Physics Colloquium Mainz

November 28, 2023 at 16 c.t.

Lecture room KPH,
Johann-Joachim-Becher-Weg 45, JGU

82 years ago, the mathematician Andrei Nikolayevich Kolmogorov postulated that a turbulent flow should have universal statistical self-similar properties. Independently, the flow researcher Ludwig Prandtl concluded similar results 4 years later. Nobel laureates Werner von Heisenberg and Carl-Friedrich von Weizsäcker and Lars Onsager each came to the same conclusion shortly thereafter. Over the years, the expected power laws have been refined, but it has not been possible to measure them at very high turbulence level necessary. Simulations of driven turbulence on the world's largest computers provide evidence of this statistical universality. These simulations are highly idealized, they live in a periodic box, and the energy is introduced globally on large scales. Experimentally, this kind of turbulent flow is not feasible. So the question is: what do experiments show?

For more than 100 years, the wind tunnel has been the canonical flow regime for turbulence research. When a fluid flows through a grid at high velocity, vortices form and decay after a short time; the flow then exhibits the universal statistical properties of turbulence. Today, electronics are highly optimized and there are the smallest hotwires made with advanced nanotechnology. This also makes it possible to measure velocities on the smallest length scales. However, very high turbulence intensity is required to measure universal static properties. In the past, experiments were mainly performed with air (hence the name wind tunnel). When using air at atmospheric pressure, the wind tunnel would have to be huge in diameter to achieve extremely high turbulence intensity to test Kolmogorov like theories. This is where the Variable Density Turbulence Tunnel (VDTT) at the Max Planck Institute for Dynamics and Self-Organization comes in. Among others, I will present recent results showing that universality is found, albeit with spatially dependent logarithmic dependence of the power-law exponents.

82 Years after Kolmogorov the Statistics of Turbulence Remains a Riddle

Prof. Dr. Eberhard Bodenschatz

MPI für Dynamik & Selbstorganisation, Göttingen

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