Self-organisation in tokamak turbulence

The most promising concept for a fusion reactor today is the tokamak, which confines the fuel plasma in a strong toroidal magnetic field. The understanding and control of energy and particle transport in a tokamak plasma is important for optimising the efficiency of the reactor, and still a major challenge in fusion research. This transport is governed by electromagnetic turbulence. Due to the strong guide field, this turbulence has a two-dimensional character and large structures can be formed by the merging of smaller ones. In tokamaks, the size of these structures is limited to intermediate scales, the so-called mesoscales, by the shape of the magnetic field.

The mesoscale structures influence the transport, which in turn can modify the driving forces for the turbulence. Since the turbulence creates the mesoscale structures, a feedback loop is set up through which self-organisation can occur. The talk will address the question what the effect and relative importance of this self-organised mesoscale structures is on turbulent tokamak transport phenomena.

The Cylindrical ElectroMagnetic 2 Fluid Turbulence (CEM2FT) model, developed at UKAEA in Culham (United Kingdom) and implemented into the numerical code `CUTIE`, is used as the main research tool. It simulates mesoscale turbulence in periodic cylinder geometry with corrections for the toroidal shape of a tokamak. For the research described in this talk, the `CUTIE` code was improved and optimised.

It is found that details of the heat transport in experiments that challenge our understanding could be reproduced by `CUTIE`, although quantitative agreement (time scales, temperatures) is usually hard to obtain. It is found that localised features of the turbulence such as zonal flows and dynamo currents play an important role in self-organisation and the global dynamics.