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Revisiting MHD stability comparison theorems: Some surprising new results ANTOINE CERFON, JEFFREY FREIDBERG, MIT PSFC — The classic MHD stability comparison theorems (Kruskal-Oberman, Rosenbluth-Rostoker) show that ideal MHD yields the most stringent stability limits according to the hierarchy $\delta W_{CGL} > \delta W_{KIN} > \delta W_{MHD}$. This has long justified the use of ideal MHD for conservative predictions of MHD stability boundaries. We reexamine these theorems, with the following conclusions:(1) It is crucial to distinguish between ergodic and closed field line systems.(2) It is essential to account for resonant particles in the kinetic MHD model.(3) For ergodic systems the original kinetic MHD analysis over-estimates stability: $\delta W_{KIN} > \delta W_{MHD}$. Our new result predicts $\delta W_{KIN} = \delta W_{MHD}$.(4) For closed line systems plasma compressibility effects become important, and resonant particle effects vanish. Both the original and new analysis predict $\delta W_{KIN} > \delta W_{MHD}$. However, using a Vlasov-Fluid model with Vlasov ions and fluid electrons we show that both δW_{KIN} and δW_{MHD}, while mathematically correct, yield the wrong physical result. The V-F model shows that at marginal stability the compressibility stabilization term vanishes identically! For ergodic systems, marginal stability is always incompressible, so $\delta W_{KIN} = \delta W_{MHD} = \delta W_{VF}$. For compressible modes in closed line systems, however, perpendicular resonant particle effects cancel the stabilizing effect of plasma compressibility predicted by ideal and kinetic MHD: $\delta W_{KIN} > \delta W_{MHD} > \delta W_{VF}$.

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