Research internship in machine learning for scientific computing

We are looking for strong candidates currently studying for an M2 Master’s degree who would be interested in pursuing an internship (stage) at the Laboratoire Jacques-Louis Lions (LJLL), Sorbonne Université, under the supervision of Georg Maierhofer and Katharina Schratz. The internship would take place over a period of 3-6 months between February and September 2023. Subject to successful funding application the internship would be remunerated at the standard rate.

Applications from exceptional students currently pursuing an M1 degree will also be considered but, unfortunately, due to funding restrictions no remuneration can be provided.

To apply please send a copy of your CV detailing your academic background and relevant prior experience via email to georg.maierhofer@sorbonne-universite.fr. The deadline for applications is 17h on Friday, 27th January.

**Project title:** Neural operators for fast computation of nonlinear frequency interactions in dispersive equations

**Project synopsis:** The efficient numerical approximation of solutions to dispersive nonlinear evolution equations plays a crucial role in a plethora of scientific and technological problems, from the simulation of water waves to Bose–Einstein condensates. Recent work has succeeded in the development of innovative integrators for low-regularity (rough) solutions to these equations [BS22], however these so-called resonance-based schemes are limited to cases where approximations to nonlinear frequency interactions can be found by hand which are accurately representable in physical coordinates. This prevents the application of these schemes to many important models relevant for example to atmospheric simulations.

Motivated by increasing success in data-driven approaches to scientific computing [KKL+21, LKA+20], this project seeks to investigate the use of neural operators as a tool to overcome this approximation problem. Neural operators are a generalisation of neural networks that can learn operators between infinite-dimensional function spaces [KLL+21] and thus can form the basis for data-driven solutions to several approximation problems.

In this project the student will investigate the feasibility of using such neural operators to design data-driven approaches that improve computations of nonlinear frequency interactions and hence resonance-based time stepping methods for dispersive equations currently out of reach for by-hand design of numerical schemes. The project will be structured into smaller workpackages which will enable the student to familiarize themselves with relevant theory and techniques based on simple examples before attempting work with complex novel systems. The student will have an opportunity to closely interact with his supervisors and attend relevant seminars at the LJLL. It is expected that through work on this project the student will acquire expertise in numerical methods for partial differential equations, experience in the use of machine learning techniques and crucial transferable programming skills in Python.


**Desired experience of candidates:**

- A strong background in quantitative sciences, including knowledge of one of the following topics in depth: partial differential equations (PDEs), numerical methods for PDEs, data-driven approaches, or machine learning;
- Experience in programming with Python;
- Prior experience with machine learning toolboxes such as PyTorch/Tensorflow is beneficial but not a prerequisite.