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Plasma jets in the near-Earth's magnetotail (Julius Bartels Medal Lecture)

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The Earth's magnetosphere is formed as a consequence of the interaction between the magnetized solar wind and the terrestrial magnetic field. While the large-scale and average (>hours) properties of the Earth's magnetotail current sheet can be well described by overall solar wind-magnetosphere interaction, the most dramatic energy conversion process takes place in an explosive manner involving transient (up to several minutes) and localized (up to a few RE) phenomena in the plasma sheet/current sheet regions. One of the most clear observables of such processes are the localized and transient plasma jets called Bursty bulk flows (BBF), embedding velocity peaks of 1-min duration, which are called flow bursts. This talk is a review of the current understanding of these plasma jets by highlighting the results from multi-spacecraft observations by the Cluster and THEMIS spacecraft. The first four-spacecraft mission Cluster crossed the near-Earth plasma sheet with inter-spacecraft distance of about 250 km to 10000 km, ideal for studying local structures of the flow bursts. The five-spacecraft THEMIS mission , separated by larger distances , succeeded to monitor the large-scale evolution of the fast flows from the mid-tail to the inner magnetosphere. Multi-point observations of BBFS have established the importance of measuring local gradients of the fields and the plasma to understand the BBF structures such as the spatial scales and 3D structure of localized Earthward convecting flux tubes. Among others the magnetic field disturbance forming at the front of BBF, called dipolarization front (DF), has been intensively studied. From the propagation properties of DF relative to the flows and by comparing with ionospheric data, the evolution of the fast flows in terms of magnetosphere-ionospheric coupling through field-aligned currents are established. An important aspect of BBF is the interaction of the Earthward plasma jets and the Earth's dipole field. Multi-point observations combined with ground-based observations enabled to resolve how the BBFs are braked , diverted, or bounced back at the high-pressure gradient region. The multi-point capabilities in space enabled to study the BBF structure as well as large-scale evolution of BBFs. These processes are also universal processes in space plasmas and are, for example, associated with the reconnection process during the solar flares or leading to auroral phenomena at different planets.