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Rapid Formation of Strong Gradients and Diffusion in the Transport of Scalar and Vector Fields

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An important issue in the theory of transport by moving fluids is the role of dissipation when the medium is nearly ideal. The central problem of this nature is understanding viscous dissipation at very large Reynolds numbers. We will discuss a few problems in the same category but linear and therefore more promising although, as it turns out, surprisingly rich and far from being resolved. Their common denominator is the interplay between diffusion and advection. In a typical flow the latter tends to decrease the characteristic length scales of the spatial variations of the transported quantity, thus increasing the rate of diffusion. Depending on a particular configuration either this rapid diffusion prevails and efficiently annihilates all gradients, or a kind of balance is reached and a quasi-steady dissipative structure emerges. We discuss both types of behaviour paying special attention to spiral structures formed by a diffusing passive scalar and to current sheets in magnetohydrodynamics.

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