Transport of angular momentum by turbulence in Keplerian rotation flow

Marlone Vernet[1], Stéphan Fauve[1], Christophe Gissinger[1,2]

[1]Laboratoire de Physique de l'Ecole normale superieure, ENS, Universite PSL, CNRS, Sorbonne Universite, Universite de Paris, Paris, France. [2]Institut Universitaire de France (IUF)
marlone.vernet@phys.ens.fr

We report the experimental study of the transport of angular momentum by a turbulent flow of a liquid metal in Keplerian rotation. The set-up is an annular channel of rectangular cross-section with a large aspect ratio. The liquid metal is driven by an electromagnetic forcing due to the presence of a vertical homogeneous magnetic field coupled with a radial current imposed between the inner and the outer cylinder. When the forcing applied to the is sufficiently large, the flow reaches a fully turbulent state characterised by a time-averaged azimuthal velocity $\overline{u_\theta} \sim r^{-1/2}$[1], known in Astrophysics as 'Keplerian rotation'.

We have identified two contributions to the transport of angular momentum. The first one is due to the poloidal recirculation induced by the presence of boundaries. The other is related to the strong turbulent fluctuations in the bulk. While they both produce effective angular momentum transport, the transport driven by the turbulent fluctuations is of major interest : this transport being independent of the molecular viscosity of the fluid, it leads to Kraichnan prediction $\mathrm{Nu}_\Omega \propto \sqrt{\mathrm{Ta}}$.

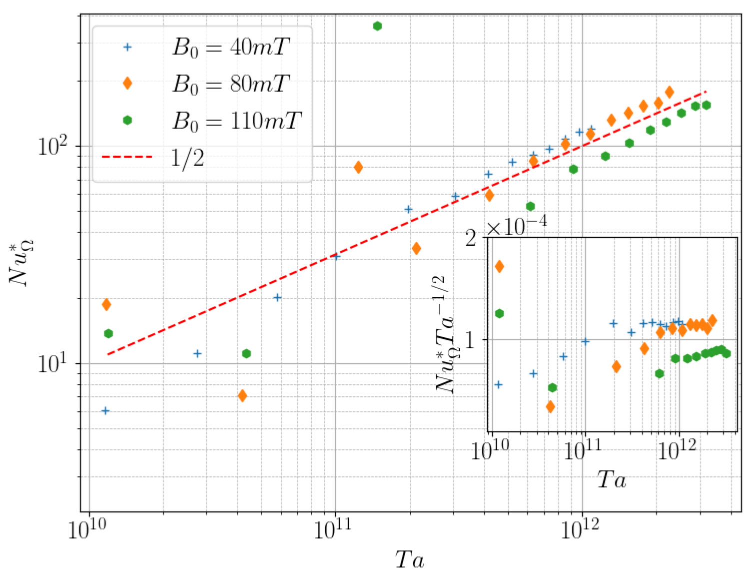

Figure 1. Nusselt number Nu as a function of the Taylor number Ta for typical values of the magnetic field.

In this so-called ultimate regime, the flow is in Keplerian rotation and exhibits fluctuations that effectively transport angular momentum. This experiment thus offers a configuration analogous to accretion disks, allowing predictions of accretion rates induced by Keplerian turbulence.

Références

1. M.Vernet, M.Pereira, S.Fauve, C.Gissinger, *J. Fluid Mech.*, **924**, A29, (2021)