Intensive and weak mixing in the chaotic region of a velocity field

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Abstract The local stirring properties of a passive fluid domain with arbitrary borders in known velocity field are discussed. Construction of maps for local stretching values in fixed moments allows to analyse informatively an evolution of regions, in which an intensive stirring takes place. The stirring process is explored in a sample of an advection problem of a passive impurity in the velocity field induced by a system of three point vortices moved periodically. It is shown that the regions of a chaotic motion of fluid particles and of an intensive stirring do not coincide. Chaotic region has a zone of weak stirring, in which contours are transported from one intensive stretching zone to another without any deformation.

As three vortices follow their paths
There's a chance for some elegant maths;
There's absolute chaos
From Kiev to Laos,
You may see this in rivers and baths.

1. Introduction

Mixing is a complex natural phenomenon that includes various mechanisms, the two most important being stretching due to velocity field and diffusion due to Brownian motion [Ottino, 1989]. In some cases diffusive effects can be neglected because of physical characteristics of fluid or time scale of the phenomenon, and the problem can be reduced to the analysis of deformation process of fluid domain in the velocity field. The velocity field is assumed to be given a priori.

The problem on deformation of appointed regions, usually called the advection problem in literature [Ottino, 1989; Aref, 1990], is limited to the analysis of the trajectories of Lagrangian fluid particles, which form borders of the region under investigation, in Eulerian velocity field. Every fluid particle can be treated as a passive fluid particle, and governing equations of the problem are the system of differential equations of the