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Assessments of Magnetic Reconnection and Kelvin-Helmholtz Instability at Ganymede's Upstream Magnetopause

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Ganymede is the largest moon of Jupiter and the only Solar System moon known to generate a permanent magnetic field. Motions of Jupiter's magnetospheric plasma around Ganymede create an upstream magnetopause, where energy flows are thought to be driven by magnetic reconnection and/or Kelvin-Helmholtz Instability (KHI). Previous numerical simulations of Ganymede indicate evidence for transient reconnection events and KHI wave structures, but the natures of both processes remain poorly understood. Here we present an analytical model of steady-state conditions at Ganymede's magnetopause, from which we conduct first assessments of reconnection and KHI onset criteria at the boundary. We find that reconnection may occur wherever Ganymede's closed magnetic field encounters Jupiter's ambient magnetic field, regardless of variations in magnetopause conditions. Unrestricted reconnection onset highlights possibilities for multiple X-lines or widespread transient reconnection at Ganymede. The reconnection rate is controlled by the ambient Jovian field orientation and hence driven by Jupiter's rotation. We also determine Ganymede's magnetopause conditions to be favorable for KHI wave growths in two confined regions each along a magnetopause flank, both of which grow in area whenever Ganymede moves toward Jupiter's magnetospheric current sheet. KHI growth rates are calculated with the Finite Larmor Radius (FLR) effects incorporated and found to be asymmetric favoring the magnetopause flank closest to Jupiter. The significance of KHI wave growth on energy flows at Ganymede's magnetopause remains to be investigated. Future progress on both topics is highly relevant for the upcoming JUpiter ICy moon Explorer (JUICE) mission.