critically thin and elongated sheet results in the burst of magnetic reconnection, a process that transforms magnetic energy into kinetic energy of accelerated and heated plasma particles. Understanding such critical current sheet states is therefore crucial to properly describe the major energy transformation processes in the magnetosphere and determine their cause-effect relationship. Thin current sheets may also play an important role in bursty convection phenomena in the magnetosphere as a core part of underpopulated flux tubes or plasma bubbles. We discuss some specific mechanisms of the energy transformations in the magnetotail. One of them is the collisionless tearing mode, which provides the onset of the classical X-line reconnection. Its properties are strongly modified by the finite component of the magnetic field normal to the neutral plane, leading to the formation of thin current sheets extended along the Sun-Earth direction and relatively small-scale plasmoids that appear as a result of the tearing instability. Recent CLUSTER observations revealed that the structure of thin current sheets may be rather complex, including embedded and bifurcated currents. On the other hand, the build-up of the current density in thin current sheets gives rise to another class of current-driven instabilities, which may be both the cause and the effect of their unusually complex structure. The universality of embedding and bifurcation effects in thin current sheets can also be explained by the role, which they play in the plasma bubbles as earthward-moving counterparts of the plasmoids.