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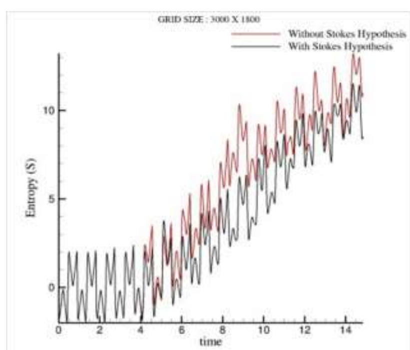
# Non-equilibrium thermodynamics of Rayleigh-Taylor instability

**Tapan K. Sengupta, Aditi Sengupta and K.S. Shruti**
**High Performance Computing Laboratory, IIT Kanpur, Kanpur 208016**

Rayleigh-Taylor instability (RTI) has been studied here as a non-equilibrium thermodynamics problem. Air masses with temperature difference of 70K, with heavier fluid resting upon the lighter fluid initially isolated by a partition, are allowed to mix by impulsively removing the partition. This results in interface instabilities, that is traced here by solving 2D compressible Navier-Stokes equation, without using Boussinesq approximation. The non-periodic isolated system is studied by solving the equations by high-accuracy, dispersion relation preserving numerical methods [1]. The instability onset is due to misaligned pressure and density gradients and is evident via creation and evolution of spikes and bubbles (when lighter fluid penetrates heavier fluid and vice versa). The assumptions inherent with most compressible formulation are: (i) Stokes' hypothesis which uses a zero bulk viscosity[2] and (ii) an equation of state for perfect gas which is a consequence of equilibrium thermodynamics. Present computations for non-equilibrium thermodynamic process do not show monotonic rise of entropy with time, as one expects from equilibrium thermodynamic concepts. Whether it is necessarily true or not is being studied here. First, we test Stokes' hypothesis, with respect to another approach that uses experimental data for the bulk viscosity of air. In the figure below, entropy of the isolated system is traced, with and without the use of Stokes' hypothesis. Without Stokes' hypothesis, one observes that the rate of increase in entropy is higher as compared to results with Stokes' hypothesis. The entropy increase from the zero datum is due to mixing; punctuated by fluctuating entropy due to creation of order at the interface by the spikes and bubbles. Prigogine [3] has noted that *if the system is perturbed, the entropy production will increase, but the system reacts by coming back to the minimum value of entropy production*. Here, apart from discussing the computational method, we will characterize non-equilibrium thermodynamics of RTI.




**References:**

1. T.K. Sengupta: High Accuracy Computing Methods: Fluid Flows and Wave Phenomenon. *Cambridge Univ. Press,* USA (2013).
2. P. A. Thomson: Compressible fluid dynamics, *McGraw Hill Book Company*, USA (1972).
3. I. Prigogine: Time, Structure and fluctuations. *Nobel Lecture in Chemistry* (1977).