On Minimum-B Stabilization of Electrostatic Drift Instabilities

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Abstract

A check is made of a stabilization theorem of ROSENBLUTH and KRALL (Phys. Fluids **8**, 1004 [1965]) according to which an inhomogeneous plasma in a minimum-B field ($\beta \ll 1$) should be stable with respect to electrostatic drift instabilities when the particle distribution functions satisfy a condition given by TAYLOR, i.e. when $f_0 = f(W, \mu)$ and $\partial f / \partial W < 0$. Although the dispersion relation of ROSENBLUTH and KRALL is confirmed to first order in the gyroradii and in $\varepsilon \equiv d \ln B / dx$ the stabilization theorem is refuted, as also is the validity of the stability criterion used by ROSENBLUTH and KRALL, $\langle \underline{j} \cdot \underline{E} \rangle \geqq 0$ for all real ω . In the case $\omega_{pi} \gg |\Omega_i|$ equilibria are given which satisfy the condition of TAYLOR and are nevertheless unstable. For instability it is necessary to have a non-monotonic $v_\perp$-distribution; the instabilities involved may thus be termed loss-cone unstable drift waves. In the spatially homogeneous limiting case the instability persists as a pure loss cone instability with $\mathrm{Re}(\omega) = 0$. A necessary and sufficient condition for stability is $D(\omega = \infty , k, \ldots) \leqq k^2$ for all k, the dispersion relation being written in the form $D(\omega, k, K, \ldots) = k^2 + K^2$. In the case $\omega_{pi} \ll |\Omega_i|$ adherence to the condition given by TAYLOR guarantees stability.