Selection of Frozen Fronts in simple flow and Avalanches Dynamics in Reaction Fronts in Disordered Flow

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Autocatalytic reaction fronts between two reacting species, propagate as solitary waves. The coupling between autocatalytic reaction front and forced hydrodynamic flow may lead to stationary fronts whose velocity and shape depend on the underlying flow field. We focus on the issue of the chemo-hydrodynamic coupling between forced advection opposed to these self-sustained chemical waves. which can lead to static stationary fronts, i.e Frozen Fronts, FF.

We perform experiments, analytical computations and numerical simulations with the autocatalytic Iodate Arsenious Acid reaction (IAA) over a wide range of flow velocities around a solid disk. Over a wide range of flow velocity , we have been able to observe static stationary fronts, i.e Frozen Fronts, FF. For the same set of control parameters, we do observe two types of frozen fronts: an upstream FF which avoid the solid disk and a downstream FF with two symmetric branches emerging from the solid disk surface. We delineate the range over which we do observe these Frozen Fronts. We also address the relevance of the so-called eikonal, thin front limit to describe the observed fronts and to select the frozen front shapes.

For the more complex and disordered flow inside a porous medium, we report on numerical studies of the dynamics of the front for the same IAA autocatalytic reaction front. The front propagation is controlled by the adverse flow resulting in fronts propagating either upstream or downstream, or remaining frozen FF. Focusing on front shape, we have recently identified three different universality classes associated with this system by following the front dynamic experimentally and numerically. Here, using numerical simulation, in the vicinity of the depinning transition between FF and upstream fronts, we find power-law distributions of avalanche sizes, durations and lateral extensions. The related exponents are compared with the so-called $qKPZ$ theory that describes the front dynamic.

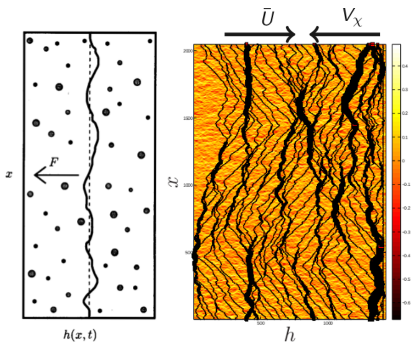

Figure 1: Autocatalytic front propagation in a heterogenous velocity field (colormap)

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