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Improved estimates for thermal fluid equations

We consider two hydrodynamic model problems (one incompressible and one compressible) with three dimensional fluid flow on the torus and temperature-dependent viscosity and conductivity. The ambient heat for the fluid is transported by the flow and fed by the local energy dissipation, modeling the transfer of kinetic energy into thermal energy through fluid friction. Both the viscosity and conductivity grow with the local temperature. We prove a strong a priori bound on the enstrophy of the velocity weighed against the temperature for initial data of arbitrary size, requiring only that the conductivity be proportionately larger than the viscosity (and, in the incompressible case, a bound on the temperature as a Muckenhoupt weight).