New quantum states in polaritonic fluids of light
Descritpion for the general public

The project concerns the study of exciton polaritons, very interesting quantum particles that can be applied in various fields such as extremely accurate interferometric measurements, ultra-low power lasers or processing of information with very low energy losses.

Exciton polaritons are formed in semiconductor materials with a specially designed structure, due to the strong coupling of photons and excitons, material particles composed of electrons and "holes". Polaritons are particles having a "Schrodinger cat" structure. The quantum state contains two alternatives: cat alive when the exciton exists, or dead cat when instead of an exciton a photon exists in the system.

The project includes three research tasks. The first task involves proposing a method for obtaining the so-called topological quantum states using a new method, which involves the use of polariton properties. Topological states are currently at the forefront of theoretical and experimental research of condensed matter physics. In contrast to traditional transport, topological states are resistant to structural weakness and defects. As a result, we do not have to worry about scattering on defects or waveguide bends. The implementation of this type of states in the visible light range and at room temperature has not yet been achieved, and could be a significant technological breakthrough.

The second task is to develop methods for the description of the so-called polariton condensates with a long lifetime. Bose-Einstein condensate is a state of matter in which particles are characterized by a high degree of coherence. It can be compared to an army moving in rhythm and unison, as opposed to random crowd corresponding to a typical gas or liquid. Polariton condensates have a limited lifetime of the order of picoseconds, but with the advancement of technology it becomes constantly longer. This requires the development of new methods of theoretical modeling.

The third task concerns condensates in the unstable regime, that has been observed experimentally in recent years, in particular in organic condensates, which are believed to bring practical applications. Properties of unstable condensate are not well known. The existence of instability may hamper their practical application, which is why we plan to develop a method to stabilize the condensate in the unstable regime, eg. by appropriate design of the semiconductor sample.