Hydrodynamic bistability explores two dynamo branches in the VKS experiment

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The dynamo instability has been observed in the Von Karman Sodium experiment, where a highly turbulent liquid sodium flow is generated by the counter rotation of soft iron impellers ([1]).
Von Kármán flows have been extensively studied in water, where hydrodynamics bifurcations for asymmetric driving were observed with possible multistability between these different flows ([2]) depending on the geometry of the impellers. The link between these hydrodynamic bifurcations and a possible modification of the dynamo magnetic field in the VKS experiment is still open, although clues linking them has been reported ([3]).
Recently, a modification of the setup where one of the soft iron impeller has been replaced by a stainless steel propeller (aiming at reversing the poloidal flow and creating a s1t2 flow according to the Dudley James classification). We denote F_1 the rotation rate of the impeller and F_2 the rotation rate of the propeller. In this study, F_1 is kept constant between 11 and 15 Hz and F_2 is increased from 13 to 44 Hz. When the driving is strongly asymmetric ($F_2 \gg F_1$), a hydrodynamic bifurcation has been observed. With $\theta = F_2 - F_1/F_1 + F_2$ being the asymmetry parameter, two states of the flow (called H-branch and L-branch) are possible between $\theta = 0.44$ and $\theta = 0.53$ as displayed in figure 1 (a), showing the evolution of the net torque with F_2 for $F_1 = 13$ Hz. The underlying dynamo is also evoluating with the control parameter. The amplitude of the magnetic field first increases then decreases as F_2 increases, on the H-branch. It suddenly switches to a lower value at $\theta = 0.53$. When decreasing F_2 again, the magnetic field stays on this low branch and then recover a high value for $\theta = 0.44$. The striking fact is that the L-branch is also a dynamo branch. We will give some details about these two dynamos, the two states of the flow with local potential measurements and analyze the dynamics of the transitions.

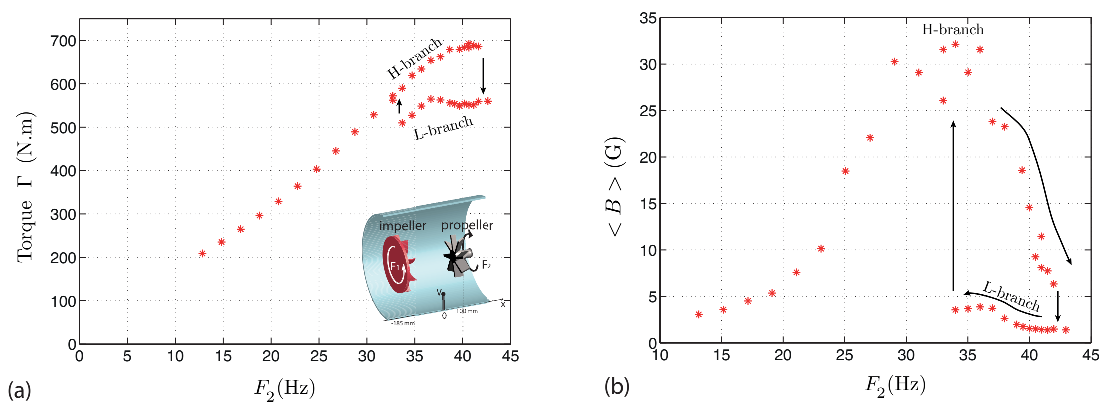

Fig. 1. (a) The evolution of the torque with the control parameter shows bistable flows. Inset: Scheme of the setup. (b) Evolution of the amplitude of the magnetic field when the rotation rate of the propeller increases.

[1] R. Monchaux et al., *Phys. Review Letters*, **98**, 2007.
[2] F. Ravelet et al., *Phys. Review Letters*, **93**, 2004.
[3] M. Berhanu et al., *J. of Fluid Mech.*, **641**, 2009.