Bistable turbulence in fusion plasmas with a sheared mean flow

Nicolas Christen, Michael Barnes, Michael Hardman, Alex Schekochihin

University of Oxford

The prevailing paradigm for plasma turbulence associates a unique stationary state to given equilibrium parameters. In this talk, we report the discovery of bistable turbulence in a tokamak fusion plasma. Two distinct, stationary turbulent states, obtained with identical equilibrium parameters in local delta-f gyrokinetic simulations, have turbulent fluxes of particles, momentum and energy that differ by an order of magnitude -- with the low-transport state agreeing with experimental observations in the JET tokamak. Occurrences of the two states are regulated by the competition between an externally imposed mean flow shear and "zonal" flows generated by the plasma. With small initial turbulent amplitudes, zonal flows have little impact, and the mean flow shear causes turbulence to saturate in a low-transport state. With larger initial amplitudes, the zonal shear tends to oppose the effect of the mean flow shear, allowing the system to sustain a high-transport state. While the existence of bistability poses a new challenge for research that has so far assumed a uniquely defined turbulent state, our results lead to some remarkable consequences for turbulent transport in fusion plasmas.