



HAL
open science

First approach of a mixed domain decomposition method for magnetostatic simulation of rotating machines

Aurélia Ruda, François Louf, Pierre-Alain Boucard, Xavier Mininger

► To cite this version:

Aurélia Ruda, François Louf, Pierre-Alain Boucard, Xavier Mininger. First approach of a mixed domain decomposition method for magnetostatic simulation of rotating machines. 23rd Conference on the Computation of Electromagnetic Fields COMPUMAG 2021, Jan 2022, online, France. pp.PB-A1-10. hal-03538690

HAL Id: hal-03538690

<https://hal.science/hal-03538690v1>

Submitted on 21 Jan 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

First approach of a mixed domain decomposition method for magnetostatic simulation of rotating machines

A. Ruda¹, F. Louf¹, P.A. Boucard¹ and X. Mininger²

¹Université Paris-Saclay, ENS Paris-Saclay, CentraleSupélec, CNRS, Laboratoire de Mécanique Paris-Saclay, France.

²Université Paris-Saclay, CentraleSupélec, CNRS, Laboratoire de Génie Électrique et Électronique de Paris, France.

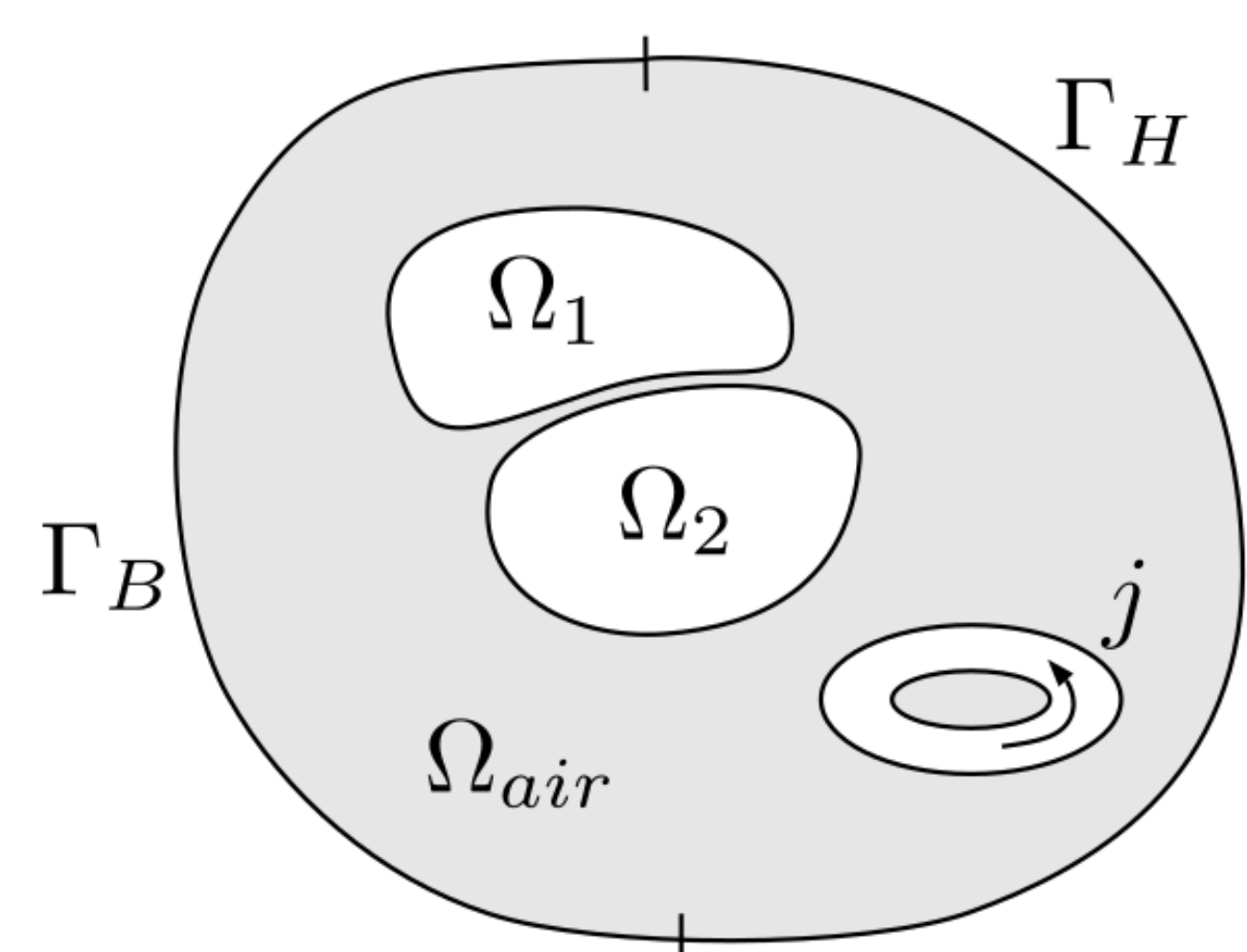
²Sorbonne Université, CNRS, Laboratoire de Génie Électrique et Électronique de Paris, France.

Abstract

In this work, a mixed domain decomposition method (LATIN) is proposed to improve the efficiency of magnetostatic simulation of rotating machines. This strategy relies on a decomposed formulation of the problem considering both primal and dual fields on the interfaces. From this formulation, the LATIN solver method gives a powerful iterative scheme to build a solution. A first implementation using the magnetic vector potential formulation in 2D is developed and is illustrated on two test cases: a ferromagnetic 2D bar and a switched reluctance motor.

1 - Problem statement

Objective: propose an innovative computational strategy based on a domain decomposition method



Problem studied

$$\begin{cases} \operatorname{div}(\underline{B}) = 0 \\ \operatorname{rot}(\underline{H}) = \underline{j} \\ \underline{B} = \mu \underline{H} \end{cases}$$

Framework of the study

Formulation with vector potential \underline{A} in 2D

Discretization with Finite Element

$$[K]\{A\} = \{J\}$$

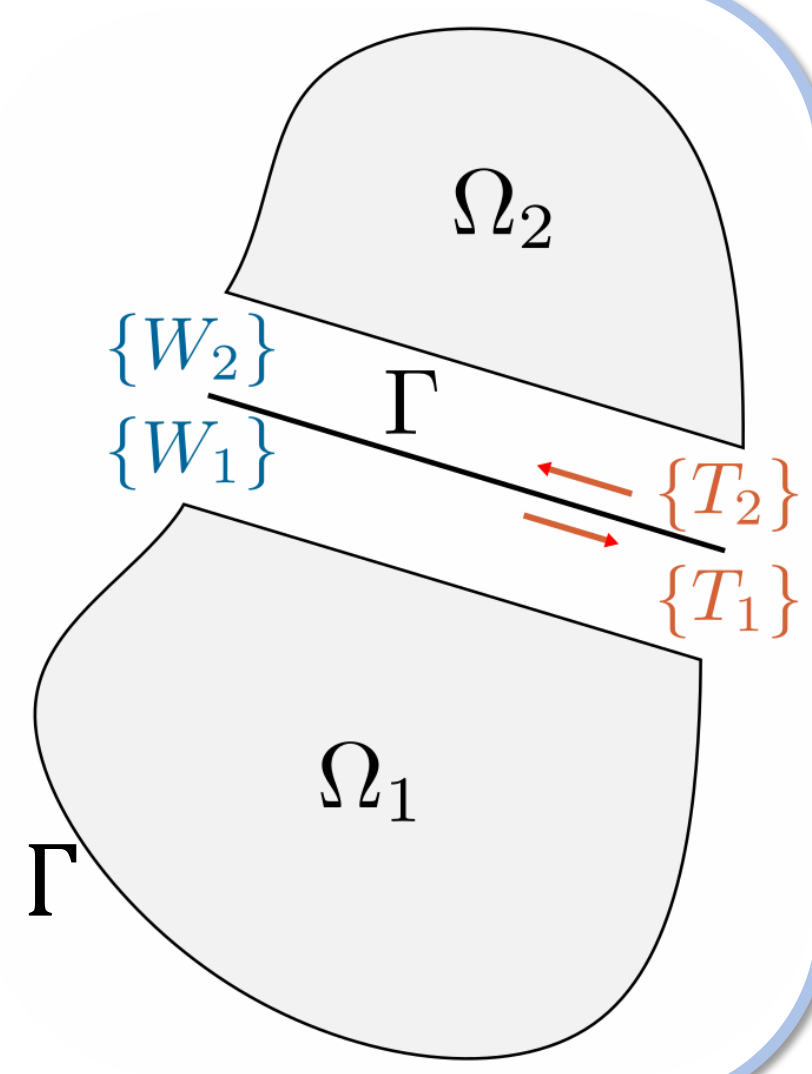
Decomposition

- Sub-domains Ω_i
- Interfaces Γ between each sub-domains

Particularity of the method:

Primal **and** dual fields on the interfaces

- $\{W\}$ restriction of vector potential $\{A\}$ on Γ
- $\{T\}$ tangential component of magnetic field $\{H\}$ on Γ
- Operator $[t]$: restriction on Γ



2 - The mono-scale LATIN method

Principles

- Separate equations into two groups A_d and Γ
- Solve with a **two stage iterative algorithm** according to search directions E^+ and E^-

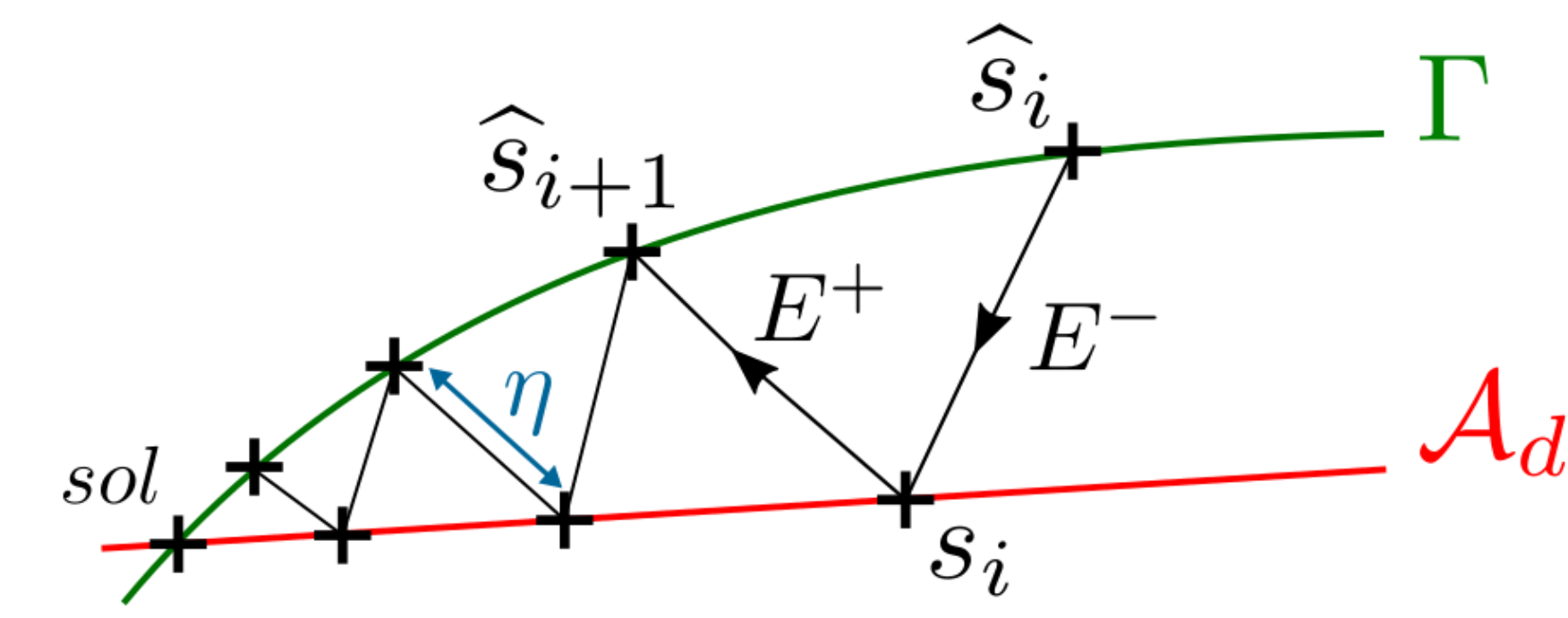


Figure: LATIN iterative scheme

Group (A_d): linear and possibly global equations

$$\begin{aligned} \text{Search } s &= (\{W\}, \{T\}) \\ [K]\{A\} &= \{J\} + [t]^T \{T\} \\ \{W\} &= [t]\{A\} \end{aligned}$$

Group (Γ): local and possibly nonlinear equations

$$\begin{aligned} \text{Search } \hat{s} &= (\{\hat{W}\}, \{\hat{T}\}) \\ [O_d]\{\hat{W}\} &= \{0\} \\ [O_s]\{\hat{T}\} &= \{0\} \end{aligned}$$

Search directions

$[k^+]$ and $[k^-]$ operators representing sub-domains behavior

$$\begin{aligned} E^- & \\ \{T\} - \{\hat{T}\} + [k^-](\{W\} - \{\hat{W}\}) &= \{0\} \\ E^+ & \\ \{\hat{T}\} - \{T\} + [k^+](\{\hat{W}\} - \{W\}) &= \{0\} \end{aligned}$$

Algorithm: Mono-scale LATIN

Input: $\hat{s}_0 \in \Gamma$ (generally set to 0)

while $\eta \geq \text{criteria do}$

Linear stage for each sub-domain

knowing $\hat{s}_i \in \Gamma$ search for $s_i \in A_d \cap E^-$

Local stage for each interface

knowing $s_i \in A_d$ search for $\hat{s}_{i+1} \in \Gamma \cap E^+$

Convergence indicator compute η

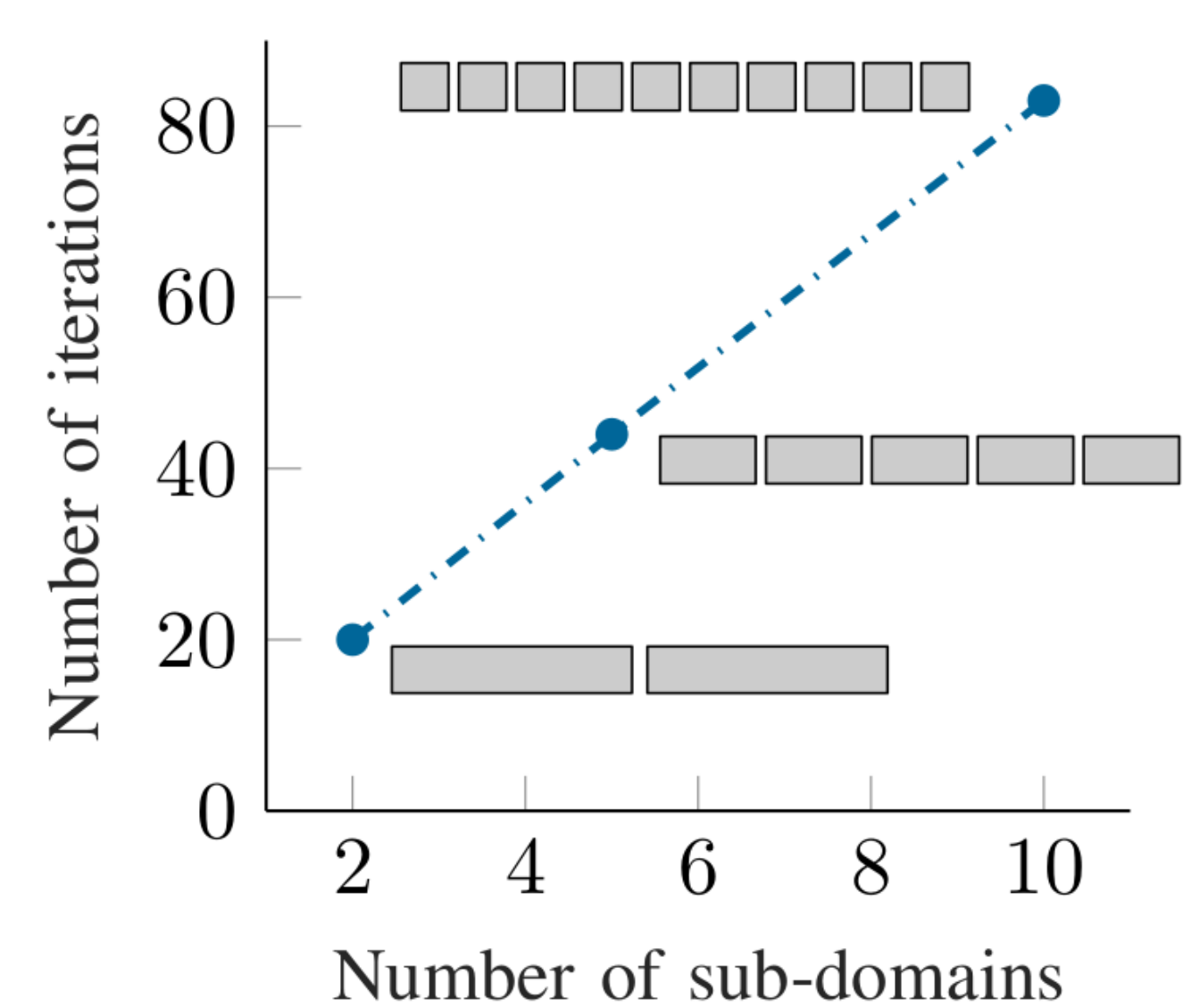
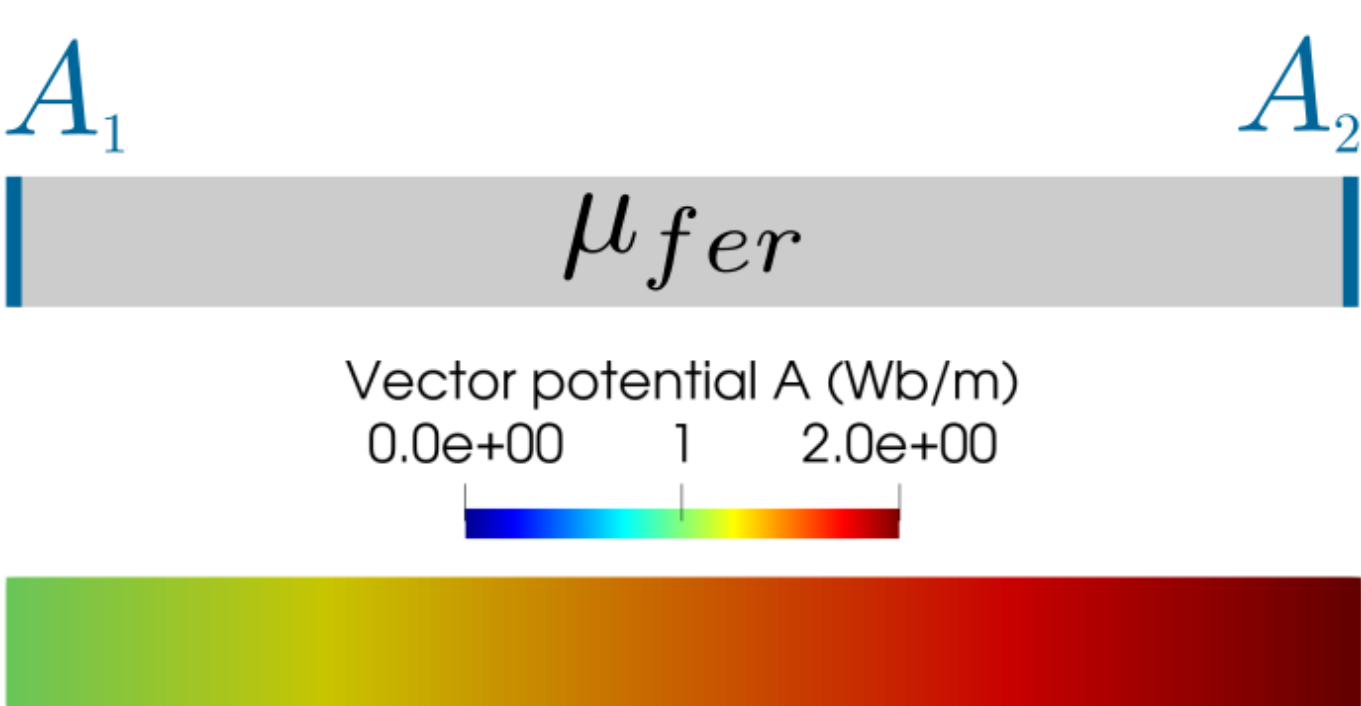
end

3 - Multi-scale strategy

Mono-scale strategy limitation

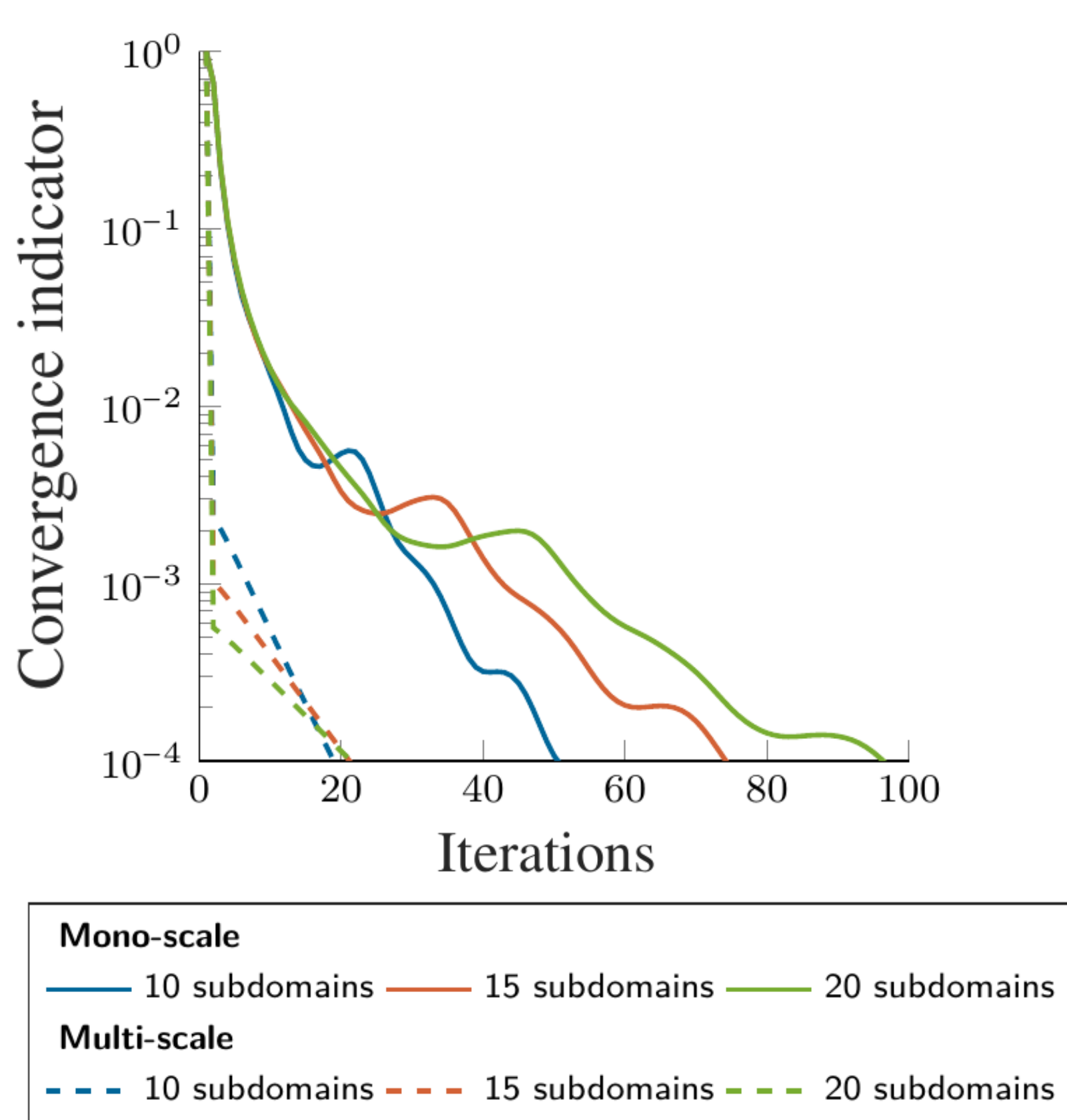
Number of iterations of the algorithm depends on the number of sub-domains

Illustration of the limitation

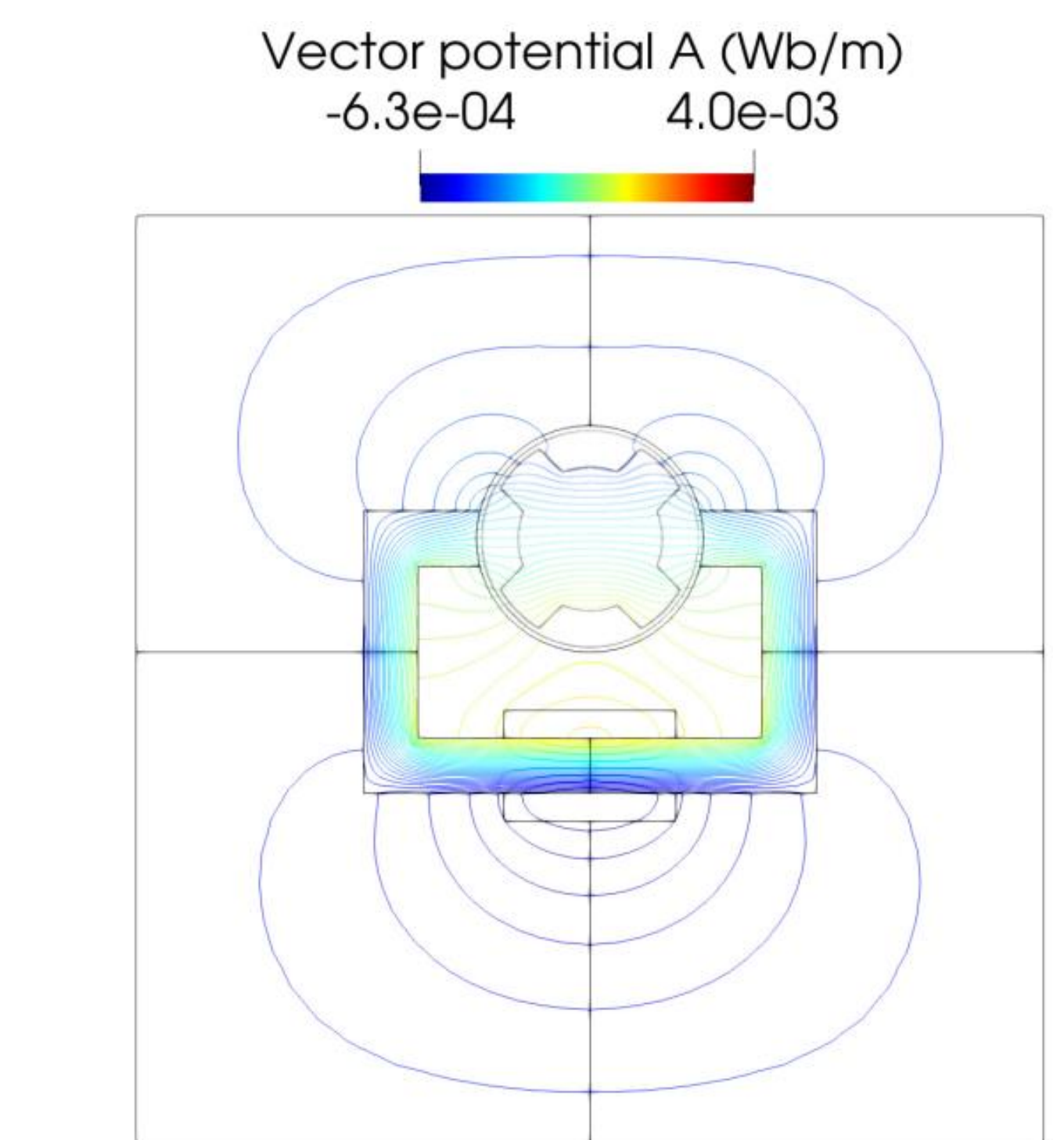
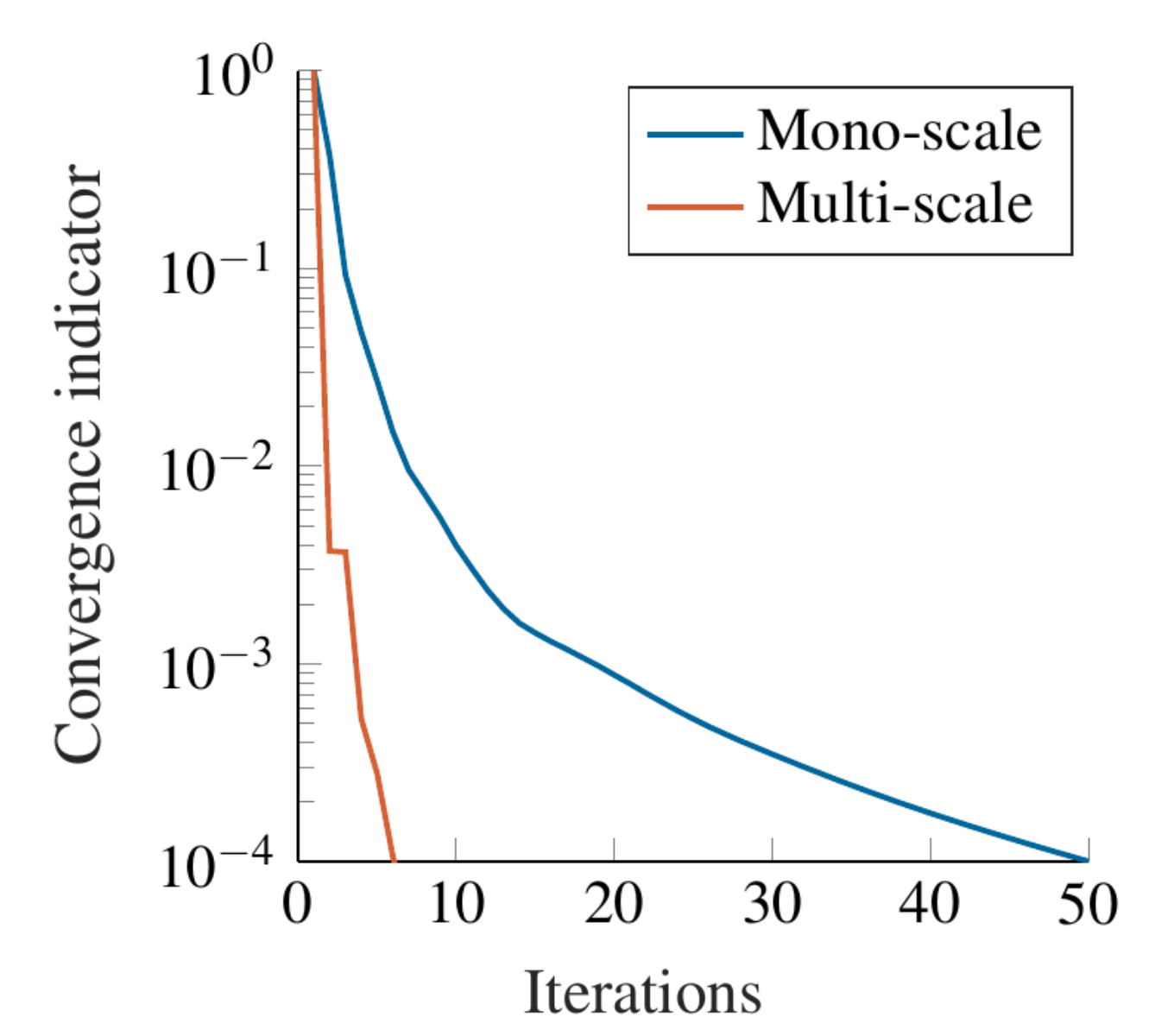
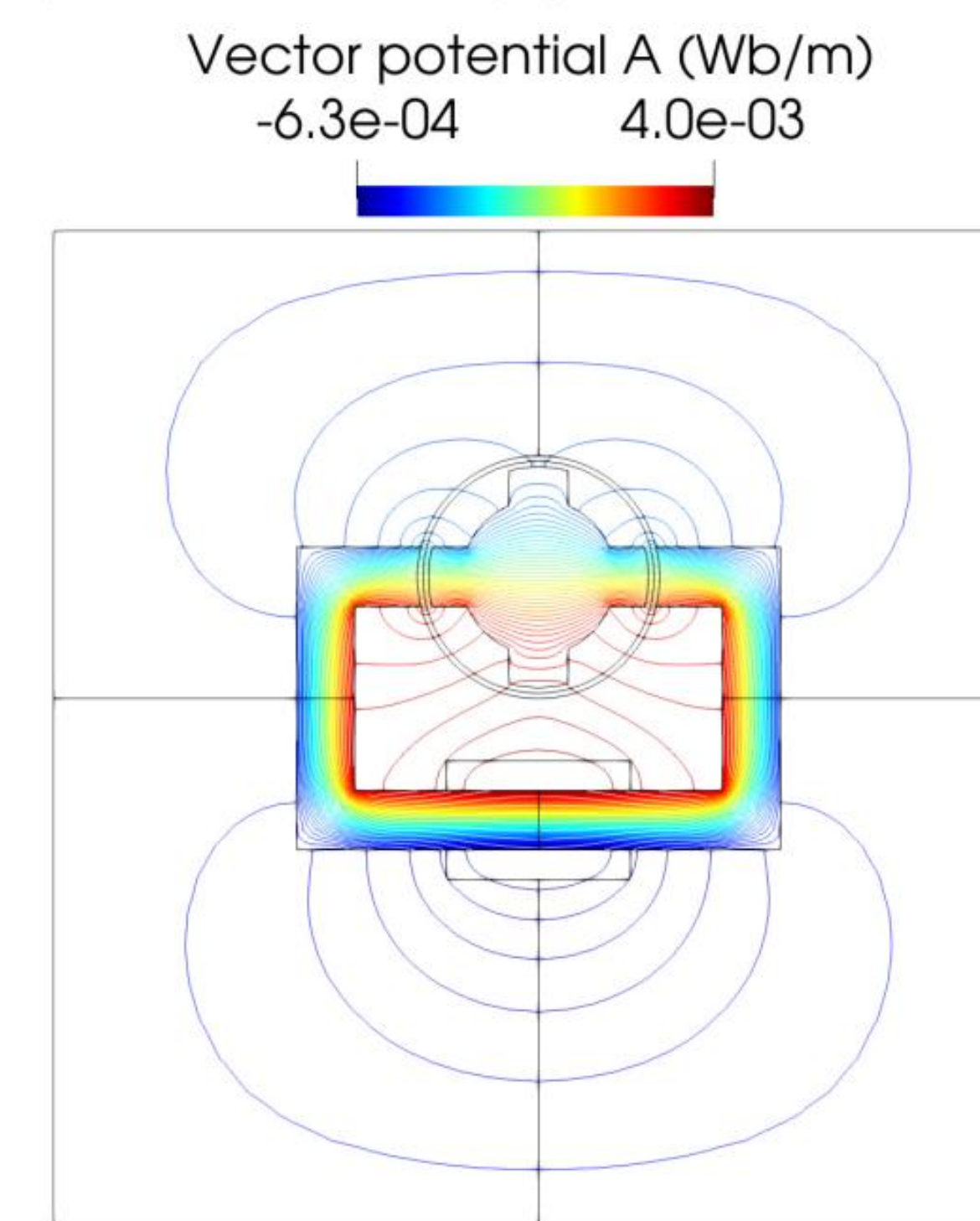
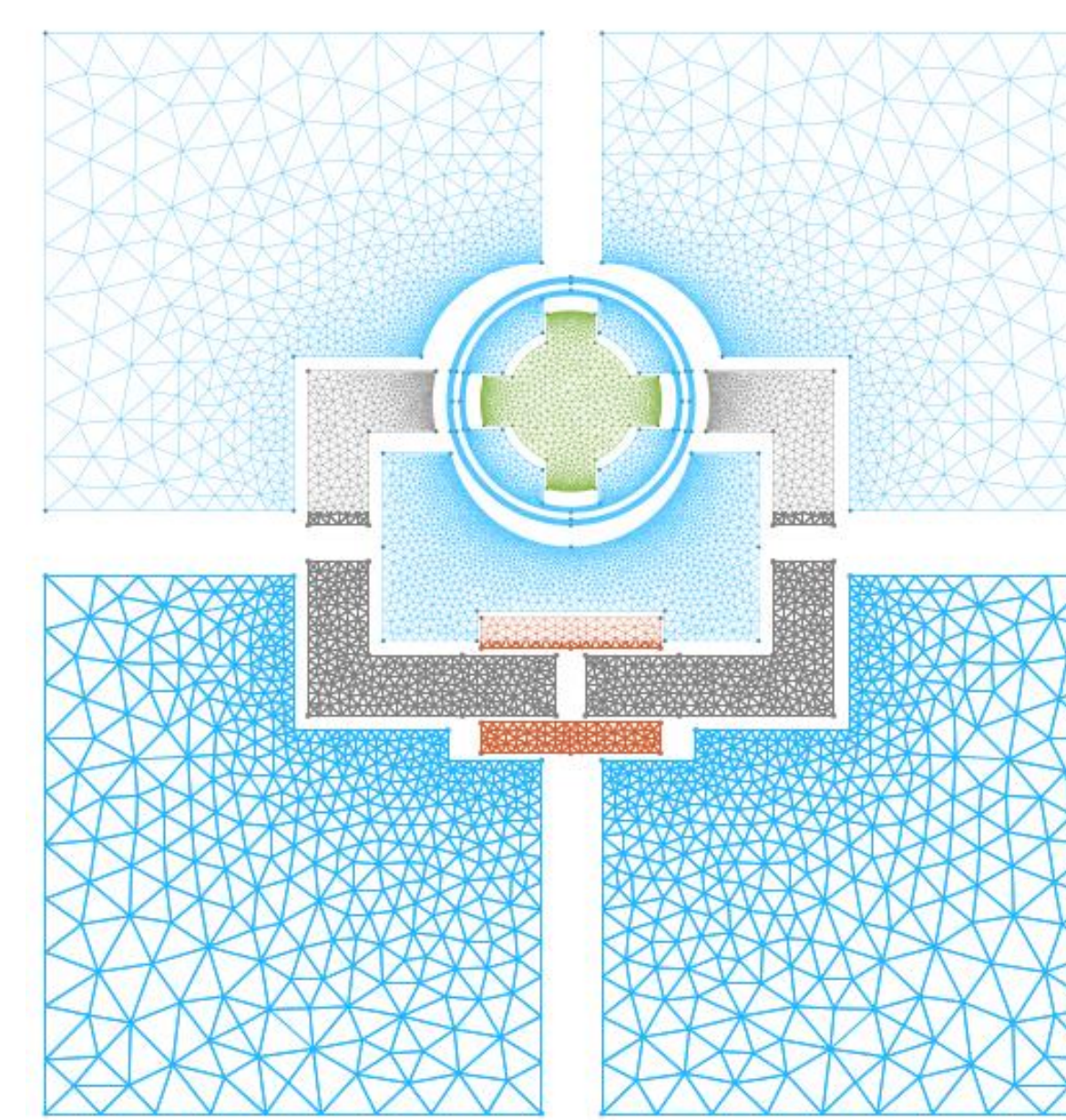


Multi-scale strategy

- Add the resolution of a **coarse problem** during the linear stage
- Allow to **propagate information** throughout the whole problem globally



4 - Study of a decomposed SRM



Conclusion

- Presentation of a **mixed domain decomposition method** adapted for magnetostatic simulation
- Implementation of a **multi-scale** computational to address the dependence on the number of sub-domains



Upcoming work

- Integrate **nonlinearities** without impacting the structure of the algorithm
- 3D** simulations with Whitney elements