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On the Rayleigh–Bénard Problem in the Continuum Limit

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The transition to convection in the Rayleigh–Bénard problem at small Knudsen numbers is studied via a linear temporal stability analysis of the compressible ‘slip-flow’ problem. No restrictions are imposed on the magnitudes of temperature difference and compressibility-induced density variations. The dispersion relation is calculated by means of a Chebyshev collocation method. The results indicate that occurrence of instability is limited to small Knudsen numbers (Kn<0.03) as a result of the combination of the variation with temperature of fluid properties and compressibility effects. Comparison with existing DSMC and continuum non-linear simulations of the corresponding initial-value problem demonstrates that the present results correctly predict the boundaries of the convection domain. The linear analysis thus presents a useful alternative in studying the effects of various parameters (e.g. temperature ratio) and models of molecular interaction on the onset of convection, particularly in the limit of arbitrarily small Knudsen numbers.

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