

## **409f The Interstate Highway System of Fluid Flow: a Flow Skeleton Method to Study Mixing in Realistic 3d Autonomous Flows**

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The study of mixing in 3D laminar liquid flows has focused on the creation and destruction of the structured regions created by elliptical periodic orbits. These elliptical regions only comprise one element of the set of structures seen in 3D flows. The concept of the flow skeleton is introduced as a structure that captures behavior in chaotic regions of 3D flows. Simple methods are discussed for constructing flow skeletons and applied to the simulation of a stirred tank agitated with a disk impeller at various eccentric positions. Results of these studies reveal the bifurcations of the flow skeleton as a function of the eccentricity of the disk position at a low Reynolds number. Analysis of the mixing by surface of section shows a correlation between poorly mixed regions and the intersection of the flow skeleton with the surface of section. The flow skeleton proves itself a useful tool for understanding the differences in mixing between 2D flows and 3D autonomous flows; however, complexity increases due to geometrically complicated connections and the multiplicity of critical points indicate a need to develop refined techniques to resolve skeletons.