# STREAMLINE SEGMENT TOPOLOGY IN THE VICINITY OF STAGNATION POINTS IN TURBULENT FLOWS

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**KEYWORDS**:

**Main subjects**: turbulent flows, extreme points, isosurface, stagnation points, flow visualization
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**Visualization method(s):** DNS, isosurface, streamlines, critical points
**Other keywords:** streamline segments, flow topology

**ABSTRACT**: Streamlines have recently received attention as natural geometries of turbulent flows [1,2]. As streamlines are a-priori infinitely long, Wang [1] proposed to partition them into segments based on local extrema of the absolute value of the velocity field u along the streamline, i.e. points where the gradient of u in streamline direction vanishes. Streamline segments can further be characterized as positive ones (positive gradient) and negative ones (negative gradient). It turns out that there exists a scalar field based on which an isosurface can be defined in which all streamline segments ending points are located. It divides space into two regions, one of which contains all positive segments while the other contains all negative segments. It follows that apart from the extreme points along the streamlines, all local extreme points (of the field of the absolute value of the velocity u and the turbulent kinetic energy $k=u^2/2$) also lie in the isosurface. It is of special interest that stagnations points, i.e. critical points of the velocity field where locally all velocity components vanish simultaneously, form a sub-group of local minimum points and thus are also situated in the isosurface. The isosurface itself can further be subdivided into two parts, one of which contains all minimum points (minimal surface), while the other contains all maximum points (maximal surface). The demarcation line between these two regions is the ensemble of points where streamlines are tangent to the isosurface. Figure 1 (left) shows such a partitioning of the surface as well as local extreme points. The velocity field in the vicinity of a stagnation point can be expanded in a Taylor series. Then the type of stagnation point can be characterized by the eigenvalues of the velocity gradient tensor. This work is concerned with the topology of the isosurface in the vicinity of stagnation points. The local shape of the isosurface is shown to also depend only on the above eigenvalues. It will be shown that at the stagnation point two folds of the isosurface come infinitesimally close to each other and the leading order expansion of the isosurface yields different shapes for the different kinds of stagnation points. Figure 1 (middle and right) shows two examples of two different stagnation points from DNS calculations together with the local isosurface shape.

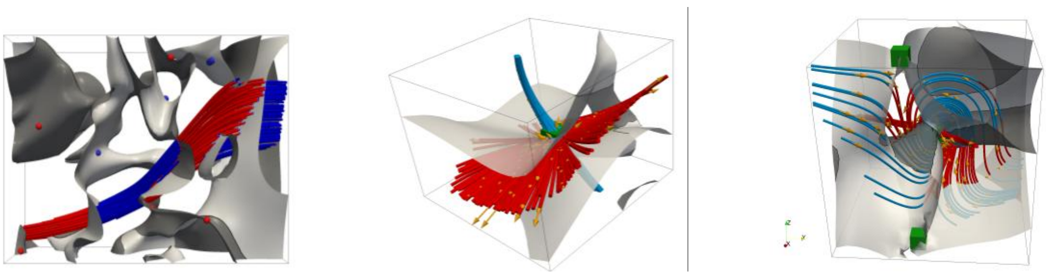

Fig. 1 Isosurface (minimal surface in light grey, maximal surface in dark grey), local extrema and bundle of streamlines (left). Stagnation point and the local topology of the isosurface (middle, right). From DNS of HIDT

## References

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