Inter-Centre Research Exchange Report

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Dates of Exchange: June–September, 2025

Exchange Institutions: Technical University of Madrid (UPM), Madrid, Spain & Technical University of Denmark (DTU), Copenhagen, Denmark

Exchange Supervisors: Gary Scavone (CIRMMT, McGill), Efren Fernandez-Grande (UPM), Samuel Verburg (DTU)

Exchange Objectives

The main objective of this summer exchange in Europe is to work with Prof. Fernandez-Grande and Prof. Verburg, while also presenting at the Forum Acusticum in Málaga and the International Conference on Digital Audio Effects (DAFx) in Ancona, Italy. This internship marks the beginning of my PhD journey, during which we worked on developing a novel representation model for spatial signal data using the scattering transform, with applications to sound field reconstruction.

Research Study

I conducted joint research with Prof. Fernandez-Grande and Prof. Verburg, spending June and July at UPM with Prof. Fernandez-Grande and August at DTU with Prof. Verburg. Prof. Fernandez-Grande is a leading expert in room acoustics, with extensive experience in radiation modeling as well as near- and far-field sound field analysis and modeling. Prof. Verburg, whose PhD was supervised by Prof. Fernandez-Grande, now focuses heavily on applying physics-informed machine learning to acoustic signal processing, closely aligned with his former supervisor's expertise.

The overarching goal of my PhD research is to develop a machine learning based virtual sound source construction framework using cutting-edge physics-informed deep learning techniques. My work sits at the intersection of musical acoustics, room acoustics modeling, and deep learning, bridging multiple disciplines. My home lab, Computational Acoustic Modeling Laboratory (CAML), offers a strong foundation in musical acoustics, particularly instrument acoustics, while Prof. Fernandez-Grande brings expertise in room acoustics to ensure the proposed techniques are applicable to spatial audio and sound recording, and Prof. Verburg contributes complementary expertise in machine learning for acoustics.

During the summer exchange, we had fruitful discussions on musical instrument radiation and the role of machine learning in acoustic signal processing. We applied the wavelet scattering transform, viewed as a white-box convolutional neural network, to sound field reconstruction. To the best of our knowledge, this marks the first application of wavelet scattering transforms to spatial acoustics. The results are promising, and we plan to continue long-term collaboration, particularly in addressing musical instrument directivity modeling. By the end of the exchange, Prof. Fernandez-Grande expressed strong interest in the project and agreed to serve as a co-supervisor for my PhD.

Research Outcomes

The work carried out during this exchange has been submitted to the 2026 International Conference on Acoustics, Speech, and Signal Processing (ICASSP).

Academic Participation and Engagements

During my stay at DTU, I had the opportunity to present a poster at the DTU Electro Seminar, entitled Physics-Informed Deep Learning for Nonlinear Friction Models of Bow-String Interaction (also presented at DAFx 2025). The presentation sparked numerous insightful discussions with researchers at DTU.

I also visited the Image and Sound Processing Lab (ISPL) at Politecnico di Milano (Polimi) to discuss my research. The visit led to engaging discussions with the researchers there and explored possibilities for future collaboration.

Conference Attendance

I presented two works, both affiliated with CIRMMT: Acoustic Field Reconstruction in Tubes via Physics-Informed Neural Networks at Forum Acusticum, and Physics-Informed Deep Learning for Nonlinear Friction Models of Bow-String Interaction at DAFx25.

Acknowledgments

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