STEP: Steps to turbulence: patterns in pipe flow

Project leaders
J Westerweel, BJ Boersma, JCR Hunt, G Ooms

Research theme
Complex dynamics of fluids

Participants
DJ Kuik, S Grosse, J Westerweel

Cooperations
B. Hof (Max-Planck institute for Dynamics and Self-organization)
B. Eckhardt (University of Marburg)

Funded
FOM
1st - 2nd 100% 3rd -

Start of the project
2007

Information
DJ Kuik
015 278 4766
d.j.kuik@tudelft.nl
www.ahd.tudelft.nl

S Grosse
015 278 2905
www.ahd.tudelft.nl

Project aim

Recently theoretical/numerical investigations have shown the existence of flow patterns in the form of non-linear traveling waves, which are exact solutions of the Navier-Stokes equations. Although these structures are unstable, they were confirmed by experiments and has given rise to a new view on transition in pipe flow. The aim of the current project is to explore this new and exciting development by studying these traveling waves in a turbulent pipe flow in a setup with slowly reducing Reynolds number. For the measurements a state-of-the-art high speed stereo PIV system will be used to determine the role of the traveling waves in the dynamics of turbulence.

Progress

As was mentioned in the project aim, non-linear traveling waves have been observed in experiments. The non-linear traveling waves were found in turbulent puffs, localized turbulent flow, at Reynolds numbers close to 2000. Around this Reynolds number the lifetime of these turbulent puffs is not infinite, therefore the aim was to determine the survival rate of turbulent puffs. For this investigation a new pipe flow facility was build and the survival rate was determined using laser Doppler anemometry and pressure sensors. Previously was assumed that the survival rate diverges at a finite Reynolds number, which was disapproved by the current investigations. The obtained results were presented at the EUROMECH Fluid Mechanics Conference 7 in Manchester, and published in Physical Review Letters.

The pipe flow facility has been entirely realigned to guaranty a well defined fully developed laminar or turbulent flow field at the measurement position. The measurement setup consists of 2 high-speed cameras and a high-speed laser has been built up. The flow field is observed in a cross-plane of the pipe. Temporally and spatially highly resolved recordings have been performed at two Reynolds number, ReB=20000 and ReB=44000. The data is momentarily being evaluated using commercial PIV software.

Dissertations

-

Scientific publications

1. B. Hof, A. de Lozar, D.J. Kuik and J. Westerweel (2008) Repellor or Attractor? Selecting the Dynamical Model for the Onset of Turbulence in Pipe Flow. PRL 101, 214501.
2. D.J.Kuik, B. Hof, C. Poelma and J. Westerweel, Lifetime of turbulence in pipe flow. EFMC 7, Manchester 2008.