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Physics of Substorm Growth Phase and Onset

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Space and ground-based observations have indicated that the substorm onset in the near-Earth plasma sheet region ($8-10 R_E$) is associated with a low frequency (in the Pi 2 range) instability. The instability has been explained as kinetic ballooning modes (KBMs) which are excited when $_eq$ increases from ∼ 20 to above 50. The global magnetosphere prior to substorm onset is modeled realistically by 3D quasi-static equilibrium solutions which consist of a current sheet with an enhanced cross-tail current density with thickness of $1 R_E$ around the local midnight and with a longitudinal extent of $60-70^$ at $X – (7-11) R_E$. The associated ionospheric Birkeland current moves equatorward with an enhanced current density shrinking in latitudinal width, consistent with the observed ionospheric growth phase signatures. To study the onset instability, we present theoretical analysis and numerical solutions of KBMs, which include kinetic effects of particle trapping, finite ion gyroradii, and wave-particle resonances. The results indicate that a new branch of unstable KBM is destabilized through wave-ion magnetic drift resonance. The KBM has a real frequency in the Pi2 frequency range. The kinetic calculations will be compared with the MHD theory.