North Caucasus Center for Mathematical Research
of the Vladikavkaz Scientific Center of the RAS

Southern Mathematical Institute
of the Vladikavkaz Scientific Center of the RAS

International Seminar
"Operator Theory, Differential Equations and their Applications"

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Nonlinear waves in a hyperbolic predator-prey system

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We'll be talking about a mathematical model of motion of a chemosensitive substance. The local macroscopic flux of such a substance gets contributions from the diffusivity and from some deterministic motion. The latter is due to sensitivity to some signal (stimulus) and Patlak-Keller-Segel law provides a widely recognized formulation of it (chemotaxis). Usage of this law can lead to mathematical models, the formulations of which represent PDE systems of qualitatively different kinds, e.g. the parabolic systems involving a nonlinear cross-diffusion. These are perhaps most common and widely studied. The alternative is the so-called hyperbolic models. The simplest of them is the so-called Cattaneo model for chemosensistive motion. It relies on the hyperbolic flux equation originally proposed by Cattaneo for the heat conductivity. We'll be discussing a model of such a kind with the usual predator-prey local kinetics. The focus will be upon the case when the Cattaneo flux equation is a conservation law. It presumes a special relation between the diffusivity and sensitivity coefficients. Fortunately, there are some pieces of argument in the biological literature for relevancy of such relations to some real populations, e.g. copepods \emph{Harpacticoida}. The mentioned conservatism allows us to consider the shock waves. We find several explicit examples in some limit cases. In the general case, we use an ansatz that bring the system into a form that is very tractable numerically and employ the numerical analysis for extending the explicit solutions to a wider parametric area. As a result, we discover smooth solitary waves, which turn out to be quite sustainable to small and moderate initial perturbations. Nevertheless, the perturbations cause shedding the predators from the main core of the wave, which can be treated as a settling mechanism. Besides, the localized perturbations make waves, colliding with the main core and demonstrating peculiar quasi-soliton phenomena sometimes resembling the leapfrog playing. An interesting side result is the onset of the migration waves due to the explosion of overpopulated cores. One more feature is spontaneous concentrating of the predators in certain narrow areas.

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