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# A Source Term Approach for Generation of One-way Acoustic Waves in the Euler and Navier-Stokes equations

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**Abstract**

We derive a volumetric source term for the Euler and Navier-Stokes equations that mimics the generation of unidirectional acoustic waves from an arbitrary smooth surface in three-dimensional space. The model is constructed as a linear combination of monopole and dipole sources in the mass, momentum, and energy equations. The singular source distribution on the surface is regularized on a computational grid by convolution with a smeared Dirac delta function. The source is implemented in the Euler equations using a Cartesian-grid finite-volume WENO scheme, and validated by comparing with analytical solution for unidirectional planar and spherical acoustic waves. Using the scheme, we emulate a spherical piezoelectric transducer and a multi-array transducer to simulate focused ultrasound fields in water. The simulated ultrasound fields show favorable agreement with previous experiments.

*Keywords:* Directional source modeling, Euler and Navier-Stokes equation, Direct numerical simulation, Transducer modeling

## 1. Introduction

Simulation of linear and nonlinear acoustic fields using the Euler or Navier-Stokes equations is of use in diverse applications such as medical ultrasound and shockwave therapy[1], aeroacoustics [2], and underwater acoustics[3]. For many applications, a

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