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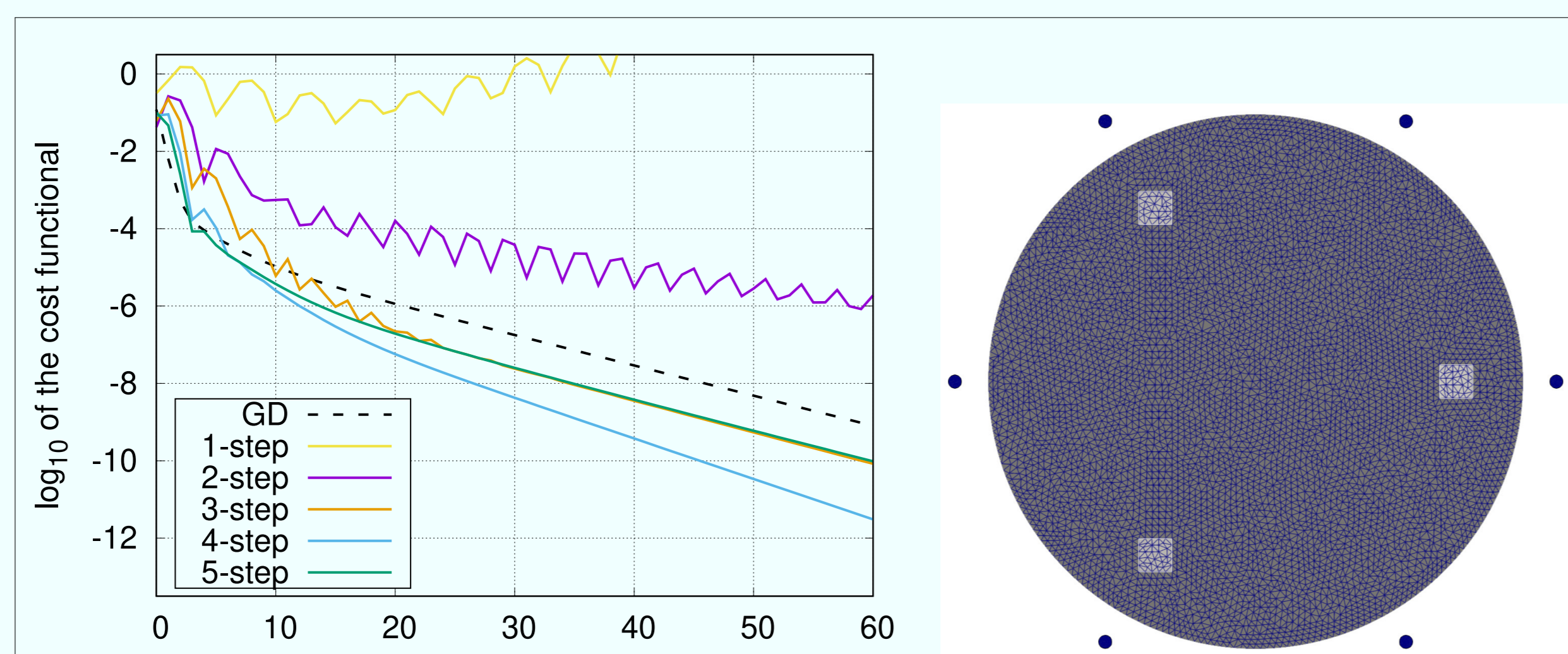
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Objectives

The goal of this associate team is to contribute to the analysis of inverse problems where the sought parameters lack regularity. A typical example is the geometric inverse problem, where the geometry to be recovered from given data represents the discontinuity set for some physical coefficients in a PDE model. This problem arises in a variety of applications such as geophysics (e.g. the parameter being the sound velocity), non-destructive testing (e.g. the parameter being the crack impedance, dielectric properties of deposits), medical imaging (e.g. the parameter being the conductivity). For this type of problem, a classical formulation of the inverse problem as an optimization problem would generally be confronted with the lack of differentiability of the state variable with respect to the discontinuity location. We explore two main strategies to address this issue. The first one is based on the design of a suitable misfit functional that would be differentiable even if the state variable is not. This is the case, for example, of the Kohn-Vogelius cost function for self-adjoint operators. The second strategy would be to develop optimization-free inversion procedures that avoid the derivative of the state variable. This is the case, for instance, of sampling methods that have been developed for cracks.

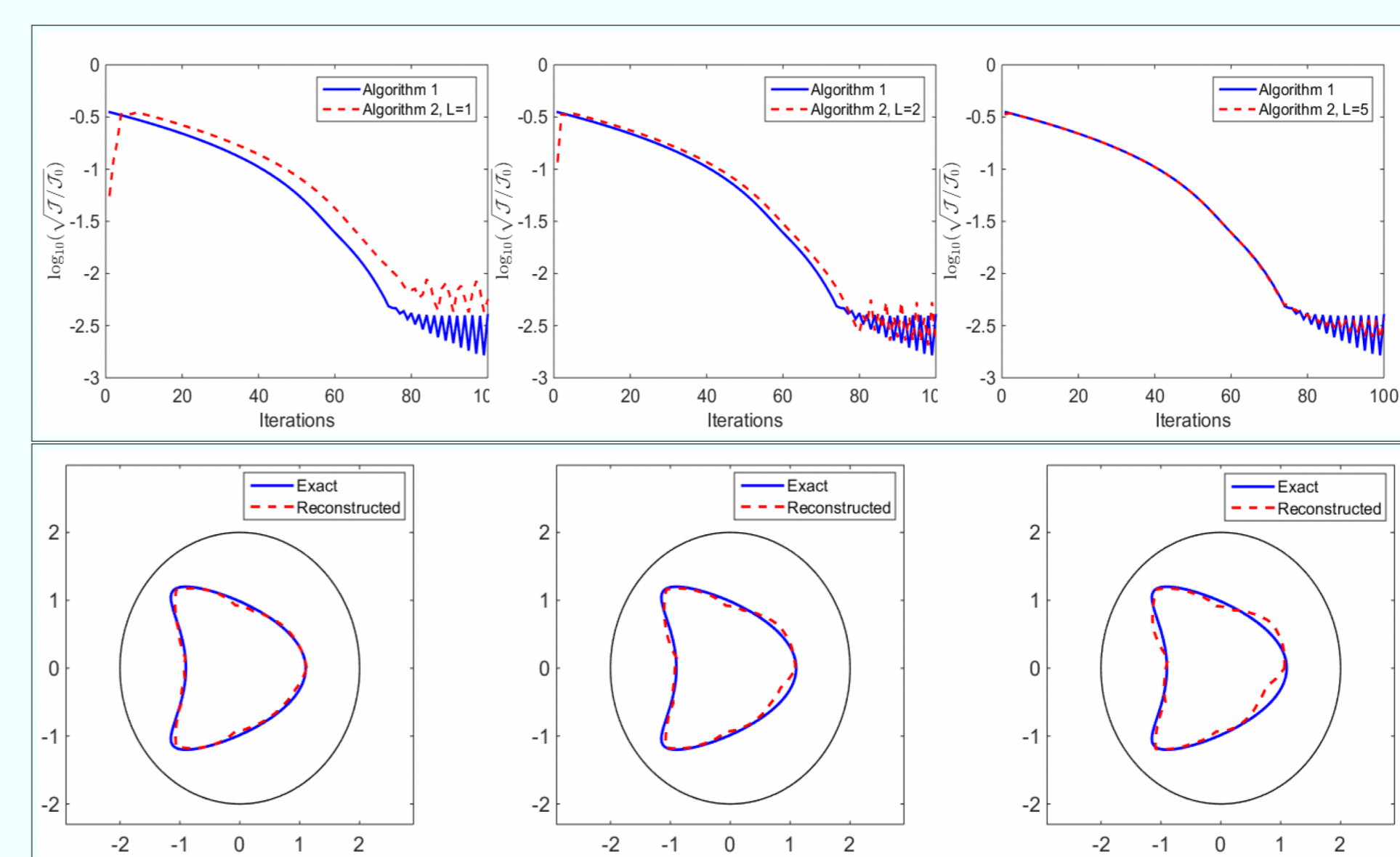
Multi-Step One-Shot Inversion Methods

- We analyzed two variants of the so-called multi-step one-shot methods to solve linear inverse problems: we iterate simultaneously on the inverse problem parameter (by the gradient descent method), and on the state/adjoint variables (by a fixed-point method). We have established sufficient conditions for convergence. We observe that very few inner iterations on the forward problem are enough to guarantee good convergence.



Convergence rates for k -step one-shot methods for linearized inverse conductivity problems

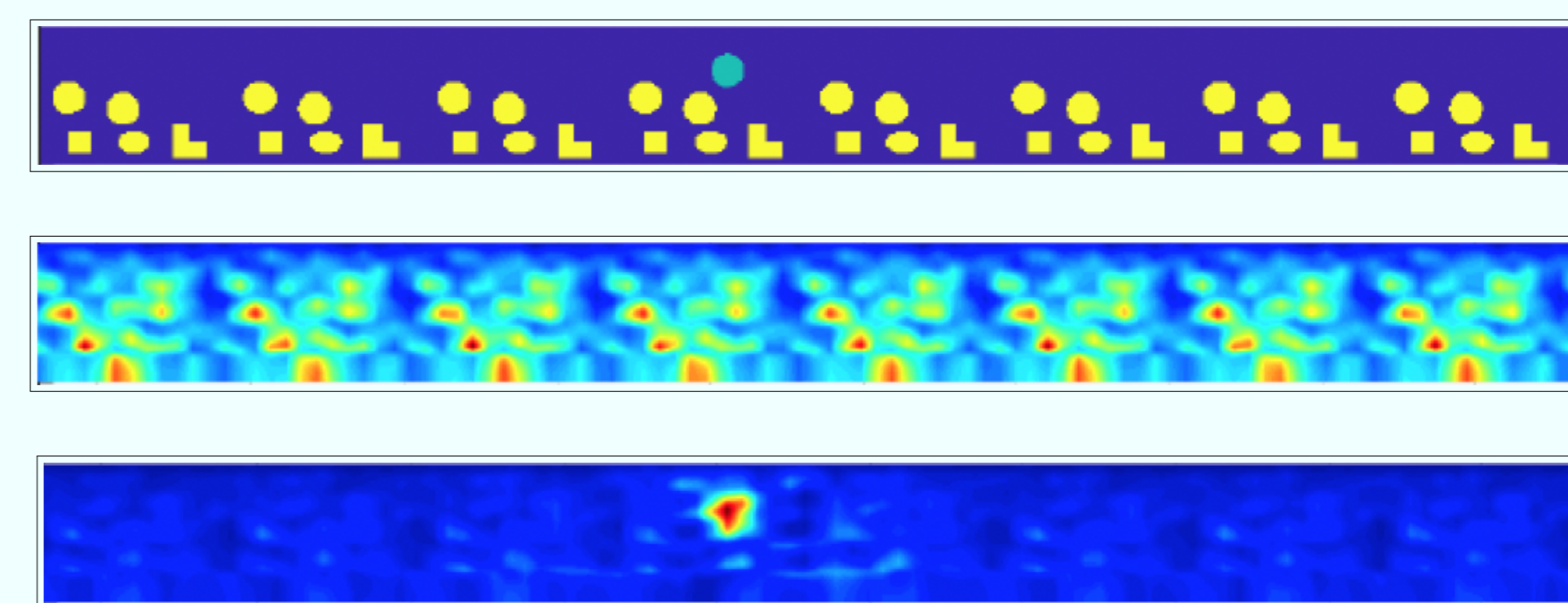
- We investigated the coupling of Kohn-Vogelius functional with a domain decomposition method (optimized Schwarz algorithm) for impedance tomography. We analyzed the convergence of this method in the simplified case of cylindrically invariant geometries and proved the effectiveness of this coupling through numerical examples.



Coupled Kohn-Vogelius - DDM (OSM) for inverse conductivity problems

Sampling methods for inverse geometrical problems

- We have revisited the differential sampling method for the identification of a periodic domain and some local perturbation. We have provided a theoretical justification of the method that avoids the assumption that the local perturbation is also periodic.
- We studied conditional stability for inverse scattering problems related to the time-harmonic magnetic Schrödinger equation. We proved logarithmic-type estimates for retrieving the magnetic (up to a gradient) and electric potentials from near-field or far-field maps.



Differential Sampling Method for reconstructing local defects in periodic layers

Publications

- M. Bellassoued, H. Haddar, A. Labidi. Stability estimate for an inverse problem for the time harmonic magnetic Schrödinger operator from the near and far field pattern. *SIAM J. Math. Ana.*, 2023.
- M. Bonazzoli, H. Haddar, T. A. Vu. Convergence analysis of multi-step one-shot methods for linear inverse problems. Research Report RR-9477, Inria Saclay and ENSTA Paris, 2022.
- M. Bonazzoli, H. Haddar, T. A. Vu. On the convergence analysis of one-shot inversion methods. Submitted, 2023.
- Y. Boukari, H. Haddar, N. Jenhani. Analysis of sampling methods for imaging a periodic layer and its defects. *Inverse Problems*, 2023.
- S. Chaabane, H. Haddar, R. Jerbi. A combination of Kohn-Vogelius and DDM methods for a geometrical inverse problem. *Inverse Problems* 2023.