1998

ABSTRACTS

STRUCTURE OF MOVING FRONTS

Cécile Appert (ENS Paris): "Speed of growth in a Tetris model"

We consider a Tetris-like model, with bricks of width 2 falling onto a lattice. If a brick falls on the sites $(i, i+1)$, the height in these sites evolves according to the rule:

$$h_i(t+1) = h_{i+1}(t+1) = \max\{h_i(t), h_{i+1}(t)\} + 1 \, .$$

This evolution law may be encountered in various systems (calculation of the maximal Lyapunov exponent in a hard sphere gas, of the efficiency of an algorithm, etc).

In our version of the model, the heights of two neighboring sites may be exchanged with a certain probability. For several values of the parameters, the growth of wall heights is studied analytically and numerically. The average speed of the front is directly related to its shape, in particular to the asymptotic form of the tail ahead the shock.

Marcel Ausloos and N.Vandewalle (Liège): "Growing reactive or not 2D fronts up to percolation"

The so-called dynamic epidemic model, for the evolution of an advancing interface through a medium containing mobile impurities has been investigated under various conditions, but always on a two dimensional lattice. The particles can be reactive or not. The seed of the growing cluster can be unique at the "center" of the lattice, or a line on the border of the semi infinite medium, or even a set of seeds randomly distributed on the lattice. The particles can be of uniform size or belong to a binary distribution. A short range repulsion between the front and the impurities is implemented in order either to trap the particles or to push them away. This leads to an aggregation process along the front, and to a pattern of trapped impurities; the latter is found to be self-organized. The kinetics of this self-organization is herein analyzed and discussed. Sometimes the process cannot go on forever. There is a percolation transition. Various simulated cases will be illustrated and shown where they apply.

[1] N.Vandewalle and M.Ausloos, *Phys. Rev. Lett.* **77**, 510 (1996)

Eric Brunet (ENS Paris): "Selection of the speed of a front by microscopic effects"

Many physical phenomena involving front propagation (combustion, reaction/diffusion, car traffic...) can be described by KPP-like partial derivatives equations. These equations have a continuous family of solutions, each of them corresponding to a different propagation speed of the front. Microscopics effects, and more particulary finite size effects, allow to understand which speed is actually selected by the physical system.

Nicolas Chabot (Marseille): "Asymptotic shape theorem for an epidemic model in dimension 3 or more"

An asymptotic shape result is established for the 'epidemic model with removal' in dimension three or more, for constant life-time. The same result was proved by J.T. Cox and R. Durrett in 1988 for some stochastic life-time, but only in dimension two. The proof is based on recent results in Bernoulli percolation. Extensions of the result will be discussed.

Bernard Derrida (ENS Paris): "Intrinsic properties of the shape of a shock"

For the Asymmetric exclusion process, there exists several ways of locating the shocks, each method giving a different profile. One can define intrinsic properties which do not depend on the method used to define the shock. These properties can be computed explicitly in the asymmetric exclusion process.

Kristinka Ivanova (Louvain-la-Neuve): "Front growth in 3D in presence of mobile particles"

The solidification process and pattern of self-organized microstructures in (2+1)D are examined. This leads to discuss a first order phase transition problem with mobile impurities interacting with the growth front. Since the solidification front is supposed to be advancing into a 3D medium containing mobile impurities and therefore contains the ingredients of a model for a semi-late stage dynamical process at a first order phase transition under isothermal undercooling condition. The approach generalizes the dynamic epidemic model previously examined in two dimensions to the three dimensional case. The quantitative and qualitative differences will be described. The presence of mobile particles shifts the usual percolation transition for 3D systems from 0.65 corresponding to static hindrances, to a value of 0.8. The particle pushing leads to an aggregation phenomenon which inhomogeneously "self-organizes" the particles near and after the interface because aggregates are trapped behind the front. The time dependence of the process is illustrated and characterized. Some theoretical work will be presented on simplified cases.

Annie Lemarchand (Paris 6): "Chemical wave fronts: internal fluctuations and speed selection"

The numerical resolution of the Langevin equations, with specific internal noises deduced from master equations, exhibits two qualitatively different behaviors for reaction-diffusion wave fronts associated with either a cubic or a quadratic chemical rate. In the case of a wave front between two stable stationary states, illustrated by the Schlögl model, the effect of fluctuations in the vicinity of a bifurcation induces deviations from the deterministic predictions on observable properties, like the propagation velocity, the profile width, and the value of the highest plateau. These deviations obey power laws that are determined. For wave fronts propagating into an unstable stationary state, like in the Fisher model, a different fluctuation effect on velocity and profile width is observed, in relation to the selection, in the presence of noise, of a particular solution in the continuum of linearly stable deterministic solutions. The selection mechanism does not obey the marginal stability criterion. In addition to these effects on mean wave-front properties, the variance of the front position is shown to grow linearly with time, whatever the dimension of the medium. This result is confirmed by simulations on a lattice gas cellular automaton.

Jean Mairesse (Paris 7): "Ergodic theorems for random heaps of pieces"

We consider a model where pieces are piled up, forming heaps, following the Tetris game mechanism. These systems appear in the modelling of timed Petri nets or in some models of surface growth. We show that the dynamics can be represented by products of random matrices in the (max,+) semiring. Using this result, we obtain short proofs for several ergodic theorems on random heaps: existence of an asymptotic growth speed, say $v = \lim x(t)/t$, where $x(t)$ is the height of the heap at instant t; stationary distribution for the quantity $x(t) - vt$. We will present some elementary cases where the constant v can be explicitly computed, together with conjectures concerning this constant.

Vadim Malyshev (INRIA Rocquencourt): "Stochastic evolution of topology"

New class of "concrete" Markov processes is introduced. It covers most well known concrete processes as branching processes, processes with local interaction, fractals etc. It gives rise also to new examples. One of such examples we present at this talk: temporal development of topology of one-dimensional complexes (graphs). The example is very simple to formulate: we just add and delete at each existing vertex certain links with certain rates. Problems considered are:

1. Law of Large Numbers for the growth rate of the number of vertices, number of generators of the fundamental group etc.
2. Local correlations and topological chaos.
3. Phase transitions for the characteristics mentioned above.
4. Thermodynamic limit of the dynamics.
5. Development of the boundary.

Marc Mézard (ENS Paris): "Disordered systems and Burgers turbulence"

We study the scaling and intermittency properties of Burgers' turbulence. We emphasize the links between this problem and that of a directed polymer in a random medium. Applying a replica variational

method to this last problem, we compute in details the intermittency properties of forced Burgers turbulence in large dimensions.

Stefano Olla (Cergy-Pontoise): "Equilibrium Fluctuations for a Ginzburg-Landau surface"

Ellen Saada (Rouen): "The shock in the simple exclusion process"

We consider an asymmetric nearest neighbor simple exclusion process on $\mathbb{Z}$, ($p(x,x+1) = p$, $p(x,x-1) = q = 1-p$, $p > q$), whose initial distribution is a product measure of density λ for $x \leq 0$, ρ for $x > 0$, with $\lambda < \rho$. A passage to the hydrodynamic limit gives a product measure whose density $u(x,t)$ is the entropy solution of the Burgers equation, for each continuity point of $u(x,t)$, that is $u(x,t) = \lambda$ if $x < (p-q)(1-\lambda-\rho)t$, and $u(x,t) = \rho$ if $x > (p-q)(1-\lambda-\rho)t$. The microscopic structure of the shock is thus a natural problem to study. This communication will be a quick review of the results on this question (results mainly obtained by P. Ferrari et al.), up to the papers by B. Derrida et al.

Birgitt Schoenfisch (Tuebingen): "Propagation of fronts and anisotropy in cellular automata"

The propagation of fronts is investigated for a class of simple totalistic two-dimensional cellular automata. For the deterministic case results about the exact shape of the front can be obtained. The investigation of propagation speeds in different directions show anisotropy effects. Several modifications of classical cellular automata have been proposed to avoid these effects. As examples simulations of the propagation on random grids, with minimal distance and with a stochastic local function are discussed. Finally patterns of different asynchronous updating methods are shown.

Igor M. Sokolov, J.Mai and A.Blumen (Freiburg): "Local ordering effects on front propagation in autocatalytic systems"

We consider the front propagation in an $A + B \to 2A$ autocatalytic reaction between particles which perform random walks on a lattice and react on contact. The classical, continuous-medium description of this reaction leads to the Fisher equation, whose front solutions can in principle propagate with any velocity $v > v_c = 2\sqrt{kDc}$, with k being the local reaction rate, D the diffusion coefficient and c the particles' concentration. The marginal stability principle holds, requiring that for rather general initial conditions the minimal velocity is the one actually attained. The discrete structure of real systems (particles!) leads to departures from this prediction. This discrete aspect leads not only to density fluctuations, but also introduces new length-scales into the problem, which are not explicitly present in a continuous approach; these length-scales are the mean interparticle distance $l = c^{-1/d}$ and the reaction radius R, and they determine the local, small-scale structure of the system. In a 1d system (for which the classical reaction scheme is absolutely inappropriate) this leads to a stable propagation of the front with the fixed velocity $v \approx Dc$, which is due to local ordering phenomena [1,2]. The front's structure is time-independent and universal. The temporal changes of the front form from the average stem from velocity fluctuations and are not a sign of unstable propagation. Even in 3d we can show that strong departures from the classical (Fisher) scheme (which is probably good only for very low concentrations) take place already at concentrations as low as 10^{-4}. Thus a stable front propagation can occur with velocities fairly below the classical, marginally stable limit. The width of the corresponding fronts is of the order of the interparticle distance, and the front's stabilisation mechanism depends on the interplay between local and global ordering.

[1] J.Mai, I.M.Sokolov and A.Blumen, Phys.Rev.Lett. **77**, 4462 (1996)

[2] J.Mai, I.M.Sokolov, V.Kuzovkov and A.Blumen, Phys.Rev.E **56**, 4130 (1997)
