LARGE SCALES FEATURES OF A TURBULENT FLOW DRIVEN BY PRECESSION

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A precession motion imposed to a rotating container drives the modes $m = \pm 1$, selected within the whole spectrum of inertial waves which may be excited within the rotating fluid. Three parameters control such flows: a fluid parameter, the Ekman number (assumed to be small), a shape parameter, which in the cylindrical case is simply the aspect ratio a (a = length/ diameter), and a forcing parameter, the precession rate Ω (Ω = precession frequency/rotation frequency).

Since direct numerical simulations may be performed up to relatively small Reynolds numbers, of the order of 5000 (to be compared with about 10^7 expected in a fluid dynamo device), we have built a water experiment (ATER = "Agitateur pour la Turbulence En Rotation") using a cylindrical container with a diameter of 300 mm, an aspect ratio which may vary between 1 and 4/3, with flow Reynolds numbers of a few 10^5. The available instrumentation is a torquemeter on the rotation axis, and a particle image velocimetry equipment (PIV) to visualize 2D flows in sections of the container.

The flow forced by precession is laminar at small precession rates Ω (Ω = precession frequency/rotation frequency) and becomes turbulent for precession rates greater than a critical value, $\underline{\Omega}$. For a cylindrical container, this value depends on the aspect ratio a (a = length/ diameter); note also that the transition has hysteretic properties. A typical value found experimentally is $\underline{\Omega} = 0.09$ when a is close to 1.3.

To evaluate the magnetic Reynolds number that could be achieved in an "MHD wind tunnel" using a sodium flow forced by precession, one needs to know its maximal speed. In the laminar regime, the speed is about $2\underline{\Omega}$ times the wall speed. We have first shown that $\underline{\Omega}$ may be doubled by inserting static blades at one end of the container: this simple device realizes an inertial driving of the azimuthal flow and allows to double the maximal magnetic Reynolds number in the laminar regime.

Numerical studies are now in progress to examine the kinematic dynamo properties of such a laminar flow. However, if dynamo action occurs, the growing magnetic field will strongly modify the laminar solution, and the flow will eventually become turbulent. In absence of a sufficient criterion for dynamo action, the experimental approach using a conducting fluid will remain the only means to know if precession forcing is indeed able to feed the flow at non-linear saturation of magnetic energy.

Nevertheless, as a preliminary step, hydrodynamic experiment may hopefully contribute to this question. It is possible to study how the largest scales of the flow, which presumably act to drive a laminar dynamo, are able to survive in the turbulent flow driven by precession. An account will be given of the experimental results obtained using particle image velocimetry, particularly in the turbulent regime, with and without blades.