

Manipulating Small Particles with Light

From trapping particles to sorting them by their material properties

Monday, 2 November 2026 | 13:00–14:30

Biwako-Kusatsu Campus (BKC), Ritsumeikan University

Frontier Research Center for Natural Disaster Mitigation [Meeting Room 2 on the second floor]

We can trap and move tiny particles using light alone. But can we also use differences in what is inside them to select the particles we want?

The key lies in how materials interact with light. This seminar highlights two approaches: changing the chemical environment to change how particles move under the same light, and using infrared light matched to molecular vibrations to strengthen the forces acting on them. We explore how techniques for trapping particles with light can lead to sorting materials and rearranging particle assemblies.

Programme | Full abstracts follow on the next pages

13:10–13:50 | Special Lecture 1

Roger Bresolí-Obach

Institut Químic de Sarrià (IQS), Universitat Ramon Llull, Barcelona, Spain

Chemically programmable optical forces: from single particles to optical matter

Optical forces can be adjusted by changing the chemical environment or the state of a particle, without changing the illumination. The talk introduces control of particle trapping and extensions to particle assemblies whose structures respond to chemical stimuli.

13:50–14:30 | Special Lecture 2

Tetsuhiro Kudo (Toyota Technological Institute)

Chemically Selective Optical Manipulation and Trapping via Molecular Vibrational Resonance using Mid-Infrared Quantum Cascade Lasers

Mid-infrared light matched to molecular vibrations enhances the forces acting on particles. The talk explores the potential for sorting particles by their material properties, drawing on the relationship between light absorption and particle motion and recent results on mid-infrared optical tweezers.

Talk in Japanese; slides in English (planned).

Researchers and students are warmly welcome, including those who do not specialise in optical manipulation.

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Project title (translated): "Development of Technologies to Identify, Separate and Analyse Nanoscale Quantum Individuality Using Optical Forces"

The two lectures listed above are the open sessions of the FY2026 Joint Mini-Workshop.

Special Lecture 1 | 13:10–13:50

Chemically programmable optical forces: from single particles to optical matter

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Abstract

Optical forces let us trap, move and assemble particles with light. Their strength and sign are usually set by the optical configuration of the incident field and by the size and refractive index of the particle. Once an experiment starts, these parameters stay fixed. We show that chemistry adds a reversible control dimension. By shifting chemical equilibria and photochemical states of the trapped object, we change its optical response and therefore the force it feels. Two routes emerge. In the first, ground-state resonant absorption modulates the linear polarisability of the particle.[1] In the second, excited-state dynamics, including triplet-state populations, create nonlinear contributions to the force. Both routes modulate trapping without any change to the optical set-up.[2] I will present single-particle demonstrations and first steps towards collective optical matter that reorganises in response to chemical stimuli. Together, these results turn optical trapping into a tool for physical chemistry and point to light-driven materials whose structure follows their chemical environment.

Funding

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References

[1] L. Torrella-Adriaensen, (et al.), R. Bresolí-Obach, pH-gated absorption forces with polyaniline-doped polystyrene microparticles. *ACS Photonics* **2026**, 13, 4577.

[2] R. Bresolí-Obach (et al.), Triplet-state force enhancement in phenalenone-doped particles, controlled by dissolved oxygen. *Adv. Opt. Mater.* **2022**, 10, 2200940.

Special Lecture 2 | 13:50–14:30

Chemically Selective Optical Manipulation and Trapping via Molecular Vibrational Resonance using Mid-Infrared Quantum Cascade Lasers

Tetsuhiro Kudo | Toyota Technological Institute

Talk in Japanese; slides in English (planned).

Abstract

We demonstrate chemically selective optical manipulation and trapping using mid-infrared (MIR) quantum cascade lasers. By tuning the MIR wavenumber to excite the fundamental vibrational modes of target microparticles (such as Si-O-Si and C=O bonds), MIR optical forces (absorption force, scattering force and gradient force) are enhanced via molecular vibrational resonance. First, we show that the particle velocity in evanescent fields correlates well with the MIR absorption spectrum. Second, we demonstrate a spectrally sharp enhancement of MIR optical forces within the Reststrahlen band, where the optical resonance exhibits metallic-like behavior. Third, we present the recent results of mid-infrared optical tweezers. MIR light may offer a promising new route for chemically selective material sorting.