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Mechanics Colloquium

Referent: Dr. Mattias Brynjell-Rahkola / Technische Universität Ilmenau

Date: 26.10.2023
Time: 15:45 – 17:15 Uhr
Location: 10.81 Emil Mosonyi-Hörsaal (HS 62)

Title: **Transition between turbulent and laminar flow in magnetohydrodynamic channels and ducts**

Abstract

Mattias Brynjell-Rahkola,∗ Yohann Duguet† and Thomas Boeck∗

During the last two decades, the understanding of subcritical transition in shear flows has significantly progressed thanks to the dynamical systems perspective[1]. In hydrodynamic systems, the appearance of turbulent flow emerges due to a saddle-node bifurcation, which appears as the Reynolds number (*Re*) is increased. In this bifurcation, two solution branches emerge additional to the laminar solution. While the upper branch typically is associated with turbulent dynamics, the lower branch involves limiting perturbations such as the *edge state*, whose stable manifold may be interpreted as the basin boundary of the laminar solution[2].
In magnetohydrodynamic (MHD) flows, energy may be dissipated not only through viscosity but also through the Lorentz force. Within the quasi-static MHD approximation considered in our work, the resulting Joule dissipation is characterized by a second non-dimensional parameter known as the Hartmann number (*Ha*), proportional to the magnetic field strength. In this setting, it is now possible to hypothesize a second saddle-node bifurcation with respect to *Ha* instead of *Re*.

However, due to the different nature of the viscous and Joule dissipation, the behavior of the flow near the two bifurcation points will be significantly different.
During the seminar, the concept of edge states will be presented, and the change in edge dynamics with increasing *Ha* for a doubly periodic channel with a spanwise magnetic field and electrically insulating walls[3] will be shown. In particular, the above described saddle-node bifurcation for sufficiently large *Ha* will be illustrated. Afterwards, the transition process in a MHD square duct with electrically insulatingwalls and a transverse magnetic field will be presented. Due to the presence of themagnetic field, this flow features two types of boundary layer, namely Hartmann andShercliff layers[4]. Given their different stability properties, two transition scenarios can be hypothesized that involve either of these boundary layers. Using edge state calculations and direct numerical simulations, the interaction between them will be outlined, along with possible transition routes for MHD square ducts. The results presented have been obtained with the open source spectral element code *NEK5000*[5], which offers high accuracy and geometric flexibility. We have recently extended its capabilities to the quasi-static MHD implementation, and hence the spectral element method along with the discretization of the electromagnetic quantities will be briefly reviewed as well.

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[1]Eckhardt *et al., Annu. Rev. Fluid Mech.* **39**, 447-468 (2007).
[2]Skufca *et al., Phys. Rev. Lett*., **96**(17), 174101 (2006).
[3]Krasnov *et al., J. Fluid Mech***., 596**, 73-101 (2008).
[4]*Müller & Bühler, Magnetofluiddynamics in Channels and Containers*, Springer (2001).
[5]Fischer *et al.*, https://nek5000.mcs.anl.gov (2020).

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You are cordially invited to take part in the event!

Prof. Dr.-Ing. Bettina Frohnapfel