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Vortex formation at the open end of an acoustic waveguide

LEON MARTINEZ DEL RIO, PABLO L. RENDON, UNAM-CCADET, CARLOS MALAGA, UNAM-Facultad de Ciencias, ROBERTO ZENIT, UNAM-IIM — For high enough levels of acoustic pressure inside a cylindrical tube, a nonlinear mechanism is responsible for the formation of annular vortices at the open end of the tube, which results in energy loss. Higher sound pressure levels in the tube lead, in turn, to larger values of the acoustic velocity at the exit, and thus to higher Reynolds numbers. It has been observed [Buick et al, 2011] that, provided the magnitude of the acoustic velocity is large enough, two nonlinear regimes are possible: in the first regime, the vorticity appears only in the immediate vicinity of the tube; for higher velocities, vortex rings are formed at the open end of the tube and are advected outwards. We use a Lattice Boltzmann Method (LBM) to simulate the velocity and the pressure fields at the exit of the tube in 3D, with Reynolds numbers based on the acoustic boundary layer thickness $18 > R_\delta > 1.8$. We also conduct experiments with phase-locked particle image velocimetry (PL-PIV) 2D within a range of $25.5 > R_\delta > 10.2$. Experimental and numerical results are compared for a range of Womersley numbers. The effects of varying both the tube geometry and the end shape are addressed.

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