Eden Model Modified by Age

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Complementary to the discovery and understanding of mechanisms responsible for pattern formation, fractal growth in natural processes has recently been subject of interest [1]. In particular, numerical models have been used to study pattern formation in biological systems. A classic growth model was introduced in 1961 by M. Eden as a model for the formation of cell colonies, such as bacteria or tissue cultures [2]. Since Eden's model, a rich variety of numerical models have been introduced to explain growth processes.

In this work, we present an Eden model type C [4], where the age of the cells has been introduced. Our model has been developed to explain plant callus growth [3].

The model is defined as follows. Consider a lattice and place a seed particles set, with $age = 1$. A new particle is added on one of the perimeter sites of the seed. While in the initial version C, an occupied site on the surface is chosen with equal probability, in our version the probability of the chosen site, p, depends exponentially on the age cell $p = e^{-age/\tau}$, where τ is the control parameter. In the next step, the new particle is added, with equal probability, to any of the empty sites adjacent to the chosen occupied particle.

The results that we have obtained with this model depend on the control parameter, τ. The model shows an equal behaviour to the classical Eden model when the values of τ are high. In linear geometry, we have calculated rough exponent, α_g, obtaining values of 0.5. In the limit of small τ, dynamical behaviour becomes more complex. In the initial state, some fingers appear growing around the lattice, then the fingers are enclosed and die. When all fingers disappear, the interface grows filling the holes.

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A different dynamical behaviour that we have observed appears with intermediate values of τ. This behaviour is a mixture of the aforementioned dynamics, obtaining compact clusters with higher roughness exponents $\alpha_g > 0.5$.

The first conclusion that we have obtained is that the mean age of the interface is the parameter that governs the model. In infinitum limit, with mean age of the perimeter much smaller than τ, we obtain a classic Eden model. For small values of τ, only cells with age lower than the mean age can grow, and this is the reason why fingers appear. In the case of intermediate values of τ a mixture of behaviours appears, with an increased roughness of the interface and higher values of the roughness exponent.

References

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