Mechanical Engineering Master's Defense

Extraction of Coherent structures using NS in 3D Turbulent flows and its effects on Chemotaxis

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abstract

We present a numerical study of chemotaxis in 3D Turbulence. DNS simulations are used to calculate the nutrient uptake for both motile and non motile bacterial species and by applying the Dynamical systems theory we analyze the effect of flow topology on the variability of chemotaxis. We do so by injecting a highly localized patch of nutrient in the turbulent flow, and analyzing the evolution of reaction associated with the observed high and low stretching regions. The Gaussian nutrient patch is released at different locations and the corresponding nutrient uptake is obtained. The variable stretching characteristics of the flow is depicted by Lagrangian Coherent Structures and we analyze the roles they play in affecting the uptake.

The Lagrangian Coherent Structures are quantified by the Finite Time Lyapunov Exponents which is a measure of the average stretching experienced by the flow in finite time. We find that in High stretching regions, the motile bacteria are attracted to the nutrient patch very quickly, but also dispersed quickly whereas in low stretching regions the bacteria responds slower towards the nutrient patch. However the total uptake is intricately determined by stretching history. These reaction characteristics are reflected in the several realizations of simulations. This helps us in understanding turbulence intensity and how it affects the uptake of the nutrient.

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