Popular science summary of the PhD thesis

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Title of the PhD thesis	Topological bifurcations in fluid flows with application to boundary layer eruption, vortex pair interactions and exotic wakes
PhD school/Department	DTU Compute

Science summary

* Please give a short popular summary in Danish or English (approximately half a page) suited for the publication of the title, main content, results and innovations of the PhD thesis also including prospective utilizations hereof. The summary should be written for the general public interested in science and technology:

A vortex is a rotating structure in a liquid or a gas. Vortices are available in all sizes. They are formed when you stir your coffee, when an airplane takes off, and when heated air form tornadoes in the atmosphere. Any object moving in a liquid or a gas will affect the structure of the flow around it. As an example, we often see a so-called vortex street in the wake behind a ship or an airplane. Vortices are basic ingredients in transitional and turbulent flows, and to keep track of the vortices is a natural way to describe the qualitative changes of a flow. Topology is the discipline in mathematics that is concerned with properties of a geometric object that are preserved under continuous deformations. The description of any fluid flow involves a continuous deformation of a transported scalar or vector field; therefore, it is natural to use a topological approach when analyzing a fluid dynamical problem.

In this thesis, we revisit three fundamental fluid dynamical problems with the aim of elucidating the topological changes of the vortex structure. From a mathematical point of view, any qualitative change in the vortex structure is associated with a so-called topological bifurcation. By applying well-known results from the field of topological fluid dynamics are we able, to give a completely new and very detailed description of how the so-called exotic wake patterns arises behind an oscillating cylinder.

Clearly, a description of the topological changes in the vortex structure depends on the way we define vortices mathematically. In addition to applying well-known results from topological fluid dynamics, we ask ourselves how this framework can be extended to deal with topological changes of any quantity describing the structure of a flow. As an example, we choose to consider the regions of a fluid where the rotation dominates the strain. These regions are by the Q-criterion defined as vortices. We develop a bifurcation theory for Q-vortices that describe the possible qualitative changes we may observe when we allow several parameters to vary.

In this project, we are motivated by a desire to understand the complicated world of fluid dynamics - more specifically, the evolution of the vortices. We believe that our approach based on bifurcation theory can contribute to a deeper understanding.

Please email the summary to the PhD secretary at the department