Mixing in Curved Pipes

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1 Thesis Proposal

Over the previous summer I studied mixing of a passive tracer by flow in a straight cylindrical pipe, under the supervision of prof. Bernoff. The mixing process can be thought of as the successive action of advection by the fluid flow and diffusion modeled by random walks. With this method we were able to distinguish three different regimes. For short times, diffusion is more relevant than advection and we observed a Gaussian longitudinal distribution of the concentration. In an intermediate regime, advection by the shear is dominant over longitudinal diffusion and we observed a distinctively asymmetric distribution which spread much faster than would be expected by the action of diffusion alone. Finally when the tracer had completely mixed across the pipe's cross-section, we recovered the classical Taylor regime with a longitudinal Gaussian distribution. In each regime we have analytical prediction of tracer distribution, confirmed by numerical calculation.

The object of this thesis is to extend our results to curved pipes; we will start by considering curved planar pipes and helical pipes. We will try to determine if mixing in these geometries displays the same three distinctive regimes of mixing. The pipe's curvature introduces a secondary flow in the form of a transverse recirculation with a dipolar form, discovered by Dean (1928). We believe this transverse flow should enhance mixing, which explains why curved pipes are used in cooling systems and other situations where heat exchange is relevant. Our object is to first understand existing analytical approximations to the flow in a curved pipe due to Dean and others and then to study analytically and numerically the spread of a passive scalar in these flows.

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