This project deals with energy cascade generation in nonlinear system of surface water waves under narrow initial excitation. This problem is of the utmost importance both for laboratory experiments and for real physical phenomena, e.g. frequency downshifting, wave breaking, freak waves nonlinear excitation. Surface water waves are usually studied in the frame of kinetic wave turbulence theory, with description basing on statistical approach and resulting in power energy spectra. However, in a wave system with a narrow initial excitation statistical description does not describe the wave field evolution satisfactory, at least at the initial stage with just a few energetically active modes.
Quite recently, a novel qualitative model of dynamical energy cascade in 3- and 4-wave systems with narrow initial excitation has been proposed, based on 1) resonance clusters of special structure, and 2) modulational instability as first step of a dynamical cascade. This cascade is described by a dynamical system (that is, no statistical assumptions are needed) and yields a discretized energy spectra of a certain structure. Contrary to the statistical description, the very appearance and various characteristics of dynamical energy cascade depend, first of all, on the initial and boundary conditions of the wave systems. Besides, such ground-breaking phenomena as wave propagation in inhomogeneous medium, dissipation rates and wave breaking can substantially modify cluster dynamics. The overall goal of this project lies in systematic theoretical, numerical and laboratory study of (1) resonance clustering originating from modulational instability, (2) non-conservative effects such as wave breaking and wind pumping, (3) current's impact on nonlinear wave propagation.

The expected outcome of the project is a description of

1. A basic model describing discretized energy spectrum in a 4-wave system of water waves;
2. Energy and momentum dissipation rates due to wave breaking; modified basic model (pumping and dissipation included);
3. Blocking phenomenon in the case of opposite current; effect of the initial steepness; modified basic model (wave-current interactions included);
4. Conditions of phase synchronization in a cascading cluster (a possible mechanism for freak wave formation), at least in the frame of the basic model.