Eden model with nonlocal growth rules and the kinetic roughening in biological systems

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Patterns formation in biological growth is a nonequilibrium process which has attracted a lot of attention. Of particular interest are the rough interfaces of compact and spherical patterns observed in bacterial colonies, as well as clusters of normal and tumor cells grown on culture under controlled experimental conditions. The Eden model is a milestone stochastic process forming radial clusters with irregular (fractal) borders. In this model, new cells are irreversibly added at random positions of the neighborhood of previously existent cells. We investigate an off-lattice Eden model where the growth of new cells is performed with a probability that depends on the availability of nutrients coming externally towards the growing aggregate. Concentration of nutrients necessary for replication is assumed to be proportional to the voids connecting the replicating cell to the outer region introducing therefore an nonlocal dependence on the replication rule. Our simulations point out that the Kadar-Parisi-Zhang (KPZ) universality class is a transient that can last for long periods in plentiful environments. For conditions of nutrient scarcity we observe a crossover from regular KPZ, passing by a quenched KPZ class at the pinning transition, and finally converging to a regime of unstable growth. Our results shed light on contrasting reports on the universality class of kinetic roughening in resembling experiments on biological growth.

Financial support: CNPq, FAPEMIG and CAPES