Scaling and predictability of substorm dynamics

V. Uritsky *(Institute of Physics, St. Petersburg State University, St. Petersburg, Russia)*

Recently, it has been found that spatiotemporal evolution of auroral emissions accompanying geomagnetic substorms follows power-law relations characteristic of multiscale dynamical systems in the vicinity of self-organized critical (SOC) point (Uritsky et al., 2002; 2003). In this talk, we propose a cellular automaton model of this effect based on a running version of 3-D non-Abelian sandpile algorithm by D.Hughes and M.Paczuski (2002) possessing a self-consistent large-scale spatial structure of sub-critical grid sites. A quantitative similarity is revealed between the critical behavior of the HP sandpile and the behavior of high-latitude ionospheric perturbations associated with localized reconnections in the magnetotail plasma sheet during the substorm development. It is shown that the critical exponents characterizing the occurrence probabilities of individual discharge events in the model are close to that governing the statistics of auroral emissions accompanying the substorm onset. Another important feature of the model is nontrivial values of roughness and growth exponents describing spatial patterns of dissipated energy density which were found to be consistent with the exponents of fractal distribution of energy deposition by the electrons precipitating in the nighttime sector of the aurora. The results obtained indicate that the dynamic magnetosphere, as a complex nonlinear system with many degrees of freedom, may belong to the same universality class as directed stochastic sandpiles with broken Abelian symmetry of local interaction rules. A possibility of creating on this basis efficient prediction techniques for stochastic spatiotemporal geospace disturbances is briefly discussed.