Universität Rostock

Traditio et Innovatio

Physical Properties of Local Wave Field Synthesis using Circular Loudspeaker Arrays

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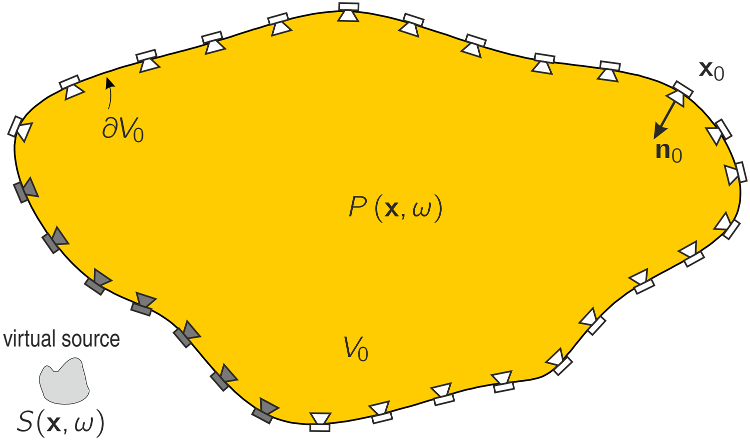
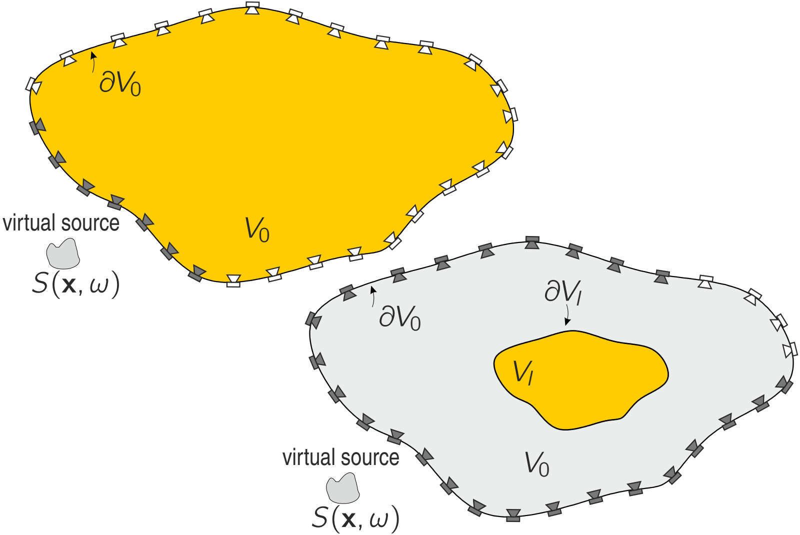
Sound Field Synthesis



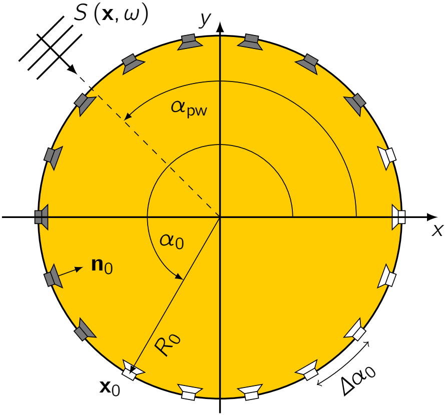
Sound Field Synthesis

Rectangular Wave Field Synthesis System with 64 Loudspeakers

Sound Field Synthesis vs. Local Sound Field Synthesis



Wave Field Synthesis for Circular Arrays

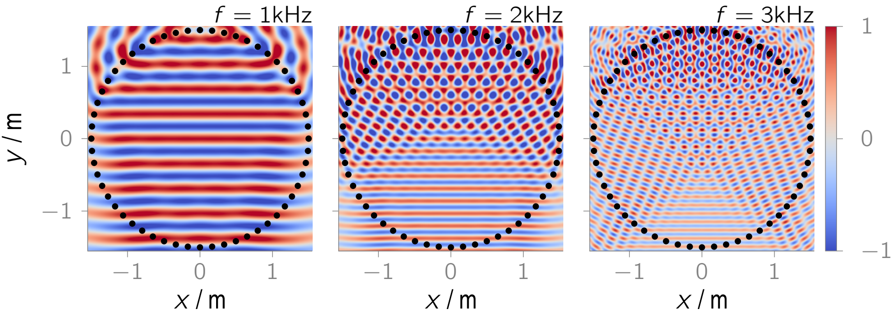


$$P(\mathbf{x}, \omega) = \int_0^{2\pi} \underbrace{-2\frac{\partial S(\mathbf{x}_0, \omega)}{\partial \mathbf{n}_0}}_{D_0(\alpha_0,\omega)} G_0(\mathbf{x} - \mathbf{x}_0, \omega)\, R_0 \,\mathrm{d}\alpha_0 \approx S(\mathbf{x}, \omega) \ \text{for } \mathbf{x} \in V_0$$

Wave Field Synthesis for Circular Arrays

Finite Spacing of Loudspeakers - Spatial Sampling

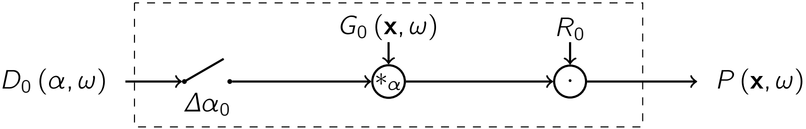
$\alpha_{\mathrm{pw}} = 90^\circ$, $N_0 = 56$, $R_0 = 1.5\mathrm{m}$, $\Delta\alpha_0 \approx 6.5^\circ$



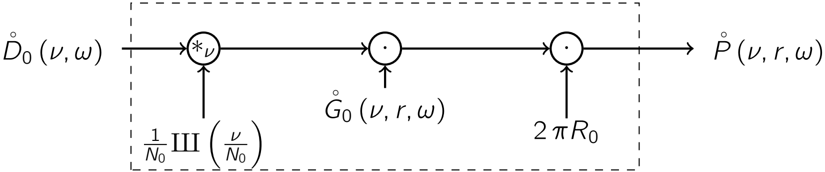
$$D_0^{\mathrm{S}}(\alpha_0, \omega) = D_0\left(\alpha_0, \omega\right) \cdot \Delta\alpha_0 \sum_{\mu=-\infty}^{\infty} \delta(\alpha_0 - \mu\Delta\alpha_0)$$

Wave Field Synthesis

Systemtheoretic View



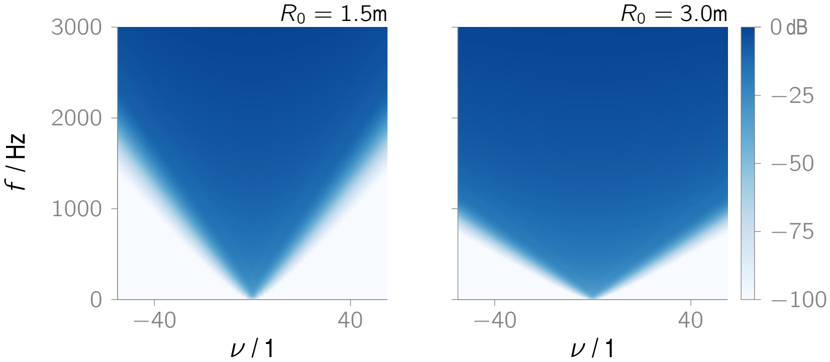
$$\mathring{F}(\nu, r, \omega) = \frac{1}{2\pi} \int_{-\pi}^{\pi} F(\mathbf{x})\, e^{-j\nu\alpha}\, d\alpha$$



Wave Field Synthesis

Fourier-Series of Driving Function

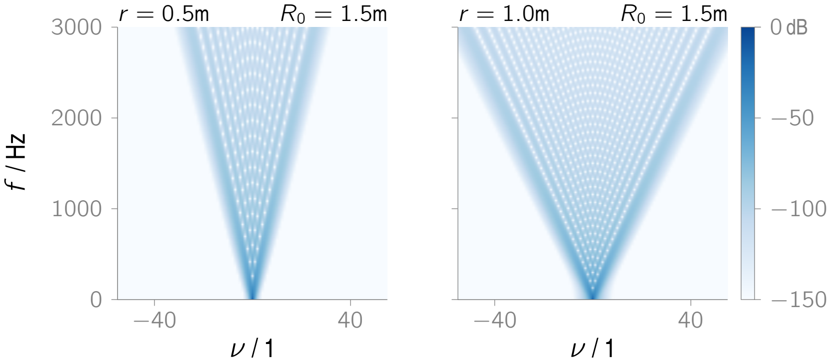
$\mathring{D}_0(\nu, \omega)$ for plane wave with $\alpha_{\text{pw}} = 90^\circ$



Wave Field Synthesis

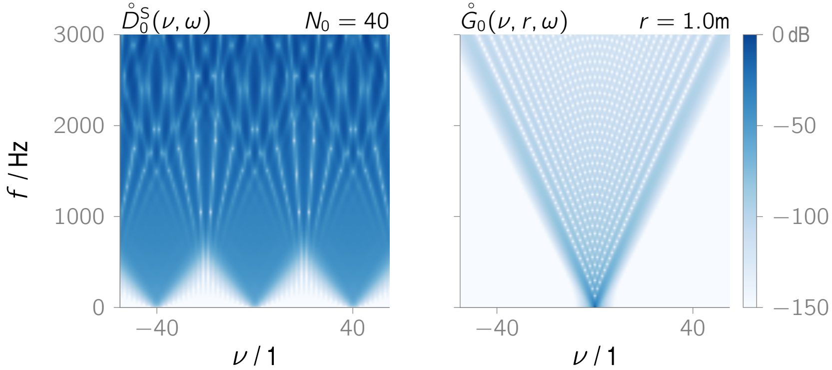
Fourier-Series of Green's Function

$$\mathring{G}_0(\nu, r, \omega)$$



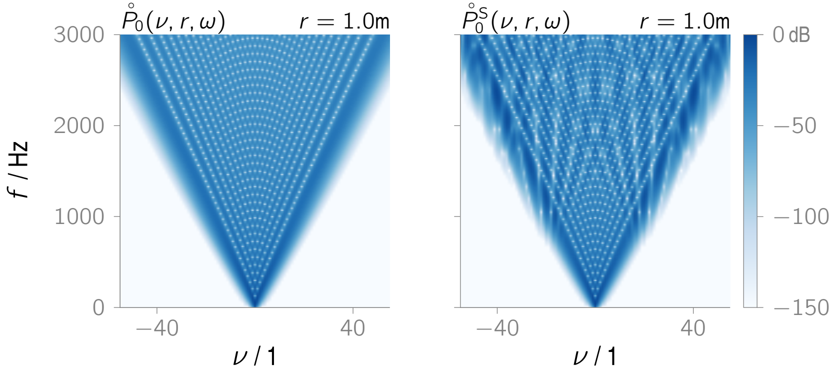
Wave Field Synthesis

Spatial Aliasing I



Wave Field Synthesis

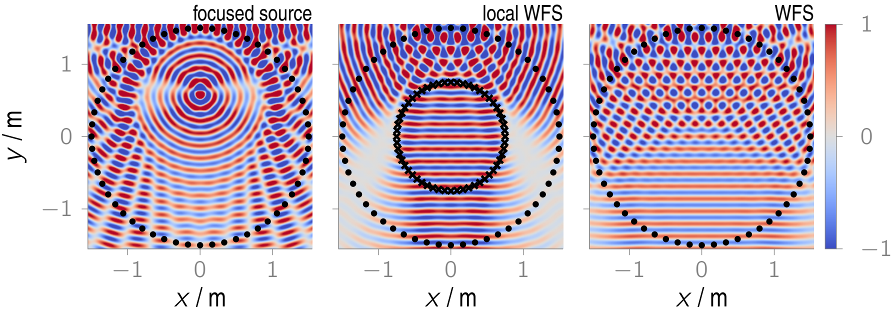
Spatial Aliasing II



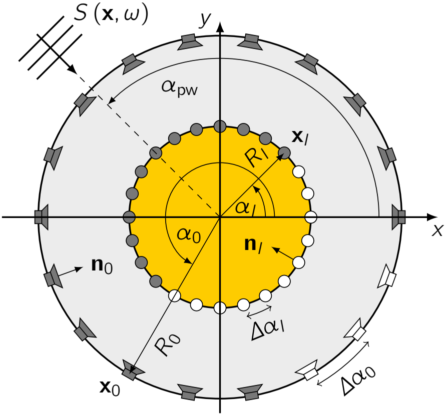
Local Wave Field Synthesis

Basic Principle

$\alpha_{pw} = 90^\circ$, $N_0 = 56$, $R_0 = 1.5$m, $\Delta\alpha_0 \approx 6.5^\circ$, $f = 2$kHz



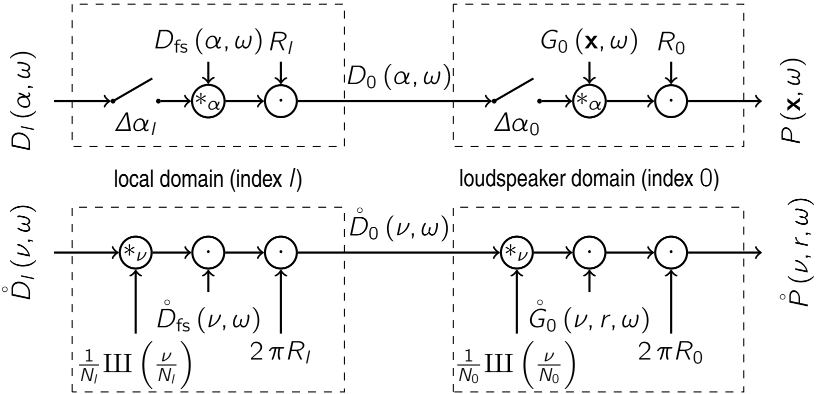
Local Wave Field Synthesis for Circular Arrays



$$P(\mathbf{x}, \omega) = \underbrace{\int_0^{2\pi} \int_0^{2\pi} \overbrace{2 \frac{\partial S(\mathbf{x}_l, \omega)}{\partial \mathbf{n}_l}}^{D_l(\alpha_l, \omega)} D_{\mathrm{fs}}(\mathbf{x}_0 - \mathbf{x}_l, \omega) R_l \, \mathrm{d}\alpha_l}_{D_0(\alpha_0, \omega)} \, G_0(\mathbf{x} - \mathbf{x}_0, \omega) R_0 \, \mathrm{d}\alpha_0$$

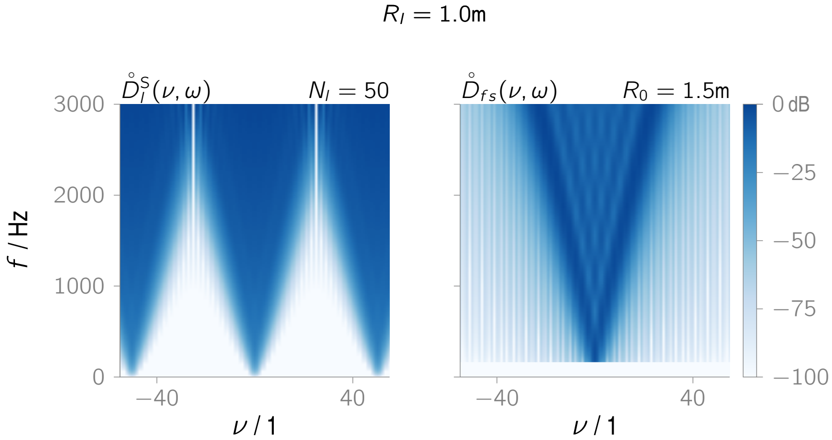
Local Wave Field Synthesis

Systemtheoretic View



Local Wave Field Synthesis

Spatial Aliasing in Local Domain

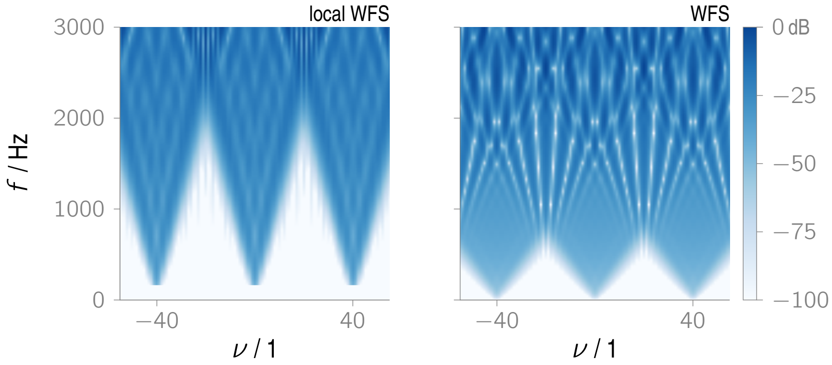


- number of focused sources has to be sufficient in order to avoid additional spatial aliasing contributed by the local domain

Local Wave Field Synthesis

Comparison of Sampled Driving Functions

$\mathring{D}_0^{\mathrm{S}}(\nu, \omega)$ for plane wave with $\alpha_{\mathrm{pw}} = 90^\circ$ using $N_0 = 40$ loudspeakers



Conlusion

- local WFS defines a smaller listening area surrounded by focused sources
- aliasing frequency can be increased by shrinking the listening area
- number of focused sources has to be sufficient to avoid additional spatial aliasing

Outlook

- close connection between spatial aliasing frequency of WFS systems and perceived coloration [Wierstorf2014]
- perceptual experiments comparing coloration in WFS, LWFS and NFC-HOA

[Wierstorf2014, Perceptual Assessment of Sound Field Synthesis, PhD thesis]

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