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Extended MHD Equations For NIMROD Simulations[1] J.D. CALLEN, C.C. HEGNA, C.R. SOVINEC, University of Wisconsin, Madison, WI 53706-1609 — The usual derivations of plasma MHD equations either neglect dissipative effects (ideal MHD) or use collisional regime approximations and embed collisional (i.e., Braginskii) closures. Here, "extended MHD" equations are derived that encompass all parallel (to $\mathbf{B}$) collisionality regimes for strongly magnetized plasmas ($\omega_c >> \nu$, $|\varrho\nabla_\perp| << \mathbf{1}$). This is accomplished by developing extended MHD equations from complete two-fluid equations with electron collisional force density $\mathbf{R_e} = -m_e n_e \nu_e[-\mathbf{J}/n_e e - (3/5)\mathbf{q_e}/n_e T_e + \cdots]$ and arbitrary closure relations for the heat flux $\mathbf{q}$ and stress tensor $\overleftrightarrow{\pi}$ for both electrons and ions. Self-consistent procedures for determining the highly anisotropic closures are emphasized: parallel (along field lines) via kinetics using a Chapman Enskog-type approach[2], cross (within flux surface) diamagnetic and gyroviscous, and perpendicular (across flux surfaces) from collisional relaxation of flows in flux surfaces. This set of extended MHD equations accounts for: viscous force effects in the plasma momentum equation, electron heat flow effects in Ohm's law, and an entropy evolution equation (from dissipative components of the closures) that determines evolution of the overall plasma pressure $P = p_e + p_e$ instead of the usual ideal (isentropic) equation of state. Possible use of these equations in NIMROD will be discussed.

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[2]E.D. Held, J.D. Callen and C.C. Hegna, Phys. Plasmas **10**, 3933 (2003).

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