Transition in channel flow with a spanwise magnetic field

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. In this respect, the concept of *edge states*, have proven to be particularly illuminating[1]. Despite this success, little attention has been paid to these developments in the magnetohydrodynamic (MHD) community, where subcritical transition can be expected in both applications involving liquid metals and astrophysical contexts.

For a channel with electrically insulated walls subject to a spanwise magnetic field, Joule dissipation inhibits motion in the streamwise and wall-normal direction, whereas spanwise velocity is unaffected. This leads to a preference in the system for structures that are elongated in span[2], which implies that the traditional picture of edge states in hydrodynamic channel flows involving periodically bursting structures[3] is modified (see figure 1).

To investigate these self-sustaining processes in detail, the quasi-static MHD approximation (assuming low magnetic Reynolds number) is invoked, wherein a one-way coupling exists between the magnetic flux density and the velocity. Direct numerical simulations are performed with the spectral element code Nek5000, whose solver capabilities have been extended to handle Ohm's law with a condition of charge conservation. For the edge state calculations, the bisection algorithm is employed.

In our contribution, the outcome of extensive edge tracking in a doubly periodic channel with different interaction parameters N (*i.e.* ratio between the Lorentz force and inertia) will be presented. Based on these results, the implications of imposing a magnetic field on the laminar-turbulent transition will be outlined and discussed.

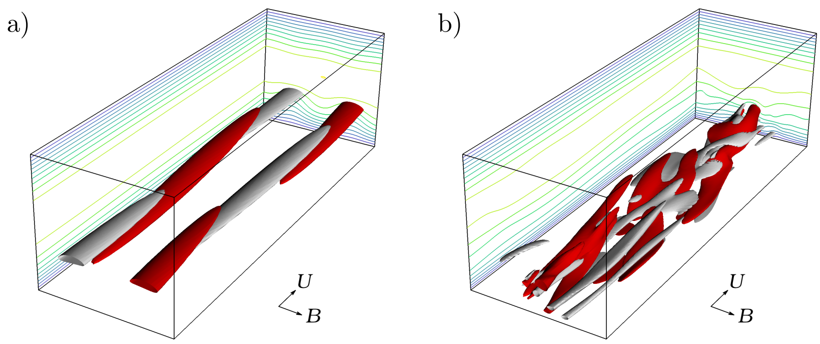

Figure 1: Edge state for (a) $N = 0$ during a quiescent phase, and (b) $N = 0.08$. Streamwise vorticity at ± 0.05 in (a), and ± 0.5 in (b) are visualized by red and white surfaces. The contours represent streamwise velocity between 0 and 1 with a separation of 0.1 units.

*Institut für Thermo- und Fluiddynamik, Technische Universität Ilmenau, Germany.
†LISN-CNRS, Université Paris-Saclay, Orsay, France.

[1] Eckhardt *et al.*, *Annu. Rev. Fluid Mech.* **39**, 447 (2007).
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