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Generalized Knudsen Number for Oscillatory Flows Generated by MEMS and NEMS Resonators[1] KAMIL EKINCI, VURAL KARA, VICTOR YAKHOT, Mechanical Engineering Department, Boston University — We have explored the scaling behavior of oscillatory flows that are generated by the oscillations of MEMS and NEMS resonators in a gas. If the gas is gradually rarefied, the Navier-Stokes equations begin to fail and a kinetic description of the flow becomes more appropriate. The failure of the Navier-Stokes equations can be thought to take place via two different physical mechanisms: either the continuum hypothesis breaks down as a result of a finite size effect; or local equilibrium is violated due to the high rate of strain. By independently tuning the relevant linear dimensions and the frequencies of the MEMS and NEMS resonators, we experimentally observe these two different physical mechanisms. All the experimental data, however, can be collapsed using a single dimensionless scaling parameter that combines the linear dimension and the frequency of each resonator. This proposed Knudsen number for oscillatory flows is rooted in a fundamental symmetry principle, namely Galilean invariance.

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