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Observations of Kelvin-Helmholtz Waves during the Third MESSENGER flyby of Mercury

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During the third MESSENGER flyby of Mercury on 29 September 2009, multiple (15) crossings of the duskside magnetopause were observed in Magnetometer data. These crossings were quasi-periodic ($\sim$8 s) recorded over a 120-s interval during which the spacecraft traveled a distance of 0.25 Mercury radii. The boundary normals of each of these crossings, estimated from minimum variance analysis, suggest that if these crossings are due to Kelvin-Helmoltz surface waves they have begun to roll-up implying that the instability is fully developed. At Earth, fully developed Kelvin-Helmholtz instability is believed to lead to the transport of solar wind plasma into Earth's plasma sheet and could be the principal source of the cold plasma sheet component. This mechanism could also be important at Mercury. Of the three MESSENGER Mercury flybys, this is the first for which multiple magnetopause crossings were clearly detected. During MESSENGER's first Mercury flyby on 14 January 2008, when the z component (normal to Mercury's orbital plane and positive in the direction of the north celestial pole) of the interplanetary magnetic field (IMF) was predominantly northward, three vortex structures were observed in the magnetopause boundary layer that could be due to this instability. During MESSENGER's second flyby on 6 October 2009, when the z component of the IMF was strongly southward, no clear evidence of Kelvin-Helmholtz waves was detected. During the third flyby, the z component of the IMF was highly fluctuating and on average mildly southward at $\sim$ -0.3 nT. Just inside the magnetopause the flare angle tends to increase with magnetic field magnitude. Unlike the other flybys, the third MESSENGER flyby was near perihelion and the radial component of the IMF was more dominant, which should suppress this instability. The observations suggest that the instability evolves to non-linear saturation at Mercury even under these conditions.