Experimental investigation of the transition to turbulence in the Plane Magnetohydrodynamic (MHD) Couette flow

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This study aims at characterising experimentally the influence of an externally applied static transversal magnetic field on the transition to turbulence in a plane Couette flow. Without magnetic field, the plane Couette flow is linearly stable for all Reynolds numbers but may be sensitive to finite amplitude perturbations, localised in time and in space: below a lower critical Reynolds number, estimated between 300 and 400 [1] [2] [3], disturbances decay in space and time. Above an upper critical Reynolds number of around 750 [1] [2], the disturbances invade the whole fluid domain and support turbulence. Between these two critical Reynolds numbers, turbulent spots coexist with the laminar flow.

The upper and lower critical Reynolds numbers are expected to significantly change under the effect of the magnetic field so that a laminar flow may survive at significantly higher Reynolds numbers than without magnetic field. To investigate this question, a unique experiment was build. A 1600 mm long, 50 mm wide and 40 mm high rectangular glass tank is filled with sulphuric acid at 30 % mass, to ensure the highest conductivity (90 S/m) whilst retaining the necessary transparency for optical velocimetry techniques. A mechanically-driven neoprene belt acts as the moving wall that entrains the fluid so as to generate a half-plane Couette flow between itself and the fixed bottom plate of the tank. The whole setup is placed in the stray-field of a superconducting solenoidal magnet, to apply a transversal continuous magnetic field in the flow of about 1T. A bespoke 2D Particle Image Velocimetry technique is used to map the velocity field and its fluctuations in the vertical and horizontal planes aligned with the streamwise direction.

The problem is controlled by two non-dimensional parameters, the Reynolds number, as in the non-MHD Couette flow, as well as the Stuart number N, that measures the ratio of Lorentz to inertial forces. We present results of the PIV measurement identifying the different regimes we encountered at $0 \leq N < 1$, and Re up to 10^4 and showing how the lower and upper critical Reynolds numbers vary with Ha over this interval. We also show how the magnetic field affects the topology of the flow patterns in the intermediate regimes between the lower and upper critical Reynolds numbers.

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[1] Dauchot and Daviaud, *Phys. Fluids* **7**, 2 (1995).
[2] Daviaud et al., *Phys. Rev. Lett* **69**, 17 (1992).
[3] Tillmark and Alfredsson., *J. Fluid Mech* **235**, 89-102 (1992).