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Identification of boundary surfaces in flows*

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Abstract In this study, boundary surfaces of a flow field are defined as stream surfaces, on which the shear rates vanish, and a procedure is proposed to find them. The method, based on calculations using the velocity vector field, is independent of the coordinate system adopted.

Key words interfacial surfaces, structure of flow, kinematics

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1 Introduction

The first step of the analysis of analytical, experimental, and numerically simulated flow fields is usually the determination of how the flow is organized and structured. The extraction of information about the structure of the three-dimensional flow fields is still a challenge mainly because of their vectorial characters. Several techniques have been proposed to reveal the structure of vortical flows (see Haller[1] and Jeong and Hussain[2]).

The boundary surfaces, defined as stream surfaces on which the shear rates vanish, are important structural elements of the flow fields, because they define the frontiers between regions with no advective or diffusive momentum exchange. The identification of these surfaces in three-dimensional flow fields is not straightforward, if one considers that, for a given point, there are infinite streamsurfaces that are candidates to be boundary surfaces. Herrera et al.[3] reported a procedure to identify boundary planes in three-dimensional flows based on the relation between the curvature of the streamlines on stream surfaces and the vorticity vector field. In this study, we propose a generalization of the procedure to detect boundary surfaces.

2 Boundary surfaces

Let $\mathcal{F}$ be a flow in $\mathbb{R}^3$ (oriented Euclidean space of three-dimension), then we can consider the trio $(\boldsymbol{v}, \boldsymbol{\omega}, D)$ formed by the smooth velocity vector field of $\mathcal{F}$ at a given time t, its vorticity

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