Probability density function for particle accelerations in turbulence and the structure of vortices

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In the last decades many investigations about the motion of particles in a turbulent flow have been conducted. The use of high speed cameras and the Doppler sonar has allowed to measure the velocity and the acceleration of particles inside the fluid. From the experimental data the probability density function (pdf) of the particle acceleration has been computed. The pdf is strongly non gaussian with accelerations as high as 200g [1].The existence of strong accelerations has been related to the trapping of particles into the vortex cores. To support this assertion we need to recover a classic picture of a vortex. In a first approximation the particles inside the vortex core (after subtracting its translation velocity) move as in a rigid body rotation. Then, the fluid particles move along circular paths. We have investigated the structure of the annular vortices for different values of the Reynolds number (Re), but always in a laminar regime. The vortices are produced by expelling the fluid contained in a box through a circular hole. The velocity has been measured using both Particle Image Velocimetry (PIV) and Hot Wire Anemometry, the latter has a better spatial resolution (we have used a probe with a diameter of 5 μm and 0.5 mm long). In the vortex core the tangential velocity is proportional to the distance to its center. For an experiment corresponding to a Reynolds number Re=1200 we have observed that tangential velocity changes from -1 m/s to 3 m/s through a distance of 4 mm. In this case the acceleration of particles in the outer limit of the core attains the value $a = 2^2/2 \times 10^{-3} = 2000\, m/s^2$. In this work we investigate the size of the vortex core and the acceleration of fluid particles for vortices having different values of Reynolds number. We discuss the trend observed when the Reynolds number increases and the role of the vortex stretching to produce strong accelerations in a turbulent flow.

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Références

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