Utrametric diffusion equation on energy landscape to model disease spread in hierarchic socially clustered population: taking specialties of covid-19 into account

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We present a new mathematical model of disease spread reflecting some specialties of the covid-19 epidemic by elevating the role of hierarchic social clustering of population. The model can be used to explain slower approaching herd immunity, e.g., in Sweden, than it was predicted by a variety of other mathematical models and was expected by epidemiologists. The hierarchic structure of social clusters is mathematically modeled with ultrametric spaces having treelike geometry. To simplify mathematics, we consider trees with the constant number p of branches leaving each vertex. Such trees are endowed with an algebraic structure, these are p-adic number fields. We apply theory of the p-adic diffusion equation to describe a virus spread in hierarchically clustered population. This equation has applications to statistical physics and microbiology for modeling {\it dynamics on energy landscapes.} To move from one social cluster (valley) to another, a virus (its carrier) should cross a social barrier between them. The magnitude of a barrier depends on the number of social hierarchy's levels composing this barrier. We consider {\it linearly increasing barriers.} A virus spreads rather easily inside a social cluster (say working collective), but jumps to other clusters are constrained by social barriers. This behavior matches with the covid-19 epidemic, with its cluster spreading structure. Our model differs crucially from the standard mathematical models of spread of disease, such as the SIR-model; in particular, by notion of the probability to be infected (at time t in a social cluster C). We present socio-medical specialties of the covid-19 epidemic supporting our model.