Simple invariant solutions representing fluid turbulence
Genta Kawahara

In this lecture, I would like to talk about theoretical approaches to the problems of subcritical transition and developed turbulence using simple invariant solutions, such as a fixed point and a periodic orbit, to the equation of fluid motion. Considering turbulent flows as dynamical systems, stable and unstable manifolds of simple invariant solutions could represent flow instability and thus turbulence dynamics, while spatiotemporal coherence in turbulent flows should be described in terms of the simple solutions themselves. Although dynamical-systems approaches have recently been taken widely to turbulence problems, in this talk I will focus on attempts to quantitatively characterize turbulent flows and their onset based on invariant solutions. Specifically, the amplitude of turbulence-driven mean secondary flow in a square duct is evaluated using the three-dimensional steady traveling-wave solution (Uhlmann, Kawahara & Pinelli 2010), and the scaling law of the Nusselt number (dimensionless wall-to-wall heat flux) with the Rayleigh number observed in thermal convective turbulence is reproduced by the three-dimensional steady solution. In the early stage of subcritical transition in minimal plane Couette flow the onset Reynolds number of transient turbulence is determined by the first tangency of homoclinic orbits to the known three-dimensional periodic edge state (Kawahara & Kida 2001). The latest results in this line of work will also be presented.