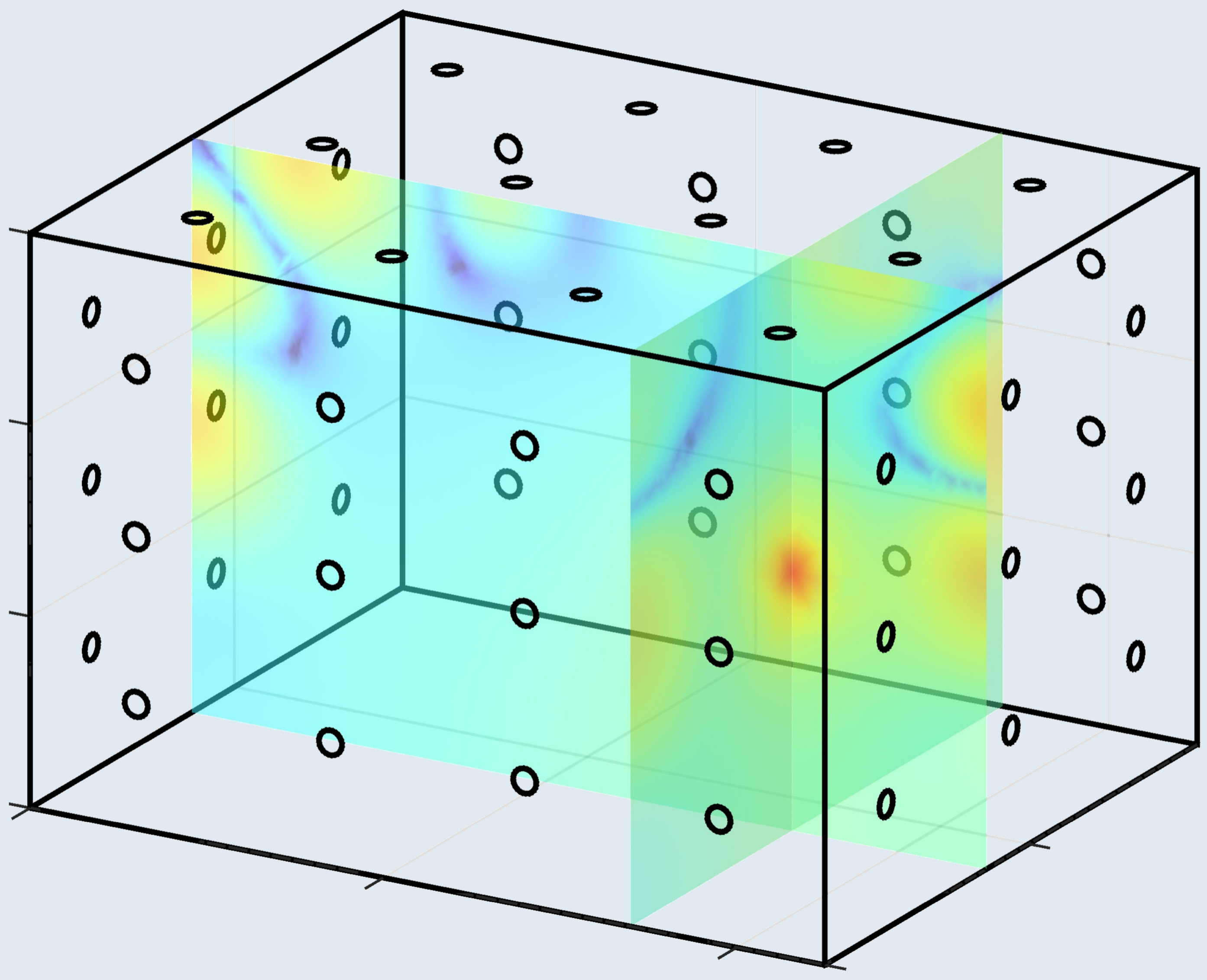

Digital Twin of a Hybrid (Passive/Active) Acoustic Measurement Room

Enhance the performance of a semi-anechoic room to very low frequency by understanding its overall behavior, including its sensitivity to tuning and design parameters.

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Abstract

A semi-anechoic chamber is an experimental room whose walls absorb sound waves, reproducing free field conditions. This is the best place to characterize microphones and loudspeakers or noise emissions in a low background because the room does not cause reflections that could disrupt measurements. However, there are some design limitations to consider. To handle low frequencies in particular, this requires heavy, costly infrastructure and a very thick, absorbent lining.

The alternative is to use active technology to minimize the pressure field scattered by the walls. The findings offer greater insight into actively controlled room response, particularly by capturing how the total sound pressure is distributed within. This information provides a useful resource for improving the design parameters and control strategy of tomorrow's active anechoic chamber, and therefore the technology they help power.

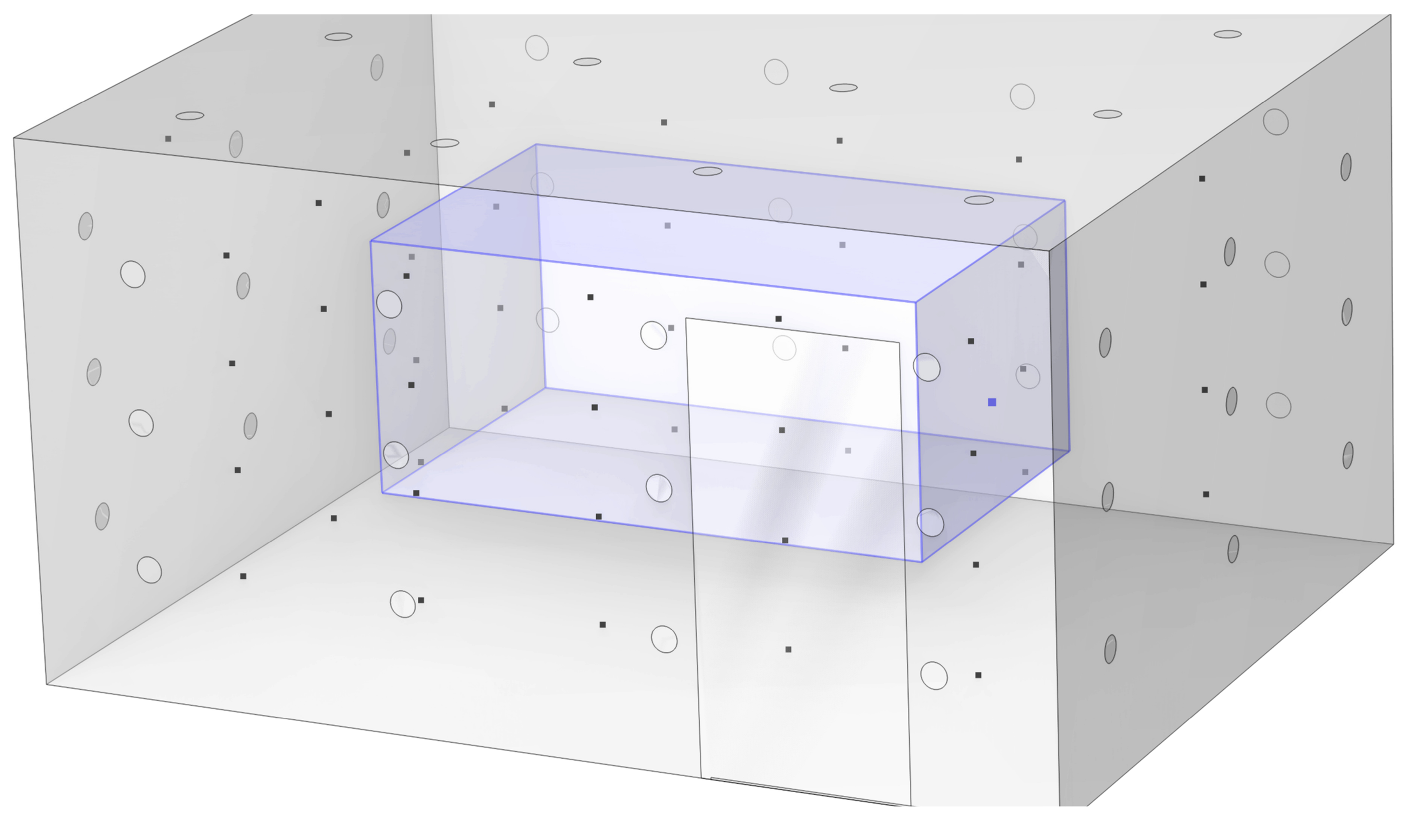

FIGURE 1. Geometry to determine the system transfer matrix where the secondary sources are modeled as flush-mounted circular pistons and the minimization points are distributed around the controlled volume.

Methodology

Let $\boldsymbol{p}_{sca} = \boldsymbol{p}_{tot} - \boldsymbol{p}_{dir}$ be the pressure field scattered by the room at the minimization points (Figure 1) when the primary source is operating alone; $\boldsymbol{p}_{dir}$ is the direct pressure field calculated offline in a semi-open acoustic domain modeled by a sound hard floor and ended by a PML and $\boldsymbol{p}_{tot}$ the total pressure field calculated in the same way but in the rectangular room.

The vector $\boldsymbol{u}$ of control signals driving the secondary sources is then determined by minimizing at each frequency step:

$$J = \|\boldsymbol{psca} - \boldsymbol{Cu}\|^2$$

where $\boldsymbol{C}$ is the system transfer matrix between the secondary sources and the resulting pressure at the minimization points.

Results

The results can be seen in Figure 2, which illustrates the frequency response and pressure distribution in the room. With control on, the total sound pressure tends towards the direct pressure field response of the test source which would be placed at the same distance from a sound hard floor. This significantly attenuates the pressure field scattered by the room. However, this is no longer the case when the frequency exceeds around 180 Hz. This is linked to number of secondary sources and minimization points, whose spacing becomes greater than the wavelength.

Having the digital twin of the actively controlled room allows control configurations to be quickly tested before considering their practical implementation in the real room.

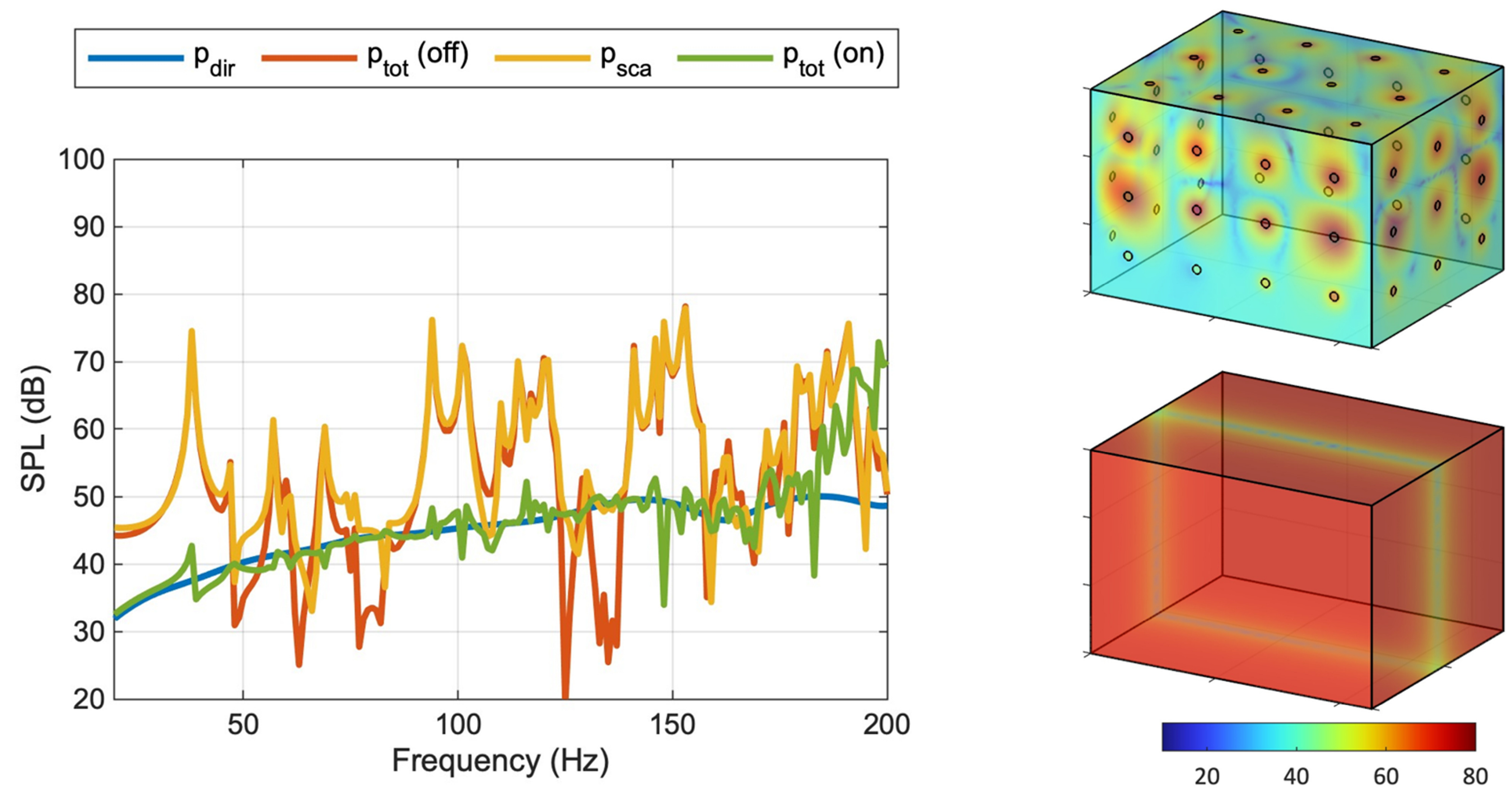

FIGURE 2. Left: Room frequency response. Right: Total sound pressure distribution in dB with the control on (top) and control off (bottom) for axial mode (010).

REFERENCES

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