Offer #2025-09200

Post-Doctoral Research Visit F/M Post-doctoral position - Space-time adaptive methods for subsurface flow simulations

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Context

Robust, accurate and efficient numerical methods is of central interest in geophysics application. In particular, the simulations of CO2 storage in deep geological formations. **Hybrid high-order** (HHO) and **discontinuous Galerkin** (DG) methods have become very popular to perform such simulations, due to their great flexibility to handle polytopal meshes generated from the complicated realistic fractured porous media. The goal of this postdoctoral fellowship is to develop and implement the reliability and efficiency of the **space-time adaptive algorithm** for combined HHO/DG methods through the use of **a posteriori error estimators** and **polytopal mesh adaptivity**.

Assignment

The postdoctoral fellowship will be carried out in the context of the ANR grant STEERS project. The STEERS project requires the combination of **applied mathematics** to build a posteriori steered space-time approximation methods and **scientific computing** to design an efficient open-source library, in the context of **geophysical applications** with theoretical modelling of fractures and multiphase flow. The postdoctoral fellow will be tasked with one research axis of the project: the design of **space-time adaptive algorithm driven by** a posteriori error estimators for a combined **HHO/DG methods** with **polytopal mesh adaptivity**.

Main activities

A posteriori error estimation for the HHO and DG method on polytopal meshes is very active research topic; [1,2] are some pioneering contributions paving the way to a sound numerical analysis. **A novel approach** to a posteriori error estimation of the combined HHO/DG methods of Darcy equations on discrete fracture networks has been recently introduced in [3]. Currently, this new approach is

limited to linear stationary PDEs, which already shows a great reduction in the computational cost without degrading the accuracy for the polytopal mesh adaptivity. However the models used in the subsurface flows simulation are non-stationary, non-linear and degenerate. Furthermore, adaptive algorithms require dynamic meshes adaptations that are allowed to change as the flow moves through the computational domain. **The goal of the postdoctoral project is therefore to develop a posteriori error estimators for the space-time adaptive algorithm that are able to handle dynamic meshes.**

The objectives of the postdoctoral project are to (i) Extend the analysis in [1,2,3] to the case of the combined HHO/DG schemes in space + DG time stepping scheme for non-linear parabolic problems with applications to capillary trapping in porous media using **dynamic mesh adaptivity**; (ii) Implement the error estimator and simple adaptive schemes in a two-dimensional setting to validate the **theoretical results;** (iii) Derive an **a posteriori error estimator** for two-phase flow in fractured porous media and design the space-time adaptive method. Libraries including basic routines for the management of meshes and finite element basis functions will be provided for the implementation tasks.

References

[1] A. Cangiani, Z. Dong, and E. H. Georgoulis. A posteriori error estimates for discontinuous Galerkin methods on polygonal and polyhedral meshes. SIAM J. Numer. Anal., 61(5):2352–2380, 2023.

[2] Z. Dong and A. Ern. *hp*-error analysis of mixed-order hybrid high-order methods for elliptic problems on simplicial meshes. ?hal-04720237?, 2024.

[3] Z. Dong, A. Ern and G. Pichot. Adaptive combined HHO/DG methods for Darcy flow in discrete fractured networks. In preparation.

Skills

We are looking for a candidate with a PhD in applied mathematics. A strong expertise in the numerical analysis of finite element methods is required. A priori knowledge in subsurface flow problems and/or a posteriori error estimation as well as programming skills (Matlab, Julia, C, C++) are also appreciated.

The knowledge of French language is welcome but by no means compulsory.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours

- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

General Information

- **Theme/Domain :** Earth, Environmental and Energy Sciences
  Scientific computing (BAP E)
- **Town/city :** Paris
- **Inria Center :** Centre Inria de Paris
- **Starting date :** 2025-10-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2025-08-21

Contacts

- **Inria Team :** SERENA
- **Recruiter :**
  Pichot Geraldine / Geraldine.Pichot@inria.fr

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Instruction to apply

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This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

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