



Offre n°2022-05023

Post-Doctoral Research Visit F/M Kinetic approximation of diffusive and dispersive conservation laws

Le descriptif de l'offre ci-dessous est en Anglais

Type de contrat : CDD

Contrat renouvelable : Oui

Niveau de diplôme exigé : Thèse ou équivalent

Fonction : Post-Doctorant

Contexte et atouts du poste

The kinetic approach is a general method for approximating systems of conservation laws [3, 1]. It relies on a representation of the equations by a finite set of transport equations with constant velocities coupled together by a stiff relaxation source term. Under a so called sub-characteristic condition, which states that the kinetic velocities have to be larger than the physical wave speeds, the kinetic representation is a stable approximation of the original system.

This approximation is very interesting on the computational point of view, because the complex resolution of the initial system is reduced to solving simple transport equations and local ordinary differential equations. This is generally done with splitting techniques and the method can be hugely optimized on recent parallel computers [7]. The Lattice Boltzmann Method (LBM, [4, 8]) enters the family of the kinetic methods. It is widely used today in research and industry.

The Tonus team has developed since several years innovative kinetic methods described in several recent papers [2, 5, 6, 7].

The kinetic method is initially designed for solving first order hyperbolic conservation laws. However, by the technique of the equivalent equation, and by tuning the relaxation source term, it is possible to approximate higher order equations: diffusive equations (with second order derivatives) and dispersive equations (with third order derivatives).

The main objective of the proposed post-doctoral study is to investigate in a systematic way the possible equations, diffusive or dispersive, that can be obtained by adapting the relaxation operator. Other interesting questions are related to the design of high order numerical algorithms and of numerical techniques for handling boundary conditions.

This post-doctoral position will give to the recruited person high skills and up-to-date knowledge on the kinetic equations and recent approximation techniques of these equations.

References

- [1] Denise Aregba-Driollet and Roberto Natalini, "Discrete kinetic schemes for multidimensional systems of conservation laws", SIAM Journal on Numerical Analysis 37, 6 (2000), pp. 1973--2004.
- [2] Jayesh Badwaik, Matthieu Boileau, David Coulette, Emmanuel Franck, Philippe Helluy, Christian Klingenberg, Laura Mendoza, and H..., "Task-based parallelization of an implicit kinetic scheme", ESAIM: Proceedings and Surveys 63 (2018), pp. 60--77.
- [3] François Bouchut, "Construction of BGK models with a family of kinetic entropies for a given system of conservation laws", Journal of Statistical Physics 95, 1 (1999), pp. 113--170.
- [4] Shiyi Chen and Gary D Doolen, "Lattice Boltzmann method for fluid flows", Annual review of fluid mechanics 30, 1 (1998), pp. 329--364.
- [5] David Coulette, Emmanuel Franck, Philippe Helluy, Michel Mehrenberger, and Laurent Navoret, "High-order implicit palindromic discontinuous Galerkin method for kinetic-relaxation approximation", Computers & Fluids 190 (2019), pp. 485--502.
- [6] Florence Druil, Emmanuel Franck, Philippe Helluy, and Laurent Navoret, "An analysis of over-relaxation in a kinetic approximation of systems of conservation laws", Comptes Rendus Mécanique 347, 3 (2019), pp. 259--269.
- [7] Pierre Gerhard, Philippe Helluy, and Victor Michel-Dansac, "Unconditionally stable and parallel Discontinuous Galerkin solver", Computers & Mathematics with Applications 112 (2022), pp. 116--137.
- [8] Pierre Lallemand and Li-Shi Luo, "Theory of the lattice Boltzmann method: Dispersion, dissipation, isotropy, Galilean invariance, and stability", Physical review E 61, 6 (2000), pp. 6546.

Mission confiée

The Tonus team has already developed a software, based on a Computer Algebra System, for equivalent equation calculation. The approach is based on a fully non conservative expansions. The recovery of the underlying conservative equation can be tedious.

1. The software will thus be modified in order to handle directly the equivalent conservative flux.

2. The method will then be applied to several systems coming from fluid mechanics, in 1D or in higher dimensions, in order to construct the relaxation models leading to the correct diffusive or dispersive terms.
3. The resulting numerical methods will then be tested on several test cases with viscous shock profiles or dispersive shocks.

Principales activités

Main activities :

- Learning software developed on the subject in Tonus
- Reading articles on the kinetic method
- Mathematical analysis of the kinetic method: stability analysis, boundary conditions.

Additional activities :

- Interaction with the other members of the team
- Interaction with the scientific supervisors
- Writing a report and an article.

Compétences

Technical skills and level required :

PhD in Applied Mathematics or computer science.

Knowledge in partial differential equations and numerical analysis is a plus.

Basics of Rust or the will to learn a new programming language. Experience in collective software development (git, continuous integration, test strategies).

Languages : French, English

Relational skills : ease of collaboration with scientists and engineers. Taste in joint software development.

Other valued qualities: the will to do research in industry. This position is more adapted to a future job in the private sector than in the academic world.

Avantages

- 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

Rémunération

Salary: 2653€ gross/month

Informations générales

- **Thème/Domaine** : Sciences de la planète, de l'environnement et de l'énergie
Calcul Scientifique (BAP E)
- **Ville** : Strasbourg
- **Centre Inria** : [Centre Inria de l'Université de Lorraine](#)
- **Date de prise de fonction souhaitée** : 2022-09-01
- **Durée de contrat** : 1 an, 4 mois
- **Date limite pour postuler** : 2022-07-06

Contacts

- **Équipe Inria** : [TONUS](#)
- **Recruteur** :
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A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie

2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

L'essentiel pour réussir

The recruited person will have:

- Tastes and appetencies in scientific software development.
- area of excellence: theory and approximation of Partial Differential Equations
- Cross-disciplinary knowledge and expertise in mathematics, fluid mechanics, computer science and numerical analysis.

Other appreciated qualities are

- Feeling at ease in an environment of scientific dynamics and wanting to learn and listen.
 - Passionate about innovation, with expertise in software development and strong influencing skills.
- A thesis in the field of scientific computing is a real asset.

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.