Universität Rostock

Traditio et Innovatio

A Comparison of Sound Field Synthesis Techniques for Non-Smooth Secondary Source Distributions

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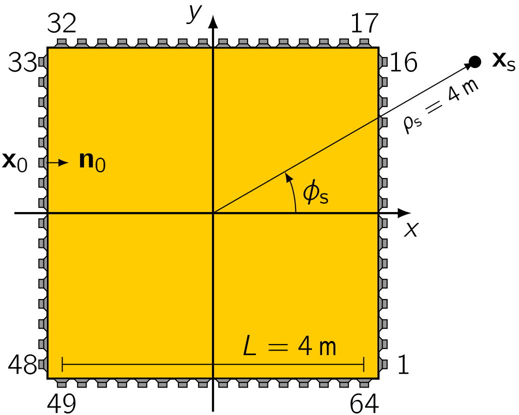
Motivation



– amplitude fluctuations as the azimuth of the virtual point source changes

Rectangular Wave Field Synthesis System with 64 Loudspeakers

Agenda

Equivalent Scattering Approach for semi-infinite Edge

- extension to rectangular secondary source distributions
- comparison with Wave Field Synthesis

Local Wave Field Synthesis

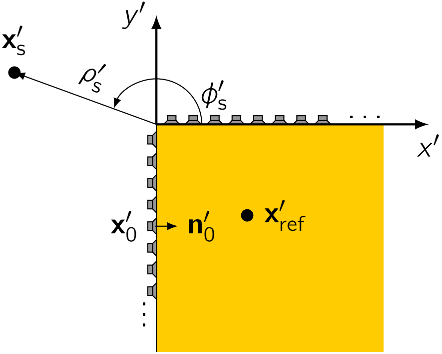
- basic concept
- comparison with Wave Field Synthesis

2.5D ESA for semi-infinite Edge [Spors and Schultz, 2016]

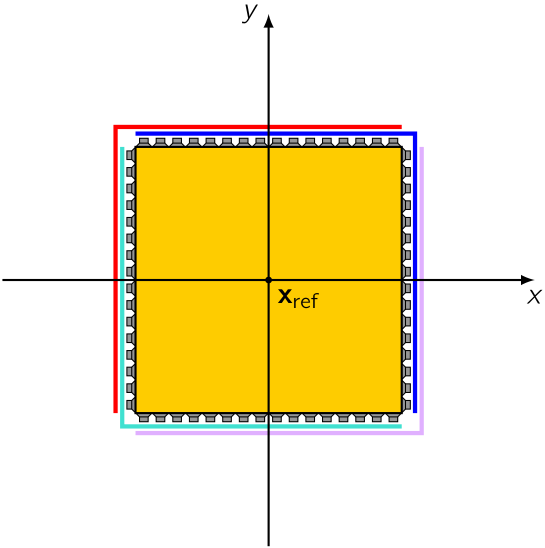
$$D(\mathbf{x}_0', \omega) = -\mathrm{j}\frac{2}{3} g_{2.5\mathrm{D}}\, a(\phi_0') \sum_{n=0}^{\infty} \frac{1}{\epsilon_n} \cos(\nu\phi_0') \sin(\nu\phi_s') \frac{\nu}{\rho_0} J_\nu(k\rho_<') H_\nu^{(2)}(k\rho_>')$$

with

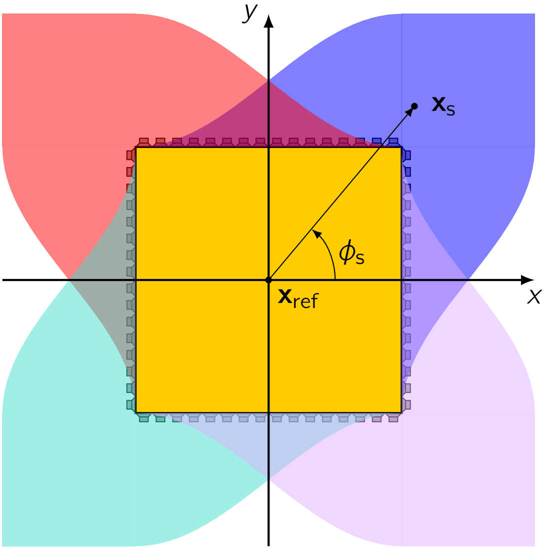
- $\nu = \frac{2}{3} n$
- $\epsilon_n = 1 + \delta_{n0}$
- $\rho_<' = \min(\rho_0', \rho_s')$
- $\rho_>' = \max(\rho_0', \rho_s')$
- $a(\phi_0') = \begin{cases} 1 & \text{for } \phi_0' = 0\,, \\ -1 & \text{for } \phi_0' = \frac{3}{2}\pi \end{cases}$
- $g_{2.5\mathrm{D}} = \sqrt{\frac{||\mathbf{x}_{\mathrm{ref}}' - \mathbf{x}_0'||}{||\mathbf{x}_{\mathrm{ref}}' - \mathbf{x}_s'||}}$



2.5D ESA for Rectangle

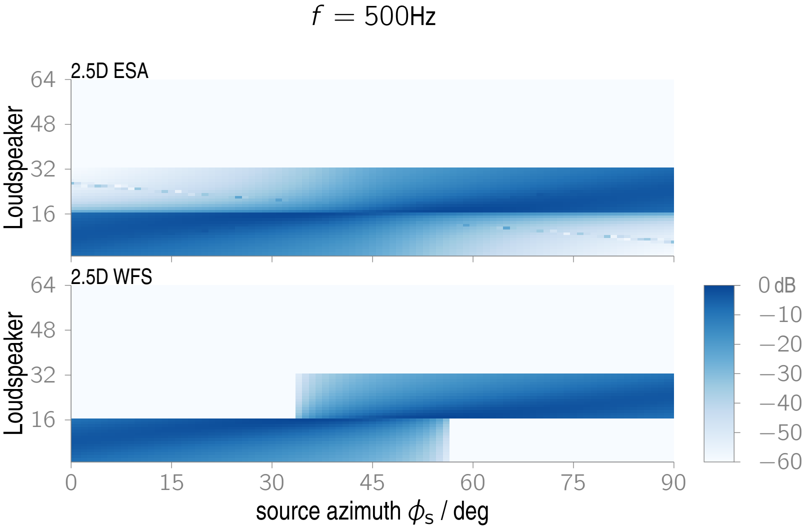


2.5D ESA for Rectangle



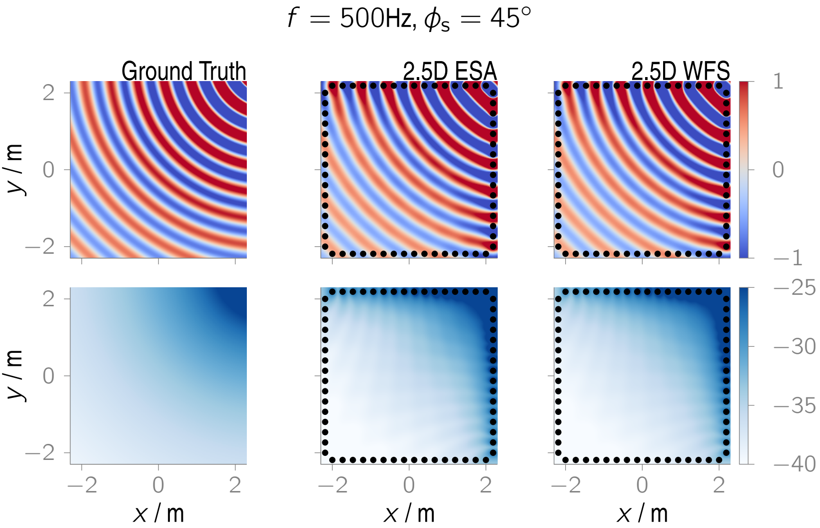
ESA vs. WFS

Driving Functions



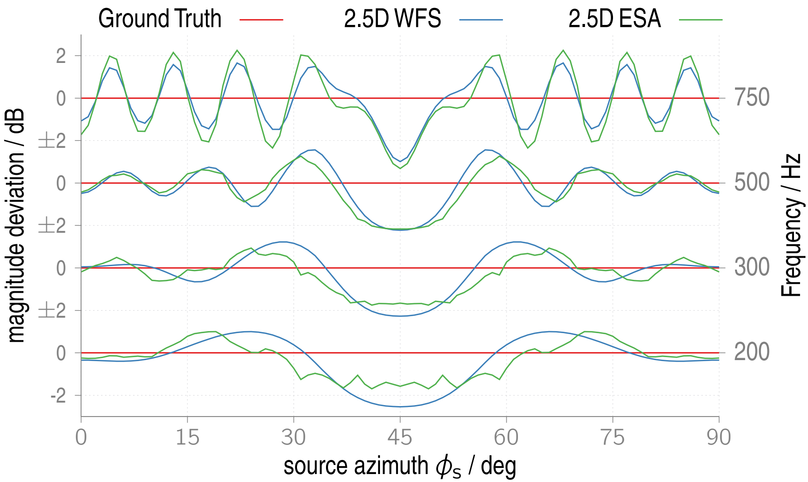
ESA vs. WFS

Reproduced Sound Field



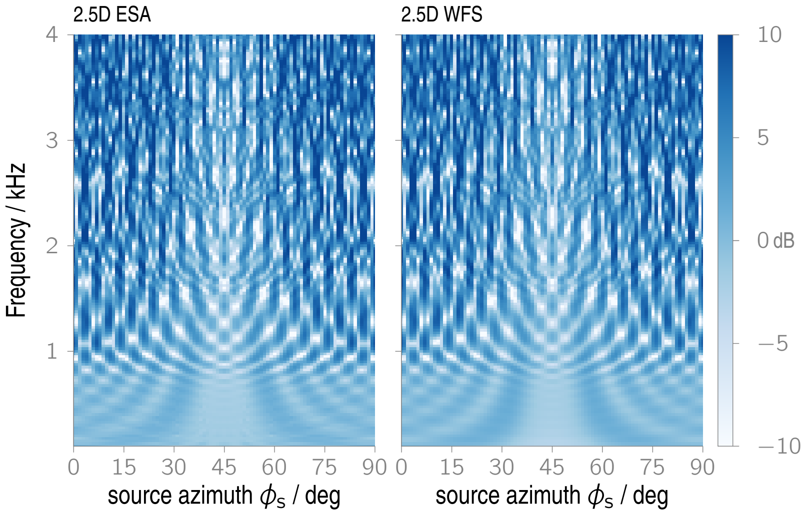
ESA vs. WFS

Amplitude Deviations at Reference Point



ESA vs. WFS

Spectral Properties at Reference Point



Intermediate Conclusion

Equivalent Scattering Approach

– no significant improvement w.r.t. spatial and spectral properties compared to WFS for the presented setup

? numerical stable implementation

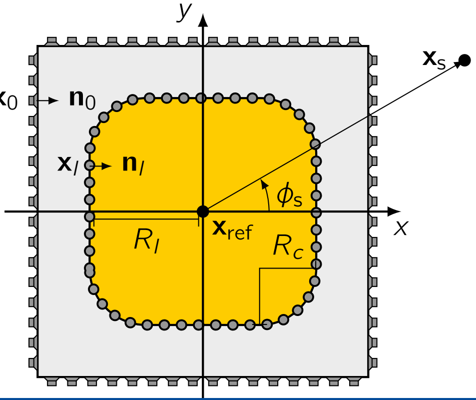
? efficient time domain implementation

\+ provides insights how to modify the secondary source distribution and the driving function [Spors and Schultz, 2016]

Local Wave Field Synthesis (LWFS)

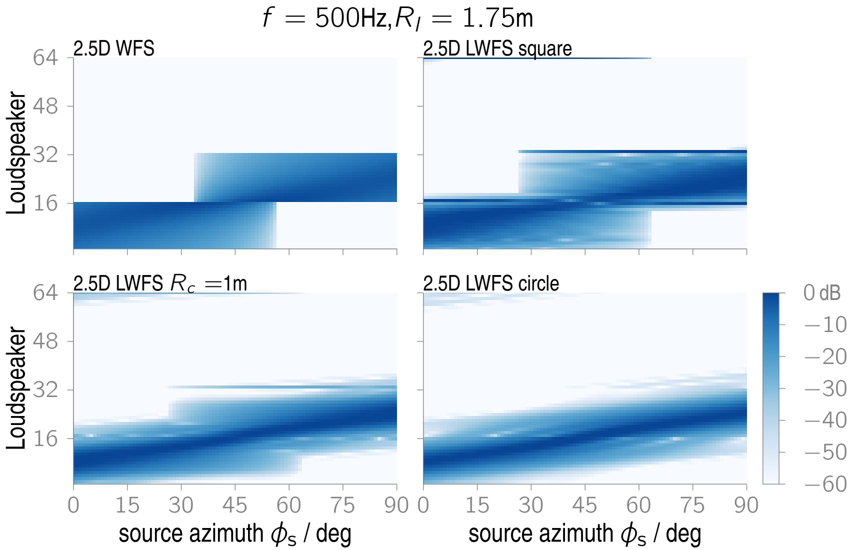
$$D(\mathbf{x}_0,\omega) = \sqrt{\frac{-\mathrm{j}k}{2\pi}} \sum_{\mathrm{x}_l \in \mathcal{X}_l} a(\mathbf{x}_0,\mathbf{x}_l) \sqrt{\frac{|\mathbf{x}_{\mathrm{ref}} - \mathbf{x}_0|}{|\mathbf{x}_{\mathrm{ref}} - \mathbf{x}_0| - |\mathbf{x}_l - \mathbf{x}_0|}}$$

$$\times \frac{(\mathbf{x}_l - \mathbf{x}_0)^T \mathbf{n}_0}{|\mathbf{x}_l - \mathbf{x}_0|^{3/2}} \mathrm{e}^{+\mathrm{j}k|\mathrm{x}_l - \mathrm{x}_0|} D_{\mathrm{WFS}}(\mathbf{x}_l,\omega)$$



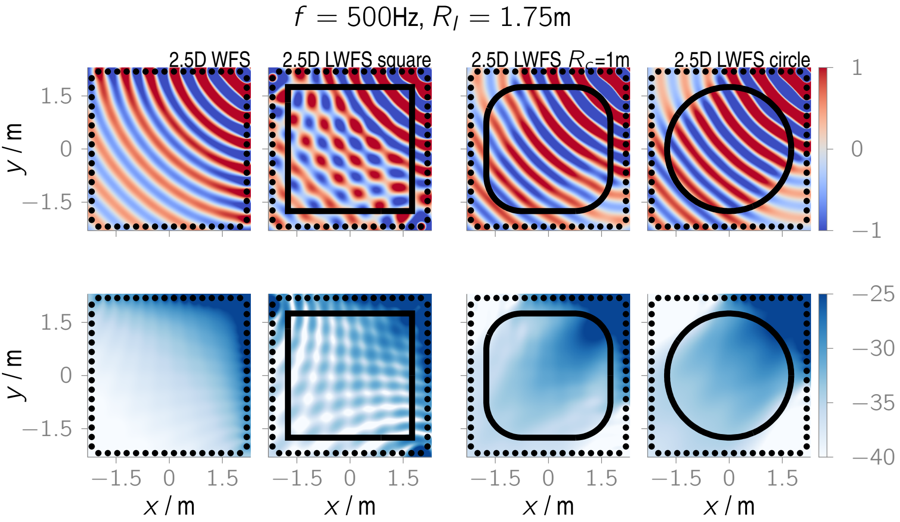
LWFS vs. WFS

Driving Functions



LWFS vs. WFS

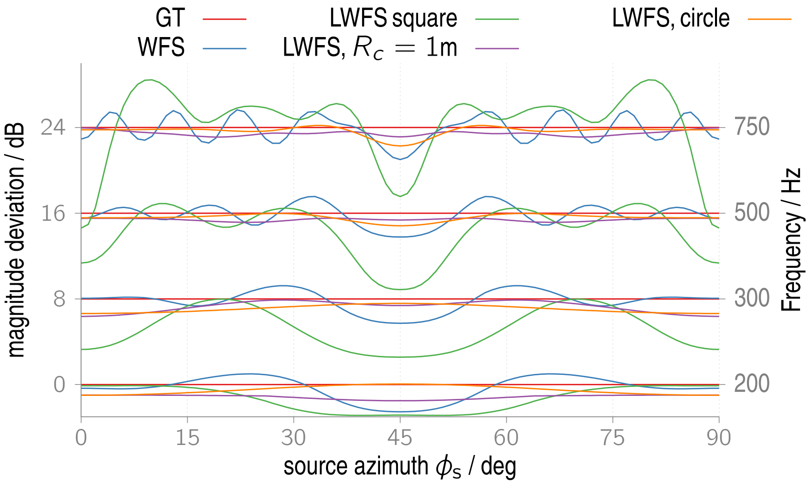
Reproduced Sound Field



LWFS vs. WFS

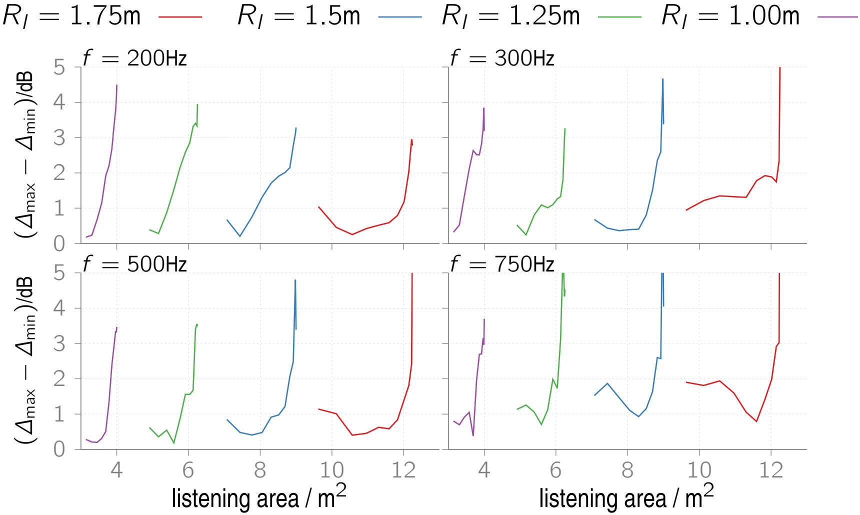
Amplitude Deviations at Reference Point

$R_l = 1.75\text{m}$



LWFS

Amplitude Deviations vs. Listening area



Final Conclusion

Equivalent Scattering Approach

– no significant improvement w.r.t. spatial and spectral properties compared to WFS for the presented setup

? numerical stable implementation

? efficient time domain implementation

\+ provides insights how to modify the secondary source distribution and the driving function [Spors and Schultz, 2016]

Local Wave Field Synthesis

\+ significant improvement compared to WFS for the presented setup

! trade-off between available listening area and amplitude fluctuations

TWO!EARS

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