Lattice Boltzmann Method for marine sustainable energy modeling

With 11 million km2 of maritime area, France has one of the most important marine energy potential in the world. Marine energies will be important sources of energy in the next decades, and the need of efficient prediction tools for marine energy systems will be necessary. These systems may use wave, stream or tidal as energy sources and are difficult to model due largely to the presence of structures in the flow.

Indeed, for each system the flow will impact on the structure, and in return, the displacement of the structure will change the behavior of the flow. Such phenomena are known under the name of Fluid Structure Interaction phenomena (FSI) or Flow Induced Vibration (FIV). They can dramatically damage the performance of many devices. For instance, blade deformation or vibration due to the wind effect and/or to the surrounding environment can impact the performance of onshore and offshore wind turbines. Modeling the impact of the flow on marine energy systems is thus essential.

Numerical modeling of fluid structure interaction phenomena enables a substantial decrease of time spent on design and optimization phases. Numerical simulations can also help to visualize phenomena that can hardly be experimentally detected. Conventional CFD (Computational Fluid Dynamics) methods which solve the Navier-Stokes equations (for the fluid flow) using numerical approaches such as the finite element, the finite volume, or the finite difference methods, provide results with high accuracy, but require considerable amount of computing time, because FSI simulations involve dense grids and small time steps.

The lattice Boltzmann method (LBM), which was developed about thirty years ago, is becoming a powerful tool for predicting flows involving complex geometries. With this method, which is derived from the kinetic theory of gases, the Boltzmann equation is numerically solved on a lattice, where particle swarms stream and collide along specific directions. The lattice Boltzmann equation is solved explicitly, and local computations are performed. This method is easy to implement, and is well suited for the parallel computing. An important advantage of this method over classical CFD approaches is that it can be very efficiently parallelized on Graphic Processor Units (GPUs), which enable a substantial decrease of computational time.

In this PhD work, we would like to focus on cases encountered in marine sustainable energy (more particularly the fluid structure interaction applied to deformable moving bodies). To do that, we seek a PhD student who will work on the lattice Boltzmann program developed in our Lab. He will introduce new developments to account for immersed deformable moving bodies, in order to model wave energy converter. The candidate will also implement the algorithm on Graphic Processing Units (GPUs), using CUDA or OpenCL.

The PhD work will be carried out in the LaSIE (Laboratoire des Sciences de l'Ingénieur pour l'Environnement) affiliated by CNRS (National Center for Scientific Research). The Laboratory of Engineering Sciences for the Environment: UMR - 7356 CNRS LaSIE - University of La Rochelle is a unit that brought together a wide range of skills (fluid mechanics, thermal, materials, engineering, numerical methods) facing the environment. The associated team concerned in mathematical modeling and numerical methods for transport phenomena, is a transverse axis. It includes modeling specialists (theorists and numerical analysts) for whom the work is oriented via an environment application. In particular, it has a strong component of advanced methods in Model Reduction and Fluid Structure Interaction modeling. They belong to the research group CNRS GDR AMORE on reduced order modeling and manage the International research group on fluid structure interaction (GDRi FSI).

Applicants should have a strong interest in fluid mechanics, numerical methods, and programming.

The applicants should send a CV, transcripts of records, a cover letter and two letters of recommendation, to Erwan Liberge (erwan.liberge@univ-lr.fr) and Claudine Béghein (claudine.beghein@univ-lr.fr).