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Computational Unique Continuation

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The problem of extending measured data from a limited observation region to a larger domain, subject to a governing partial differential equation (PDE), is known as a unique continuation problem. Such problems arise frequently in data assimilation, inverse problems and control theory. They are typically severely ill-posed, making their accurate numerical approximation particularly challenging.

In this talk, we present recent advances in the finite element approximation of unique continuation problems. We place special emphasis on the interplay between physical stability (inherent to the PDE) and numerical stability (introduced by discretisation). This tension motivates a critical reassessment of classical approaches, such as Tikhonov regularisation applied at the continuous level prior to discretisation.

We introduce a novel computational framework that integrates numerical stability with the conditional stability of the underlying physical problem. This approach yields approximations that are provably optimal under certain conditions. We conclude by exploring several variants and applications of the method, supported by computational illustrations.

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