In this project, we are going to study the properties of different semiconductor nanocrystals using experimental methods of optical spectroscopy, such as ultralow frequency Raman scattering or micro-photoluminescence. The nanometer-sized objects investigated in this project consist of two dissimilar semiconductor materials joined together to form spherical core-shell dots, cylindrical dot-in-rods or flat core-shell nanoplatelets. These so called colloidal nanocrystals are additionally capped with organic ligand molecules and for this reason they can be selectively attached to different biological objects. The combination of ease of fabrication and processing and flexibility in property-tailoring has turned this kind of nanostructures into promising materials for a multitude of applications, including biomarkers (e.g. ZnSe/ZnS nanocrystals for selective labeling and detection of human antibodies), light-emitting diodes (e.g. ZnSe/ZnS structures for ultraviolet and blue light emission), lasers (e.g. random lasers involving colloidal CdSe/ZnS nanocrystals plasmonically coupled to Ag nanoparticles), or luminescent solar concentrators (using e.g. CdSe/CdS nanorods).

For the purposes of this project, we are going to synthetize colloidal nanocrystals using wet-chemistry methods. The main focus of our research will be on the ultralow frequency acoustic vibrations of these colloidal nanocrystals. We are going to experimentally determine the influence of nanocrystal size, shape, architecture and composition on the vibrational properties of such ultra-small objects. It turns out that the ultra-small sizes of colloidal nanocrystal have significant effect not only on their electronic properties but also on their vibrational dynamics. As a matter of fact, colloidal nanocrystals can be regard as completely zero-dimensional systems, where both electronic states and vibrational motion are fully quantized. This have many important consequences, which manifest themselves practically in all electronic, thermal and optical phenomena in nanocrystal structures. In theory, by tuning size, shape or composition of colloidal nanocrystals, one can engineer their vibrational properties in a desired way, and obtain e.g. more efficient light emitters. Moreover, the knowledge about the vibrational dynamics of colloidal nanocrystals is important because monitoring the acoustic vibrational frequency of very small nanoparticles as molecules adsorb on their surface has the potential to enable mass-based sensing or even molecule-selective weighing in the nanoscale. Nevertheless, before such exciting ideas can be implemented, it is important to thoroughly understand the vibrational properties of different colloidal nanocrystals and to study the effect of nanocrystal environment on the discrete frequencies of acoustic vibrations confined in these structures.

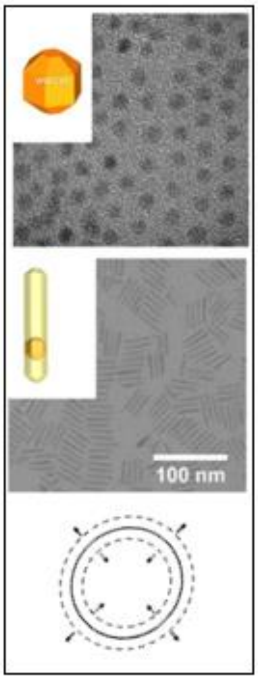

Figure 1. Transmission Electron Microscope images of two different colloidal nanocrystals (dots and dot-in-rods). Bottom: vibration of a spherical nanocrystal.