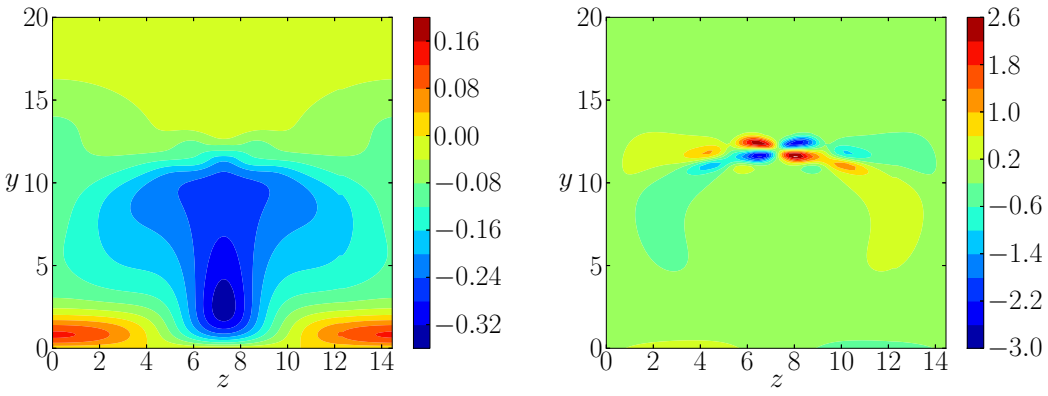
Exact coherent structures in the asymptotic suction boundary layer

Studies on the transition to turbulence in various shear flows have revealed how exact coherent structures determine the transition and influence the dynamics. In spatially extended systems, this role is taken over by localized structures that can provide a theoretical framework for turbulent superstructures. The aim of the project is therefore to study the relation between exact coherent structures and turbulent superstructures for the case of the asymptotic suction boundary layer (ASBL). This flow is part of a family of flows that mediates between parallel shear flows and spatially developing boundary layers, and thus provides a flexible model for superstructures in several shear flows. The connection to plane Couette flow has already helped to identify a key bifurcation that leads to non-trivial spatio-temporal dynamics with violent bursts in the ASBL.

In the case of the ASBL, certain exact structures reach very well beyond the laminar boundary layer thickness and introduce mixing over large distances. One example of such a state at Reynolds number 1000 is shown in the Figure. In units in which the scale of the laminar profile is 1, it extends well over 10 times as high, and the downstream velocity is rather uniform over that distance, establishing a connection to the constant momentum zones that are frequent in shear flows.



Downstream velocity (left) and vorticity (right) for a coherent structure in the ASBL