1.ISUD
1st International Symposium on Ultrasonic Doppler Methods
for Fluid Mechanics and Fluid Engineering
September 9-11, 1996
Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

Velocity measurements in a vortex of liquid Gallium

Ph. CARDIN*, H.C. NATAF*, B. PASCAL* and J.C. ATTIACH†.
* Géophysique, École Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex 05, France.
† LOT Oriel, Z.A. de Courtaboeuf, 9 av. de Laponie, 91951 Les Ulis Cedex, France.

We present experimental measurements of the fluid velocity in a vortex of fluid Gallium. Liquid Gallium is an opaque metallic liquid, which melts at 29 $^\circ C$ and has a dynamic viscosity similar to that of water. The liquid Gallium is contained in a nylon 6,6 tank (cf figure 1). Nylon was chosen because its sound velocity is close to the sound velocity of liquid Gallium. The external boundaries are a parallepipede 230 mm (height) $\times$ 94 mm $\times$ 94 mm. The internal boundary is a cylinder 80mm (diameter) $\times$ 230 mm (height). A single vortex, with vertical axis, is produced by spinning a crenellated 40 mm diameter disk. The disk is driven by a tachimetric brushless motor, which maintains the rotation velocity constant within 10^{-3}. The maximum rotation velocity is 8000rev/min. The tank is symmetrically placed between the 160mm diameter poles of an electromagnet, which can produce a horizontal magnetic field up to 0.1 T. This experiment was designed to study the interaction between the magnetic field and the fluid motion and to model electromagnetic induction in the Earth's core which is responsible for the generation of the Earth magnetic field. In this presentation, we will focus on the velocity measurements we have done. We have five different methods of measurement:

1. Ultrasonic Doppler measurements with a DOP 1000 multigate, built by Signal Processing. The ultrasonic probe is orthogonal to the vertical boundary of the tank. We introduce small balls (5 μm) of Borure of Zirconium inside the fluid Gallium. The balls are the scaterers required by the Doppler technique. Different profiles were done for different velocity disk ,different ultrasonic beam lines and different magnetic fields (cf figure 2).

2. Direct measurements using a particle tracking method. These experiments were done in water.

3. Dynamical pressure profiles at the top of the cylinder obtained by measuring height of Gallium in a set of Venturi tubes.

4. Differences of electrical potential on the side and on the bottom of the cylinder.

5. Induced magnetic field measured by a gaussmeter or magnetic fluxmeter on the side or below the cylinder.

We will discuss the precision, the validity and stability of the Doppler measurements in comparison with the other methods, and the results of numerical models built to reproduce the flow. This Doppler results are a breakthrough for velocity measurements in liquid metals and this technique could be applied in a more general environment.

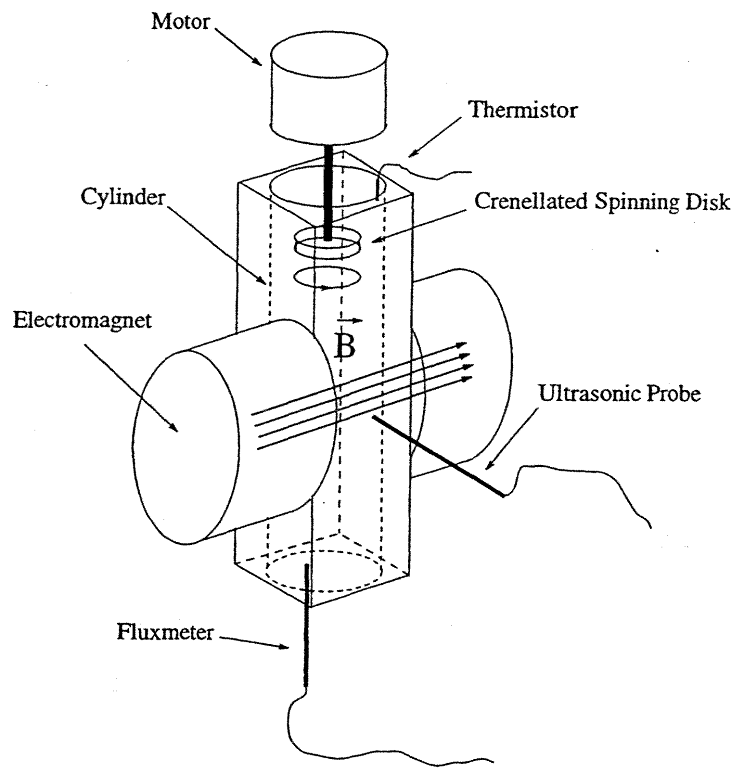

FIG. 1 - sketch of the experimental set-up

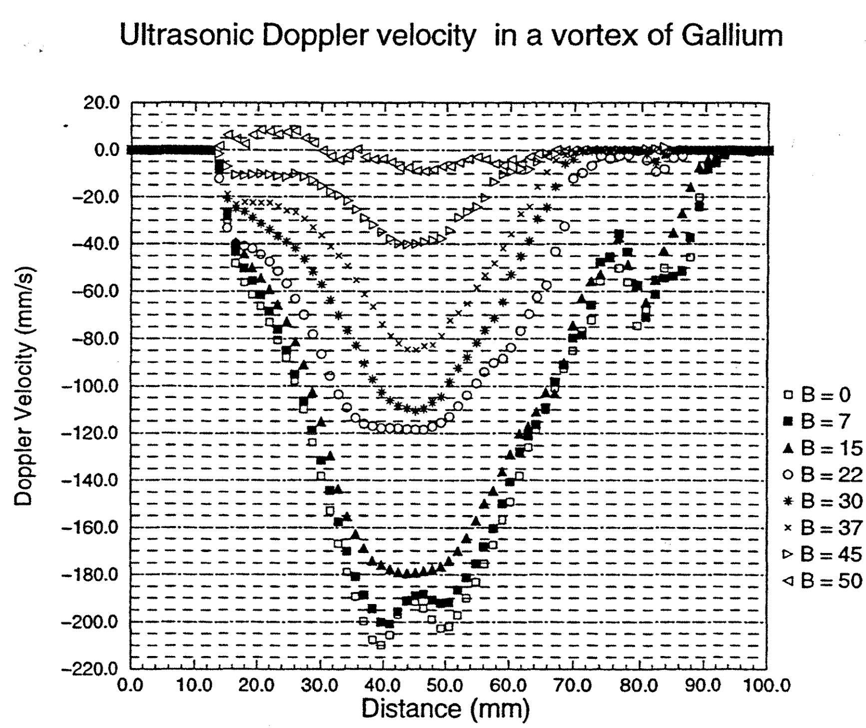

FIG. 2 - Direct measurements of velocity using the DOP 1000 multigate in a vortex of liquid Gallium for different magnetic fields (values in mT)