Hamiltonian and Action Principle Derivations of Reduced Magnetofluid Models for Plasma Dynamics – Consequences

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For decades various reduced fluid models have been constructed for describing the nonlinear dynamics of plasma phenomena, ranging from gradient driven turbulence like ITG with FLR, including electromagnetic effects, to reconnection studies with extensions of magnetohydrodynamics (MHD) (e.g., [1]–[5]). A goal of these models has been to describe the most relevant physics, while maintaining computability. Such models have been obtained by various means, asymptotic and other, and the Hamiltonian character (e.g., [6]–[9]) of their nondissipative limits has served as a sieve for acceptability, as well as a means for obtaining variational principles for equilibria and stability, and the identification of conservation laws (e.g., [10]–[12]). This talk will describe a general procedure for constructing action principles for continua, fluid or kinetic, including a discussion of the Eulerian closure principle, a necessary condition for an acceptable model. Then, the procedure will be followed to obtain consistent extended MHD models with nondissipative gyroviscous effects [13]–[14]. The Hamiltonian structure will emerge, along with the gyromap (e.g., [2]), and be used in examples. Comparisons to previous models will be made.

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