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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DAAA-2026-24**
(à rappeler dans toute correspondance)

Lieu : Châtillon

Département/Dir./Serv. : DAAA/AIMF

Tél. :

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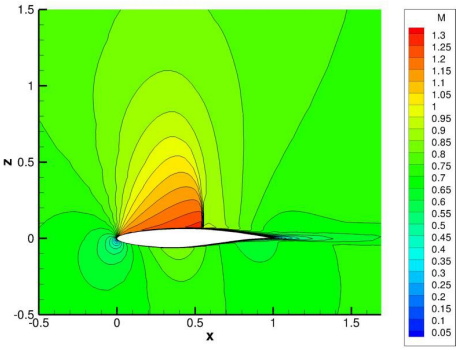
DESCRIPTION DU STAGE

Thématique(s) : 09 - Méthodes et outils numériques pour les simulations hautes-performances

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

Title: Flux-corrected Transport (FCT) limiter for the approximation of steady-state solutions to gas dynamics

Keywords: hyperbolic PDEs, gas dynamics, numerical analysis, high-order discretization schemes



Simulation of the transonic flow past an airfoil with a high-order numerical scheme [Agh].

Context: we are interested in the **numerical approximation** of solutions to problems described by nonlinear **hyperbolic** partial differential equations (**PDEs**) and by problems in compressible gas dynamics in particular (see figure). The solution to these problems is known to be contained in some **invariant convex domains**. In the context of gas dynamics, invariant domains refer for instance to positive density and internal energy, or to a minimum principle on the specific entropy. We here look for **high-order** accurate **discretization schemes** that satisfy these properties at the discrete level. However, these schemes usually suffer from spurious oscillations that may occur in the neighborhood of discontinuities in the solution, such as shock waves. In contrast **low-order** approximations do not suffer from spurious oscillations and preserve invariant domains, but offer low accuracy.

Description of work: we will consider the flux-corrected transport (FCT) limiter [KMT09] that modifies the discrete high-order solution to impose the preservation of the invariant domains. The FCT limiter relies on a low-order solution that is known to preserve the invariant domains, while keeping the limited solution as close as possible to the high-order solution. The main objective is here to apply this limiter in the context of high-order schemes [R25] for the approximation of steady-state solutions in gas dynamics (see figure).

The internship student will investigate theoretically the extension of the FCT limiter to steady-state flow simulations which usually rely on an iterative quasi-Newton method using a linearized backward-Euler scheme at every iteration. He will follow the approach proposed in [K09] and will then implement the limiter in the code Aghora [Agh] for computational fluid dynamics (CFD). Numerical tests will be carried out to validate the implementation and compare the limited scheme with standard discretization schemes (already available in Aghora) in terms of accuracy, stability and efficiency.

Bibliography:

[KMT04] D. Kuzmin, M. Möller, S. Turek, High-resolution FEM–FCT schemes for multidimensional conservation laws, Computer Methods in Applied Mechanics and Engineering, Volume 193, Issues 45–47, 2004, 4915-4946, https://doi.org/10.1016/j.cma.2004.05.009.

[K09] Dmitri Kuzmin, Explicit and implicit FEM-FCT algorithms with flux linearization, Journal of Computational Physics, Volume 228, Issue 7, 2009, 2517-2534, https://doi.org/10.1016/j.jcp.2008.12.011.

[R25] F. Renac, Maximum principle preserving and entropy stable time implicit DGSEM for nonlinear scalar conservation laws, ESAIM : Math. Model. Numer. Anal., 59 (2025), pp. 2583–2612, https://doi.org/10.1051/m2an/2025070.

[Agh15] F. Renac, M. de la Llave Plata, E. Martin, J. B. Chapelier, and V. Couaillier, Aghora: A High-Order DG Solver for Turbulent Flow Simulations, pp. 315–335, Springer International Publishing, 2015. https://doi.org/10.1007/978-3-319-12886-3_15.

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 : 4 Maximum : 6

Période souhaitée : February to September 2026

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
A solid background in Computational Mechanics (numerical analysis of PDEs), programming skills and motivation to learn are required.	M.Sc. or Research Master in Applied Mathematics, Mechanics or a related discipline, with excellent academic records.