Susceptible–infected–recovered model with recurrent infection.

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Abstract

We analyze a stochastic lattice model describing the spreading of a disease among a community composed by susceptible (S), infected (I) and removed/recovered (R) individuals. A susceptible individual becomes infected catalytically with infection rate b. An infected individual becomes spontaneously either recovered with rate c or susceptible with rate a. This model is a modification of the SIR model by the introduction of recurrent infection. In addition to the two processes of the SIR model, S + I -> I+ I and I -> R, the model displays a third process I -> S. In epidemiology terms, this model for a much larger than c can be seem as a model which can be understood as a simplified version for the spreading of a disease in which the process S-> I and I-> S occurs many times before the occurrence of the process I -> R, in which case the individual acquires a permanent immunization. The recurrent infection is relevant to those diseases for which the full immunization is achieved after the infection has been acquired more than once. This model also can be interpreted as a model in which there is n immunization, but there is a possibility that the individual dies. By rescaling the time it is possible to reduce the number of parameter to two. We thus introduce the parameters p and q, understood as the effective immunization and recovery rates, defined by p = a/b and q = c/b. The phase diagram (p-q) was obtained by means of simple and pair mean field approaches as well as by numerical simulations of the model defined on a square lattice. We found that the critical properties place the model in the DyP universality class except when the rate c vanishes, in which case the model reduces to the contact model. In this case, the model belongs to the DP universality class. We remark that our numerical results indicate that the critical line goes continuously into the critical point of the contact model. Assuming that is the case, it was found that the axis-p is tangent to the critical line. If we interpret the model studied here as a contact process with the addition of the process I -> R, then we may conclude that the parameter c is a relevant parameter. That is, for c nonzero, the model leaves the DP universality class. The DyP universal critical behavior of the model found here confirms the idea that some modifications of a model does not change the critical behavior. Our results were published in Physica A 467 (2017) 21–29. We would like to thank the financial support from FAPESP.

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