Call for two postdoctoral positions: advanced structured grid generation & massive (CPU/GPU) parallelization of high-order PDE solvers for diffusion & wave propagation phenomena

Supervisor

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Context & objectives

These projects concern the study, development, and enhancement of a new class of recently-introduced high-order numerical methods for time-dependent (hyperbolic, parabolic) partial differential equations (PDEs) governing wave propagation and diffusion phenomena in solids, fluids and their interactions. Such methods are based on a technique for the accurate trigonometric interpolation of non-periodic functions, enabling the construction of fast Fourier transform (FFT-)speed solvers that can treat more general boundary conditions, that can provide high-fidelity resolution by means of relatively coarse discretizations, and that can faithfully preserve the dispersion/diffusion characteristics of the underlying continuous problems.

In order to facilitate broader applicability for real-world complex geometries and extremely large-scale configurations—notably for applications in geophysics and medicine (see Figure 1)—two postdocs are sought to focus, respectively, on two outstanding (and related) challenges: 1) fully-controlled, automated construction of boundary-conforming, fully-structured, curvilinear computational domains with appropriate treatments of geometric singularities; and 2) massive (space-time) parallelization on CPU/GPU cluster architectures (the latter of which is well-suited for rapid FFT calculations). These projects are heavily motivated by challenging scientific applications in seismic hazard (earthquakes, long-distance wave propagation, tsunami dynamics) and cardiovascular hemodynamics (fluid-structure blood flow, dye/drug diffusion)—with the spirit of mutually validating simulation and natural, experimental, or clinical data.

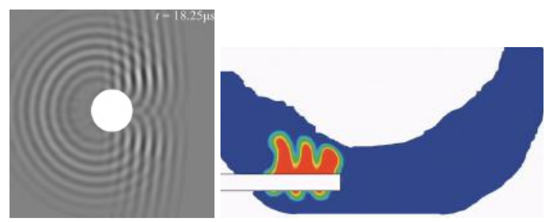

Figure 1: Temporal snapshots of (left) the scattering of ultrasonic elastic waves (simulated by the solver proposed in [1]) and of (right) dye evolution from a catheter injection in a brain ventricle (simulated by the solver proposed in [2]).

Position details & how to apply

Profile

Ideal profiles are those with backgrounds in computational mathematics and/or advanced scientific computing. Candidates will have (or about to have) earned a PhD in applied math, in computational mechanics, or in a related field. Experience in implementing (especially from scratch) numerical methods for PDEs in both higher- (i.e., MATLAB) and lower-level (e.g., C++ or Fortran) programming languages is essential for both topics. Knowledge of computational geometry (mesh generation) or HPC parallelization is encouraged but not necessary. Work can be conducted entirely in English (French competency is not required).

Location

Postdocs will be affiliated with the École normale supérieure of Paris-Saclay University (15th worldwide by current Shanghai rankings, 1st in continental Europe), located in the heart of the "French Silicon Valley".

Salary & timeline

Both positions are full-time for 12-18 months, funded by the *Agence nationale de la recherche* (*ANR*, the “National Agency for Research"), with salaries commensurate with experience (min. 2400€ net monthly) and with included social benefits provided by the French government (health, unemployment, etc.). Start dates are flexible and will be determined on a case-by-case basis.

Submission & questions

Applications can be submitted from December 2023 onwards, and the process will remain open until the positions are filled. Interested candidates should submit a cover letter and CV to faisal.amlani@ens-paris-saclay.fr. Any questions are welcomed and should be addressed to the same.

[1] Amlani & Bruno, *Journal of Computational Physics* 307, 2016. DOI:10.1016/j.jcp.2015.11.060

[2] Amlani, et al., *Journal of Computational Physics* 493, 2023. DOI:10.1016/j.jcp.2023.112472