Main Title

Here Goes the Subtitle

Jiaxin Zhong

The Sound Innovation of Metamaterials and Biomedical Acoustics (SIMBA)
The Pennsylvania State University (PSU)

April 20, 2023

Outline

Introduction

This is a template for the academic presentation.

Block title

- Line 1
- Line 2

Example block title

Description here

- Line 1
- Line 2

Sound fields on **front side**:

- **Near field**: second-order nonlinear or Kuznetsov equation (local effects are strong)
- **Westervelt far field**: Westervelt equation (local effects are negligible)
- **Inverse-law far field**: $p \propto 1/r$
- Proposed simple formulae for the **transition distances**

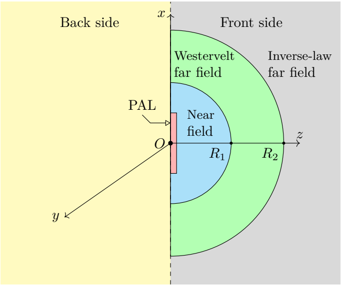

Figure 1: Sound fields generated by a PAL.

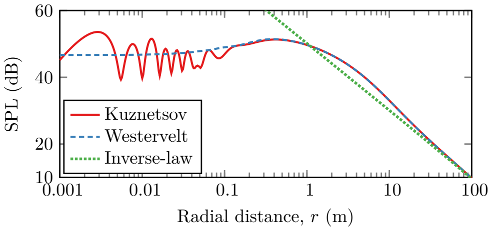

Figure 2: Audio SPL as a function of the propagating distance at 1 kHz.

References:

1. J. J. Wen and M. A. Breazeale. "A Diffraction Beam Field Expressed as the Superposition of Gaussian Beams". In: **J. Acoust. Soc. Am.** 83.5 (1988), pp. 1752–1756

Sound fields on **back side**:

- Proposed a **non-paraxial theoretical model** validated by experiments
- Audible sound behind a PAL especially at **low frequencies**

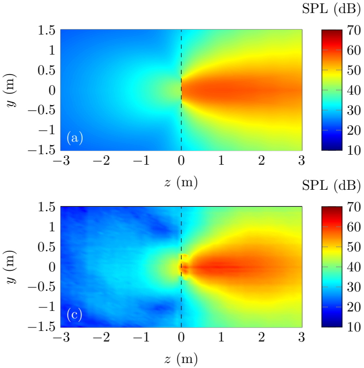

Figure 3: Audio SPL. Left column, 315 Hz; right column, 800 Hz; top row, simulations; bottom row, measurements.

References:

- J. J. Wen and M. A. Breazeale. "A Diffraction Beam Field Expressed as the Superposition of Gaussian Beams". In: **J. Acoust. Soc. Am.** 83.5 (1988), pp. 1752–1756

Improved numerical methods

- Difficulty: nonlinear wave equation
- Proposed a **spherical wave expansion** based on both **Westervelt** and **Kuznetsov** equations
- $100 \sim 500$ times faster than the existing method
- Without loss of accuracy
- Fast and reliable simulations in ANC and other audio applications

$$\text{Existing method:} \qquad p(\mathbf{r}) = \iiiint\!\!\int \cdots \mathrm{d}^2\mathbf{r}' \mathrm{d}^3\mathbf{r}'' \tag{1}$$

$$\text{Proposed method:} \qquad p(\mathbf{r}) = \sum\sum\sum\sum\int \cdots \mathrm{d}r' \tag{2}$$

Research outputs:

- **Jiaxin Zhong**, Ray Kirby, Xiaojun Qiu, "The near field, Westervelt far field, and inverse-law far field of the audio sound generated by parametric array loudspeakers," **J Acoust Soc Am** 149(3), 1524–1535 (2021).
- **Jiaxin Zhong**, Ray Kirby, Xiaojun Qiu, "A spherical expansion for audio sounds generated by a circular parametric array loudspeaker," **J Acoust Soc Am** 147(5), 3502–3510 (2020).
- **Jiaxin Zhong**, Xiaojun Qiu, "On the spherical expansion for calculating the sound radiated by a baffled circular piston," **J Theor Comput Acoust** 2050026 (2020).

Thanks!