Manipulation of structures and superstructures in turbulent Rayleigh-Bénard convection and Taylor-Couette flow by stiff wall roughness

Taylor-Couette (TC) flow, the flow between two coaxial co- or counter-rotating cylinders, and Rayleigh-Bénard (RB) flow, the flow in a box heated from below and cooled from above, are paradigmatic systems in physics of fluids. When driven strongly enough, in both cases the flow becomes turbulent and in both cases structures or even superstructures can evolve, strongly affecting the transport properties of the flow. In TC flow, these are the so-called Taylor vortices and in RB flow the convection rolls, which when laterally sheared elongate in shear direction. While in the first round of the SPP1881 program we have numerically analyzed the heat transfer and flow organization in sheared RB flow and numerically studied TC flow with rough walls, building on this, in this second round of the program we want to utilize spatially periodic wall roughness (stripes) to manipulate the flow structures and superstructures and thus the transfer properties of the turbulent TC and sheared RB flow. The objective of this numerical project is to understand the competition between the natural length scale of the structures in TC and sheared RB flow with the imposed length scale by the stripy roughness, which triggers locally enhanced plume emission. Our hypothesis is that the flow (super)structures are able to follow the imposed periodicity to some degree, but once the mismatch between the internal and externally imposed length scales is too large, this will no longer be possible. In any case, the tuning of the transfer properties of the flow by modifying the stripiness can open the door to many applications. The numerical calculations will be done with a ultra-high-performance code based on a finite difference scheme with the stripy roughness embodied through immersed boundary methods, in close collaboration with Roberto Verzicco, who is intensely involved in this project. The results for the TC flow will be compared with corresponding experiments with the Twente Turbulent Taylor-Couette (T3C) facility, where we will employ stripy sandpaper roughness at the cylinders. Just as in the first round of SPP1881, we will closely interact with several further SPP projects. On RB flow, these are those of Olga Shishkina, Eberhard Bodenschatz and Stephan Weiss, all in Göttingen, and on TC flow those with Bettina Frohnapfel (Karlsruhe) and Christoph Egbers (Cottbus).