Post-doctoral position

Computational modelling of three-phase liquid-vapor-gas flows

The Department of Mechanics of the *École Nationale Supérieure de Techniques Avancées* (ENSTA Paris) is inviting applications for a post-doctoral position in the domain of computational fluid dynamics funded by the French Government Directorate for Armament (DGA). The position is for 12 months and it will be available starting from October 2020 (and it should start no later than January 2021). The ENSTA Mechanics Department belongs to the Institute of Mechanical Sciences and Industrial Applications (IMSIA), together with research units from EDF (*Électricité de France*), CEA (*Commissariat à l'Énergie Atomique et aux Énergies Alternatives*) and CNRS (*Centre National de la Recherche Scientifique*). The post-doctoral work will be carried out in collaboration with the EDF team of IMSIA.

Context

The ENSTA Department of Mechanics conducts several research activities on the numerical modelling of multiphase compressible flows, and especially liquid-vapor flows, in collaboration with an EDF team belonging to the common IMSIA laboratory. In particular, a new project funded by DGA has started in January 2019 on the numerical modelling of three-phase compressible liquid-vapor-gas flows with interfaces, cavitation, evaporation waves and shocks. One of the principal application of interest is the simulation of underwater explosions, where a high pressure bubble of combustion gases triggers cavitation phenomena in water. Another application of interest in the framework of the joint work with EDF is the modelling of problems in nuclear power plants such as RIA events (Reactivity Insertion Accidents).

We have already developed a computational three-phase flow model [5] based on a single-velocity hyperbolic multiphase flow model with heat and mass transfer terms. These interphase transfer terms are expressed as thermo-chemical relaxation source terms. The numerical model uses a second-order finite volume HLLC-type scheme and it has been implemented in one and two dimensions (on curvilinear grids) by using the libraries of the CLAWPACK software [3], a free software package developed at the University of Washington (Seattle, USA).

Mission

The objective of the post-doctoral work is to improve and enhance the current three-phase computational model [5]. The work includes extensions of the thermodynamic model, the design of novel numerical procedures, and the implementation in a different software platform allowing the handling of complex geometries.

The tasks are the following (chronological order):

- Implementation of the three-phase flow model [5] in the EUROPLEXUS software. EUROPLEXUS is owned by CEA and the Joint Research Centre (JRC) of the European Union, and is co-developed by EDF. A two-phase version of the model [4] has been already implemented in EUROPLEXUS by a former IMSIA doctoral student (Marco De Lorenzo).

- Extension of the numerical model to a general equation of state (the current model handles only the stiffened gas equation of state). Coupling with the table look-up method already developed at EDF [1] for employing the IAPWS-IF97 equation of state for water, a very accurate equation of state based on experimental data.

- Development of numerical procedures for heat and mass transfer of arbitrary relaxation times (in the current model only two cases are possible: no transfer or instantaneous infinite-rate transfer). Preliminary work on this for the two-phase model [4] has been already done at IMSIA [2].

Supervisors

1. Marica Pelanti, Assistant Professor, ENSTA Paris, Department of Mechanics & IMSIA
2. Philippe Lafon, Senior Research Engineer, EDF R&D Saclay & IMSIA

Laboratory

Institute of Mechanical Sciences and Industrial Applications (UMR 9219 EDF-ENSTA-CEA-CNRS)
828, Boulevard des Maréchaux, 91120 Palaiseau, France

Candidate profile

- Ph.D. in Applied Mathematics or Fluid Mechanics or Computer Science
- Strong background in numerical analysis and computational fluid dynamics
- Very good knowledge of finite volume schemes for hyperbolic systems
- Expertise in multiphase flows modelling
- Very good skills in programming in Fortran
- Very good fluency in spoken and written English

Application process

Candidates should send a detailed CV, a concise research statement (maximum three pages) and the names and contact information of two referees to

Dr. Marica Pelanti, marica.pelanti@ensta-paris.fr

References

[1] M. De Lorenzo, P. Lafon, M. Di Matteo, M. Pelanti, J.-M. Seynhaeve, and Y. Bartosiewicz, Homogeneous Two-Phase Flow Models and Accurate Steam-Water Table Look-up Method for Fast Transient Simulations, Int. J. Multiphase Flow, 95,199-219, 2017.

[2] M. De Lorenzo, P. Lafon, and M. Pelanti, A hyperbolic phase-transition model with non-instantaneous EoS-independent relaxation procedures, J. Comput. Phys., 379, 279-308, 2019.

[3] R. J. LeVeque and M. Berger, CLAWPACK, https://www.clawpack.org.

[4] M. Pelanti and K.-M. Shyue, A mixture-energy-consistent six-equation two-phase numerical model for fluids with interfaces, cavitation and evaporation waves, J. Comput. Phys., 259, 331-357, 2014.

[5] M. Pelanti and K.-M. Shyue, A numerical model for multiphase liquid-vapor-gas flows with interfaces and cavitation, Int. J. Multiphase Flow, 113, 208-230, 2019.