SELECTED PUBLICATIONS OF LAURI OKSANEN

My research lies at the intersection of pure and applied mathematics, spanning analysis, geometry and numerical analysis. I will focus here on my three main lines of research.

The Loretzian Calderón problem. The theory of this problem is comprehensive in the case of time-independent coefficients. A generalized Laplacian on a Hermitian vector bundle can be recovered, see [7] in selected publications below, and problems with disjoint data can be solved [10]. Resources provided by my EPSRC fellowship allowed me to transition to study the case of time-dependent coefficients. We solved the Loretzian Calderón problem in stationary geometries [4] and under curvature bounds [1]. This line of research is a major reason why I was awarded the JiongWei Young Researcher Award and the Calderón Prize.

Inverse problems for nonlinear wave equations. A methodology to solve these problems has been established very recently. My contributions to the theory include showing how to recover lower order terms via a reduction to broken [2] and truncated ray transforms using techniques from microlocal analysis. We also solved the inverse problems for the Yang–Mills [3] and Einstein equations.

Computational methods for inverse problems. Even in the time-independent case, the Loretzian Calderón problem is challenging to solve in practice since it is nonlinear and unstable. In [9] we showed that it is possible to reconstruct a low-pass filtered speed of sound in a stable way, and in a series of works including [8], we studied the problem computationally, aiming towards applications in geophysical imaging. Regularization is needed in computational implementations, and we have developed a theory of regularization of unique continuation problems using stabilized finite element methods, see [6] for the hyperbolic case. We also used a dual version of this theory to give an optimally convergent method for the control problem for the wave equation [5], thus solving a long standing problem in numerical analysis.

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[2] X. Chen, M. Lassas, L. Oksanen, and G. P. Paternain. Detection of Hermitian connections in wave equations with cubic non-linearity. *J. Eur. Math. Soc.*, doi.org/10.4171/JEMS/1136, 2021.

[3] X. Chen, M. Lassas, L. Oksanen, and G. P. Paternain. Inverse problem for the Yang–Mills equations. *Comm. Math. Phys.*, 384(2):1187–1225, 2021.

[4] A. Feizmohammadi, J. Ilmavirta, and L. Oksanen. The light ray transform in stationary and static Lorentzian geometries. *J. Geom. Anal.*, 31(4):3656–3682, 2021.

[5] E. Burman, A. Feizmohammadi, and L. Oksanen. A fully discrete numerical control method for the wave equation. *SIAM J. Control Optim.*, 58(3):1519–1546, 2020.

[6] E. Burman, A. Feizmohammadi, and L. Oksanen. A finite element data assimilation method for the wave equation. *Math. Comp.*, 89(324):1681–1709, 2020.

[7] Y. Kurylev, L. Oksanen, and G. P. Paternain. Inverse problems for the connection Laplacian. *J. Differential Geom.*, 110(3):457–494, 2018.

[8] M. V. de Hoop, P. Kepley, and L. Oksanen. Recovery of a smooth metric via wave field and coordinate transformation reconstruction. *SIAM J. Appl. Math.*, 78(4):1931–1953, 2018.

[9] S. Liu and L. Oksanen. A Lipschitz stable reconstruction formula for the inverse problem for the wave equation. *Trans. Amer. Math. Soc.*, 368(1):319–335, 2016.

[10] M. Lassas and L. Oksanen. Inverse problem for the Riemannian wave equation with Dirichlet data and Neumann data on disjoint sets. *Duke Math. J.*, 163(6):1071–1103, 2014.