化学科談話会のお知らせ

日時：2023 年 7 月 31 日（月）16:00～17:30

場所：大阪公立大学杉本キャンパス理学部第 10 講義室（E211）

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Optical Resonance Force: how to finely control the induced optical force onto a micro-/nano- object

So far, the optical trapping potential has been only controlled by tuning the optical conditions. Herein, for the first time, we report an approach, in which the induced optical force or optical potential is controlled, by an external chemical stimulus. The key to realize this is optical trapping in conjunction with resonant excitation, the so-called optical resonance effect (ORE). Recently, we reported that the optical resonance force can be heavily enhanced at an interface (a 4-fold trapping stiffness enhancement compared to the 10-35% in bulk solution).[1] The resonance force can be even stronger than the scattering and gradient force combined. This unprecedented trapping stiffness enhancement can be attributed to the simultaneous use of two different lasers. Typically, the trapping laser is resonant with the S_0-S_1 transition. Instead in our scheme, a widefield laser excites the dye to the first singlet excited state (S_0-S_1) while the trapping laser is resonant with an upper excited state transition (S_1-S_n). Under this condition, the number of optical resonant cycles (S_1-S_n-S_1 vs S_0-S_1-S_0) is widely increased due to the shorter S_n lifetime compared to S_1 (picosecond vs nanosecond range).
In principle, the upper excited-state optical resonant cycle concept can be expanded to other types of excited states, such as triplets.[2] For this purpose, phenalenone, a well-known triplet photosensitizer, is embedded inside polystyrene particles. The optical resonance effect is achieved through a two-laser system: a 405 nm widefield laser to excite the phenalenone molecules to T_1 and a 488 nm trapping laser to induce the T_1-T_n-T_1 resonance cycle (as phenalenone has a positive transient absorption signal at that wavelength). Since oxygen is an excellent triplet quencher, the triplet populations and hence the optical force is controlled by changing the dissolved oxygen concentration. The results presented here pave the way to chemically control the optical force through ORE with promising applications in several research fields ranging from physics to biology.

Reference

[1] R. Bresolí-Obach, et al. *ACS Photonics* **2021**, 8, 1832-1839.
[2] R. Bresolí-Obach, et al. *Adv. Opt. Mat.* **2022**, 10, 2200940.

Dr. Boris Louis

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Optical binding outside the irradiation area: The creation of primeval optical matter

Optical binding has recently gained considerable attention because it enables the light-induced assembly of many-body systems; however, this phenomenon has only been described between directly irradiated particles. Here, we demonstrate that optical binding can occur outside the focal spot of a single tightly focused laser beam. By trapping at an interface, we assemble up to three gold nanoparticles with a linear arrangement which fully-occupies the laser focus. The trapping laser is efficiently scattered by this linear alignment and interacts with particles outside the focus area, generating several discrete arc-shape potential wells with a half-wavelength periodicity. Those external nanoparticles inside the arcs show a correlated motion not only with the linear aligned particles, but also between themselves even both are not directly illuminated. We propose that the particles are optically bound outside the focal spot by the back-scattered light and multi-channel light scattering, forming a dynamic optical binding network.

This is related to the following paper: https://www.nature.com/articles/s41467-022-33070-w

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