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THERMAL CONVECTION OF COMPLEX FLUIDS

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We examine numerically the linear temporal stability of complex fluids, such as viscous compressible rarefied gases and nanofluids. These fluids present common challenges as they are governed by nonlinear constitutive equations of non-Newtonian and non-Fourier character, and therefore do not obey the Navier-Stokes-Fourier equations. The fluid is placed between two flat plates, with the lower plate held at a slightly higher temperature (Rayleigh–Benard problem). The rarefied gas is assumed to be a perfect gas, obeying a Maxwellian interaction potential. In this case, both the thermal conductivity and viscosity depend linearly on the temperature. In addition to the wavenumber, the Knudsen and Froude numbers are parameters in the problem. The resulting eigenvalue problem is solved using a spectral approach in the gap direction. The onset of convection exhibits a significant departure from the familiar Boussinesq approximation for an incompressible viscous fluid. For a compressible gas, convection appears to be confined to a narrow domain of the fluid close to the upper wall and is characterized by large wavenumbers. For a given Froude number, the marginal instability is predicted only up to a critical Knudsen number beyond which conduction remains stable. For a nanofluid, considerable enhancement is observed in its thermal conductivity. The atypical competition between conduction and convection will be discussed. The reader is referred to Khayat et al. (2015, 2016) for further details. Convection is treated using a combination of a nonlinear perturbation expansion near criticality, coupled with a spectral approach.

R. E. Khayat, J. deBruyn, M. Niknami, D.F. Stranges, R.M.H. Khorasany. Non-Fourier effects in macro- and micro-scale non-isothermal flow of liquids and gases. Review. *Int. J. Thermal Sciences* **97** (2015) 163-177.

Rahim Khorasani, Roger E. Khayat and Mohammad Niknami Nonlinear thermal convection of a non-Fourier fluid. *Int. J. Num. Methods Heat Fluid Flow* **26** (2016) 639-670.

Mohammad Niknami, Zahir U. Ahmed, Bashar Albaalbaki and Roger E. Khayat. A combined spectral-amplitude-perturbation approach for systematic mode selection in thermal convection. *Int. J. Num. Methods Heat Fluid Flow* **25** (2015) 782-802.