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Geometric characterization of the rotation centers of a particle in a flow

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Abstract. We provide a geometrical characterization of the instantaneous rotation centers $\overrightarrow{O}(p,t)$ of a particle in a flow $\mathcal{F}$ over time t. Specifically, we will prove that: a) at a specific instant t, the point $\overrightarrow{O}(p,t)$ is the center of curvature at the vertex of the parabola which best fits the path-particle line $\gamma(t)$ on its Darboux plane at p, and b) over time t, the geometrical locus of $\overrightarrow{O}(p,t)$ is the line of striction of the principal normal surface generated by $\gamma(t)$.

Keywords: Geometry of flows, structure of flows

MSC 2000 classification: primary 53Z05, 76U05 , secondary 53A05, 53A04

1 Introduction

It is well known that the path-particle lines of flows are important objects in Fluid Mechanics, since these lines make up vortices and also determine the movements of any object immersed in the fluid. In this paper we present novel geometric results that help to understand the geometry of the path-particle lines and the geometry of the instantaneous rotation centers of the particles. These results –deriving from a theory which has been applied to the study of vortices in [10] and [15]– relate the fluid with the curvatures of certain curves and surfaces which are intrinsically linked to the geometry of the path-particle lines. Many issues related with the fluid/fluid and fluid/solid interfaces are intimately associated with the curvature of the path-particle lines on such interfaces (see

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