Ion Scale Flux Rope Observed at the Trailing Edge of the Hot Flow Anomaly

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Magnetic reconnection occurring during the development of a Hot flow anomaly (HFA) has been generated in hybrid simulation, but has never been observed by spacecraft. Using MMS we report an ion scale flux rope like structure, which is Earthward moving, embedded within the trailing edge of a hot flow anomaly (HFA) upstream from the quasi-parallel bow shock. The driver discontinuity of the HFA, a tangential discontinuity, is observed in the solar wind, but no flux rope signatures are observed around it. This suggests that the earthward moving flux rope was generated inside the HFA. This flux rope is close to a one-dimensional structure and expands due to a strong magnetic pressure gradient force. Solar wind ions are decelerated inside the flux rope by the static electric field likely caused by the charge separation of solar wind particles. Our observations imply that magnetic reconnection may have occurred inside the HFA. Reconnection and flux ropes may play a role in particle acceleration/heating inside foreshock transients.