Abstract for the general public in English
Proposal title: Anti-Stokes Cooling for Fluidics

Temperature is one of the most important parameters in physics, chemistry and biology. It determines the feasibility and rate of many processes like mixing of compounds, speed of chemical reactions or metabolism of living organisms. Yet, temperature is often only controlled as a global parameter of a large volume slowly changing in time, e.g., by electric refrigerators or hot plates.

Recent advances in laser-heating of small absorbing metal nanoparticles of sizes well below micrometers pushes temperature control to the micro- or even nanometer scale, comparable of the size of bacteria and cells. Significant reduction of the volume allowed for much faster, even rapid changes of temperatures. This leads to the development of many applications ranging from medical treatments and local heat-assisted chemistry to fluidic applications allowing to construct small devices to trap and manipulate molecules for the study of Alzheimer's disease-related metabolic processes.

Cooling in a very small volume is much harder to realize than heating. Laser cooling is one of the possible options with the most efficient cooling of rare earth doped glasses and crystals. This effect is based on luminescence, which can be excited with light of lower energy than the emitted one. The missing energy comes from the vibrational motion of glass or crystal atoms called phonons. The process is called anti-Stokes luminescence and usually is very week, but in case of some rare earth ions, e.g., Ytterbium ions, it might be efficient enough to cool down microscopic volumes. The temperature decrease strongly depends on the environment of the cooled particle, it is possible to reach very low, cryogenic temperatures in vacuum, but in liquids the cooling process is very limited. One of the greatest limitations is that it is limited to heavy water (D_2O) and a maximum of 20 deg. C cooling was obtained for a single microscopic particle in have water.

It this project we will try to solve the problem of cooling in water (H_2O), what would have a great impact at biochemical studies. We will simultaneously work on remote temperature measurements using scattered light, so called Raman scattering. We will also incorporate the local cooling to observe the motion of liquid solution in a temperature gradient and combine it with salty solutions, which contain small ions, which can be attracted or repelled from the could source.

The optical cooling of small particles in water would have tremendous influence on biological studies, as it will allow for measurements of the specimen properties and its response to low temperature stress. It may also find applications in local cryotherapy to disable or kill diseased or cancerous cells.