The fluctuations were primarily present as an oscillation in the $B_x$ component and as saw-tooth-shaped waves in $B_y$. This pattern is considered a typical signature of KH waves [8]. No oscillations were recorded after the magnetopause exit at ~09:31:20 UTC, and the magnetic field remained strongly northward throughout the magnetosheath. After the bow shock crossing, MESSENGER also recorded a strong, steady northward IMF in the solar wind for more than an hour after the vortex encounters.

Figure 1: Overview of MESSENGER Magnetometer measurements on 15 May 2011. The panels show the magnetic field components and magnitude versus time and position, given in units of Mercury radius $R_M$. A vertical red line marks the magnetopause (MP).

The Fast Imaging Plasma Spectrometer (FIPS) measurements [3] for this event are displayed in Figure 2. The plasma measurements also showed clear periodic signatures of dense magnetosheath plasma at each wave encounter. This behavior is
strong evidence for a train of KH vortices traversed by the spacecraft on the inside of the magnetopause, filled with magnetosheath plasma and twisting the magnetic field lines as they roll-up.

Figure 2: FIPS plasma measurements for 15 May 2011. Top to bottom are relative phase space density (arb. units) of H$^+$ versus energy per charge (E/Q), total H$^+$ relative phase space density (arb. units), the magnetic field properties, the FIPS and spacecraft pointing angles, and the spacecraft position.

3. Discussion

The IMF observations suggest that the solar wind was extremely stable and held favorable conditions for the KH instability for the duration of the event. The saw-tooth pattern observed in the $B_y$ component of the magnetic field is a clear signature of non-linear KH waves, which, together with the repeated pattern of the particle observations, show that magnetosheath plasma was being merged into the magnetosphere by KH waves that were already fully developed in the post-noon sector of the magnetopause. This observation implies high KH growth rates at the subsolar magnetopause. In comparison, most KH observations at Earth have reported non-linear waves only tailward of the dawn-dusk meridian. The observations reported here indicate that there is a substantial plasma transport connected with Kelvin-Helmholtz waves at Mercury and may provide an explanation for the thick dayside boundary layer detected inside Mercury's magnetopause [2,6,7].

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