ACOUSTICS2008/1885
Modeling and simulation of Taconis oscillations in a framework of the boundary-layer theory

Nobumasa Sugimoto and Dai Shimizu
Osaka University, Department of Mechanical Science, Graduate School of Engineering Science, Toyonaka, 560-8531 Osaka, Japan

This paper develops a simplified one-dimensional model to simulate numerically the onset of Taconis oscillation in a helium-filled, quarter-wavelength tube in cryogenics. Introducing a boundary layer on the tube wall, nonlinear fluid-dynamical equations are averaged over the cross-section of the acoustic main-flow region outside of the boundary layer. The boundary layer gives rise to memory effects, which are taken into account in the form of half-order derivatives. For a smooth temperature distribution of the tube wall, an initial and boundary-value problem of the equations derived is solved numerically for evolution of a small disturbance. The boundary condition at the open end neglects radiation and requires the excess pressure to vanish, while the condition at the closed end takes account of the boundary layer. When the ratio of the temperature at the closed end to the one at the open end exceeds a critical value, the initial helium column becomes unstable to grow in amplitude and stationary self-excited Taconis oscillations of finite amplitude emerge. It is shown that even the first-order boundary-layer theory can describe such an evolution of a small unstable disturbance into self-excited oscillations.