Ph.D. position in Numerical Simulation of Magnetohydrodynamic (MHD) flows in rectangular ducts with flow control

from Prof. J. Schumacher and Dr. D. Krasnov at TU Ilmenau, Germany

INTRODUCTION: The Fluid Mechanics group of Prof. J. Schumacher at the Institute of Thermodynamics and Fluid Mechanics at TU Ilmenau has a broad experience and research interest in theoretical and numerical studies of turbulent flows, thermal convection and magnetohydrodynamic flows in channels and ducts as well as the development of corresponding reduced order models. We have developed a family of in-house flows solvers for performing direct numerical simulations (DNS) of turbulent flows at high-performance parallel supercomputers. The group participates in European high-performance computing initiative and is working in close collaboration with the German supercomputing facilities in Garching and Jülich. Over the past 20 years we have also established strong and active ties within the turbulence, convection and MHD communities world-wide.

PROJECT DESCRIPTION: A new research project, which is funded by the Deutsche Forschungsgemeinschaft (DFG), combines numerical studies in MHD flows with data-driven surrogate model development to control and optimize the heat and momentum transfer in these flows. The project is a collaborative effort between TU Ilmenau (Dr. D. Krasnov and Prof. J. Schumacher, Mechanical Engineering) and TU Dortmund (Prof. S. Peitz, Computer Science).

More detailed, the project aims at studying the dynamics of liquid-metal flows in cooling blankets of fusion reactors. Liquid-metal blankets are an essential part of the TOKAMAK-type of fusion reactors, serving two important purposes: (i) withdrawing a huge amount of heat, produced by the plasma core and (ii) breeding of tritium fuel. Flows in such systems are exposed both to very strong thermal loads (due to neutron fluxes) and very strong magnetic fields (confinement of the plasma core). As a result, the overall flow dynamics is quite far from the usual hydrodynamic turbulence – the flows in blankets are known to exhibit highly intermittent states, anisotropic quasi-2D structures and random outbursts of excessively strong temperature fluctuations. In the project we will study such non-trivial dynamics and will explore novel promising concepts of their control by vortex promoters (e.g., flat jets) supplied at the duct entry. The ultimate goal is to embed an active control, capable of optimizing the heat and mass transport properties within a wide range of the parameter space. Therefore, the project is composed of two major topical and tightly linked parts – simulations of liquid metal flows and data analysis/development by machine learning. This will require active involvement of both parties, including regular research exchange and visits.

RESPONSIBILITIES: The main task of the Ph.D. student at TU Ilmenau is to perform simulations with an in-house Finite-Difference flow solver, to analyze the results, explore the mechanisms of magneto-convective instabilities and the associated flow structures. It will also include the development of data-driven models. Other responsibilities include contribution to writing research papers, reports and computing time proposals. The candidate will also be involved with a small load in the teaching (classes on basic fluid dynamics level) and in co-supervision of the local students at Master level.

PROFILE: Candidates are expected to have completed M.Sc. degree in one of the following programs: Mechanical or Aerospace Engineering, Physics, or Applied Mathematics. Experience in fluid mechanics with an emphasis on numerical simulations of unsteady flows are highly welcomed, but not compulsory. The same holds for skills in High-Performance Computing, parallel programming, or flow visualization. For applications or further questions on the opening please contact

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