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A Second Order Continuum Theory of Fluids – Beyond the Navier-Stokes Equations SAMUEL PAOLUCCI, Univ of Notre Dame — The Navier-Stokes equations have proved very valuable in modeling fluid flows over the last two centuries. However, there are some cases where it has been demonstrated that they do not provide accurate results. In such cases, very large variations in velocity and/or thermal fields occur in the flows. It is recalled that the Navier-Stokes equations result from linear approximations of constitutive quantities. Using continuum mechanics principles, we derive a second order constitutive theory that application of which should provide more accurate results is such cases. One important case is the structure of gas-dynamic shock waves. It has been demonstrated experimentally that the Navier-Stokes formulation yields incorrect shock profiles even at moderate Mach numbers. Current continuum theories, and indeed most statistical mechanics theories, that have been advanced to reconcile such discrepancies have not been fully successful. Thus, application of the second order theory based solely on a continuum formulation provides an excellent test problem. Results of the second-order equations applied to the shock structure are obtained for monatomic and diatomic gases over a large range of Mach numbers and are compared to experimental results.

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