

Three-dimensional vortex structures and vorticity topology

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Abstract. In this paper we describe the formation of steady, three-dimensional flow structures as changes of flow topology. Possible changes are analyzed in the space of divergence-free, Navier–Stokes vector fields. Changes occur at structurally unstable flow states, for instance at incipient separation, incipient vortex formation and vortex breakdown, etc. and whenever the flow around a nominally two-dimensional or axisymmetric body becomes three-dimensional. Vortices may be defined as helical flow of fluid particles around a common axis, but we have to distinguish between the topological structure of the velocity field and the vorticity field of such vortices (vortical flows). At first we review our results on near-wall velocity-field structures and then we discuss the topology of the associated vorticity fields. Finally we develop a geometric description which allows to give a local definition for a three-dimensional vortex based on the invariants of the Jacobian matrix of such Navier–Stokes vector fields.