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Low-frequency waves and instabilities in gyrotropic plasmas with arbitrary distribution functions

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We will present a general formalism for the study of low-frequency waves and instabilities in collisionless plasmas with gyrotropic thermal pressure ($P_\perp \neq P_\|$), multiple components, and arbitrary distribution functions, that are embedded in a stratified and rotating medium. Our formalism lies at the interface between magnetohydrodynamics and kinetic theory, in the sense that all our equations are fluid except the equations of state for $P_\perp$ and $P_\|$, which are given by the correct second-order moments of the gyro-kinetic equation. We will show that the waves are generally non-adiabatic, and we will describe the physical reasons for their non-adiabatic behavior. We will also derive a global necessary condition for stability, which, quite remarkably, consists of the simple superposition of a criterion against instabilities triggered by thermal pressure anisotropies (the firehose and mirror instabilities) and a criterion against instabilities triggered by stratification (the quasi-interchange instabilities). In the case of a nonrotating bi-Maxwellian plasma, our stability condition turns out to be not only necessary, but also sufficient.