Turbulent Taylor-Couette Flow

Taylor-Couette flow – the flow between two coaxial co- or counter-rotating cylinders – is a paradigmatic system in physics of fluids and many new concepts have been tested with it.

While the low Reynolds number regime (i.e., weakly driven systems) has been very well explored in the ‘80s and ‘90s of the last century, in the fully turbulent regime major research activity only developed in the last few years. In this talk we will first briefly review this recent progress in our understanding of fully developed Taylor-Couette (TC) turbulence, from the experimental, theoretical, and numerical point of view. We will explain the parameter dependences of the global transport properties of the flow and the local flow organisation, including velocity profiles and boundary layers, which are closely connected to the global properties. Next, we will discuss transitions between different (turbulent) flow states. We will in particular focus on the so-called ultimate regime, in which the boundary layer has become turbulent, and which therefore has enhanced transport properties. This ultimate regime can also be achieved in our high-performance numerical simulations, showing excellent agreement with our experiments on the Twente Turbulent Taylor-Couette (T3C) facility.

In the last part of the talk we will discuss TC turbulence with rough walls. There the results can be expressed in terms of the skin-friction factor, revealing analogy to turbulent flow in rough pipes. Finally, we will present our results on TC flow with bubbles, focusing on bubbly drag reduction and its origin.

This is joint work with many colleagues over the years, and I in particular would like to name Chao Sun, Roberto Verzicco, Siegfried Grossmann, Rodolfo Ostilla-Monico, Xiaojue Zhu, Dennis van Gils, Sander Huisman, Ruben Verschoof, and Gert-Wim Bruggert.

Detlef Lohse graduated from the University of Bonn in 1989 with a degree in Physics, and completed his Ph.D. at the University of Marburg in 1992. He served as a postdoctoral research fellow at the University of Chicago from 1993 to 1995, and was made chair of Physics of Fluids at the University of Twente in 1998.

His present work includes turbulence and two-phase flows, granular flow, micro- and nanofluidics, and the biomedical application of bubbles.

Professor Lohse was a recipient of the 2019 Max Planck Medal, 2018 Balzan Prize, 2017 Fluid Dynamics Prize, 2012 Batchelor Prize, and 2005 Spinoza Prize for his work on turbulence, thermal convection, multiphase flow, microfluidics and sonoluminescence, and was awarded with a knighthood in the Order of the Netherlands Lion in 2010. He is also a member of the Royal Netherlands Academy of Arts and Sciences since 2005, a member of the National Academy of Engineering since 2017, and a Fellow of the American Physical Society.