Walen and Slow-mode shock analysis of magnetopause crossings by MMS

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Magnetic reconnection is the main driving process behind phenomena like solar flares, magnetic storms and astrophysical plasma jets. The fast rate of reconnection as seen in observations was explained by Petschek's model [1964] in MHD regime. In this model, X-line geometry with a narrow diffusion region and two pairs of slow-mode shocks helps to achieve faster reconnection than Sweet-Parker's model [Sweet, 1958 and Parker, 1957]. On one hand, resistive Hall MHD simulations show that the quadrupole magnetic fields formed by inclusion of the Hall term achieve the X-line geometry in scale of the ion inertial length and thus fast reconnection [e.g., Drake et al., 2008].

Laboratory experiments support the importance of the Hall physics, while they have not observed the slow-mode shocks till date [Zweibel and Yamada, 2016]. However, in-situ observations in space show the existence of slow shocks on MHD scale [Feldman et al., 1987, Saito et al., 1995]. Recent studies on presence of slow-mode shocks in Earth's magnetotail have been carried out extensively using THEMIS and Cluster data [e.g., Erikson et al., 2004]. Also, in the asymmetric reconnection at the Earth's magnetopause, the combination of slow-mode shock and other discontinuity such as the rotational discontinuity is theoretically predicted [Levy et al., 1965, Hau and Wang, 2016] and observed [Walthour et al., 1994]. Thus, the structure and presence of slow-mode shocks seems to established on MHD scale but on ion inertial scale, it still remains controversial.

We aim to study the inside structure (on ion inertial length scale) of the slow-mode shocks. As a first step towards our final aim, we investigated the presence of slow-mode shocks and other discontinuities in Earth's magnetopause by using Magnetospheric Multiscale (MMS) data. High time resolution of MMS data enables us to observe reconnection structure from the ion diffusion to MHD scales. The results of the Walen test and slow-mode shock analysis (Rankine-Hugoniot conditions) of magnetopause crossings by MMS are presented.

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