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Thesis abstract

Biophotonics characterisation of up-conversion nanoparticles

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Up-conversion materials have attracted enormous attention for a broad range of applications in biological imaging, energy-related light harvesting, and sensing, due to their unique physicochemical properties. However, the comprehensive understanding and characterization of up-conversion nanoparticles for novel applications remain challenging. In this thesis, we set four goals to refresh the present characterization and provide a wider and deeper cognition of these up-conversion nanoparticles. After the delicate design of optical setups and nanomaterials, we realise the property-based resolution enhancement, optical force sensitivity improvement, Rayleigh scattering modulation, and a new water-soluble molecular up-conversion probe.

Experimentally and theoretically, we upgrade the nanoscopy by applying the unique nonlinearity of up-conversion nanoparticles to conventional confocal microscopy. We develop the novel measurement of the three-dimensional optical force of optical tweezers and realize the attonewton-level force sensitivity via revolutionising the configuration and data collection and analysing based on the property of up-conversion nanoparticles. We refresh the morphology-independent method of engineering Rayleigh scattering at the nanoscale level based on the resonance effect of up-conversion nanoparticles. We develop water-soluble molecular up-conversion materials based on the ionic equilibrium of up-conversion dyes.

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