Microcavity Raman Laser and Its Application in Single-Nanoparticle Detection

Yun-Feng Xiao
Peking University

Stimulated Raman scattering holds great potential for various photonic applications, such as label-free high sensitivity biomedical imaging, and for extending the wavelength range of existing lasers, as well as for generating ultra-short light pulses. In high Q microcavities, stimulated Raman scattering, also called Raman lasing, has been experimentally demonstrated to possess ultra-low thresholds, due to the greatly increased light densities in microcavities. Such microcavity Raman lasers have great potential for sensing applications, using the following mechanisms. Raman lasing can initially occur in any of the two initially degenerate counter-propagating traveling wave modes. These two traveling wave modes couple to each other due to backscattering when a nanoscale object binds to the microcavity surface. For a sufficiently strong coupling, in which the photon exchange rate between the two initial modes becomes larger than the rates of all the loss mechanisms present in the system, two new split modes form and can lase simultaneously. Thus, by monitoring the mode splitting, i.e., the beat frequency of the split-mode Raman lasers, ultrasensitive nanoparticle detection can be realized. In this talk, we report the experimental demonstration of single nanoparticle detection using split-mode microcavity Raman lasers. The principles underlying this Raman lasing sensor are first analyzed and demonstrated in air, by controllably binding or removing single 50-nm-radius polystyrene (PS) nanoparticles to and from the cavity surface using a fiber taper, and measuring the changes in the beat frequency of the two split Raman lasers. We then perform real-time single nanoparticle detection in an aqueous environment using this method.