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Microscale dynamics within Kelvin Helmholtz waves: A probe of localized reconnection occurrence

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Interactions between the solar wind and the Earth's magnetosphere at the magnetopause are the key to the mixing of these two plasma regimes. During periods of northward IMF, an absence of low latitude reconnection at the magnetopause is expected. However, this gives rise to questions as to how the low latitude boundary layer (LLBL) can be populated with magnetosheath-like plasma under these conditions. Cluster multi-spacecraft observations have shown the existence of non-linear waves at the magnetopause that are thought to be results of Kelvin-Helmholtz instability; these waves can grow and form rolled-up vortices. It has been postulated that reconnection within these vortices may be the cause of transfer the solar wind plasma into the magnetosphere. However, the particle behaviour at these small scales is yet to be fully understood. In December 2007, Cluster encountered on-going KH waves as the four spacecraft crossed the Earth's dusk flank magnetopause through its LLBL. During this event, the particle instruments returned a full 3D plasma distribution once every 4 s while the magnetic field remained closely aligned with the spacecraft spin axis. In this study, we are thus able to use the 3D particle data to reconstruct near-full pitch angle distribution of electrons and ions at sub-spin resolution. These high-time resolution observations (up to 32 times faster than normal mode data) provide new insights into particle dynamics during the inbound-outbound movements of Cluster across the magnetopause. We present the multi-spacecraft measurements by Cluster (the macroscale), as well as high-time cadence observation by each spacecraft (the microscale) to demonstrate the plasma behaviour within Kelvin-Helmholtz waves. We highlight multiple separate regions of field-aligned particles, observed as the spacecraft encountered various structures with typical width of 0.5 to 1 Re in the magnetopause boundary layer. The details within these structures can only be revealed at such high time resolution. We aim to distinguish between plasma signatures that may be the result of globally-driven reconnection from those which are generated rather more locally. This is perhaps, the key to understanding if reconnection bursts within the growing KH waves are able to make a significant contribution to transferring magnetosheath plasma into the magnetosphere.