

PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DAAA-2026-23**
(à rappeler dans toute correspondance)

Lieu : Châtillon

Département/Dir./Serv. : DAAA / AIMF

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DESCRIPTION DU STAGE

Thématique (s) : 09 - Digital methods and tools for high-performance simulations

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Title: Design of memory-aware hybrid linear solvers to accelerate CFD simulations

Context: High-fidelity simulations of turbulent compressible flows in aerodynamics usually imply the numerical analysis of three-dimensional flows around complex geometries. The resulting large sparse ill-conditioned linear systems require parallel robust and efficient strategies that still cost a large part of the CPU time of the Computational Fluid Dynamics (CFD) simulations. The number of computing cores for these parallel simulations is usually driven by the characteristics of the CFD study case and the linear systems must be solved under this fixed global memory budget.

Objectives: The current strategy is a restarted flexible Krylov solver where the preconditioning operator is defined by an inner GMRES solver itself preconditioned by a Block-ILU(0) algorithm on each MPI partition. This last cheap preconditioner has the same sparsity pattern as the original matrix and performs poorly. The direct multifrontal solver *MUMPS* [1,2] exploits possible low-rank property of matrices to reduce complexity of its factorization and solve phases in terms of floating-point operations and memory requirement. First numerical tests with a preconditioner now defined by a Block Low-Rank (BLR) multifrontal factorization per partition have brought promising CPU gains. The goal is to design fast hybrid direct-iterative strategies taking better advantage of the allocated memory budget. Performance and scalability of such approaches will be evaluated with the high-order CFD code *Aghora* on representative cases varying some factors: partitions size, accuracy of approximate direct solvers, number of OpenMP threads during *MUMPS* BLR factorization phase. This internship will be in collaboration with the PEQUAN team at LIP6.

[1] P. Amestoy, O. Boiteau, A. Buttari, M. Gerest, F. Jézéquel, J.-Y. L'Excellent, T. Mary. [Mixed precision low rank approximations and their application to block low rank LU factorization](#), IMA JNA, 43(4), 2023.

[2] P. Amestoy, A. Buttari, J.-Y. L'Excellent, T. Mary, [Performance and Scalability of the Block Low-Rank Multifrontal Factorization on Multicore Architectures](#), ACM TOMS, 45(1), 2019.

Keywords : Krylov solvers, low-rank approximations, mixed precision algorithms, LU factorization, preconditioner

Est-il possible d'envisager un travail en binôme ? Non

Méthodes à mettre en œuvre :

☒ Recherche théorique ☐ Travail de synthèse
☒ Recherche appliquée ☒ Travail de documentation
☐ Recherche expérimentale ☒ Participation à une réalisation

Possibilité de prolongation en thèse : Oui

Durée du stage : Minimum : 5 mois Maximum : 5 mois

Période souhaitée : Février – Septembre 2026

PROFIL DU STAGIAIRE

Connaissances et niveau requis :
Mathématiques Appliquées, Informatique,
Bac+5, Master 2 Recherche

Ecoles ou établissements souhaités : Universités,
Ecoles d'ingénieurs