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Distortion of acoustic shockwaves by U-shaped tube portions *

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Abstract

Nonlinear propagation models for wave propagation in the resonator of brass instruments are generally based on a one-dimensional description. This description is made under the hypothesis that sound wave propagation does not depend on bends, and is the same for straight or curved resonators. However, brass instruments resonators are not straight, and the effects of bends have to be considered. Modal approaches have shown that the pressure field has no symmetry in curved ducts, both in linear and weakly nonlinear propagation. The present study addresses the question of the behavior of shockwaves in U-shaped tubes with geometries close to some parts of brass instruments resonators, For this purpose, both experiments and numerical simulations in time domain have been performed. The experiments are based on "Schlieren" optical measurements requiring a square section of the U-shaped portion of the duct. The corresponding numerical simulations have been performed by solving the 2D Euler equations in curvilinear coordinates using a finite-difference time-domain approach. Results reveal the dynamics of shock propagation: an initial plane shockwave is strongly distorted by bends, secondary shocks are generated, multiple reflections generate oscillations in the waveform, nonlinear interaction of shocks can occur.

Keywords: shockwaves, nonlinear propagation, brass instruments

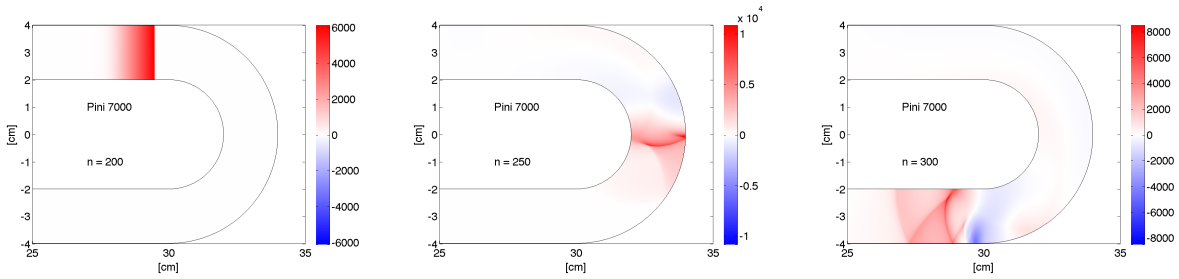

Figure 1. Example of propagation of a shockwave in a 2 cm × 2 cm cross section waveguide with a 30 mm radius bend. Result of a 2D numerical simulation of the propagation of an initial short duration pressure pulse. Simulation method: FDTD solution of Euler's equations in curvilinear coordinates. Color scale: pressure in Pascals.

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