

光で操るナノ物質のマクロな運動

- ナノ物質の選択的^o光マニピュレーション

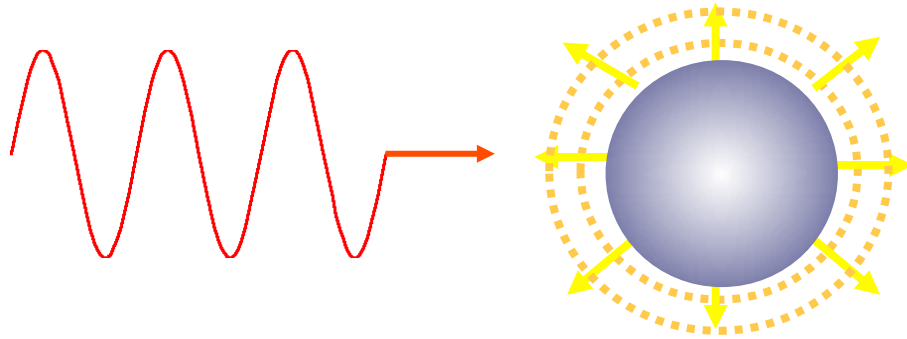
What is a “radiation force”



An interstellar cloud caught in the process of destruction by strong *radiation pressure* from a nearby hot star. Snapped by the Hubble telescope (<http://hubblesite.org/>)

輻射力

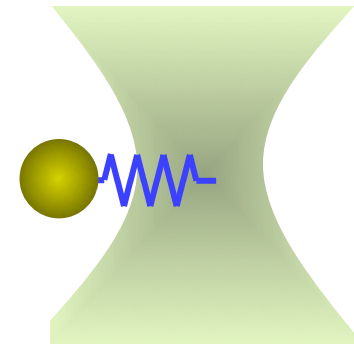
散乱力、吸収力



$$F_z = \frac{1}{8\pi} \{ \sigma_{scat} (1 - \overline{\cos\theta}) + \sigma_{abs} \} |E^{(i)}|^2$$

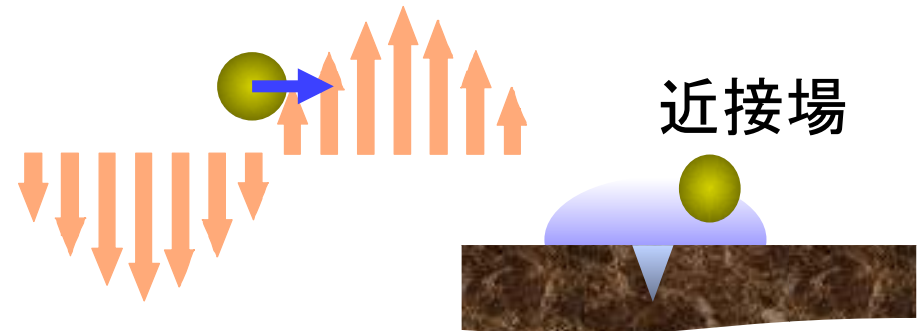
勾配力 (Dipole force)

集光ビーム



$$\langle F \rangle = \frac{1}{2} \alpha \nabla |E_i| \quad \alpha: \text{分極率}$$

定在波



レーザーピンセット

A. Ashkin, et al. Opt. Lett. 11, 288 (1986)
Optical tweezers

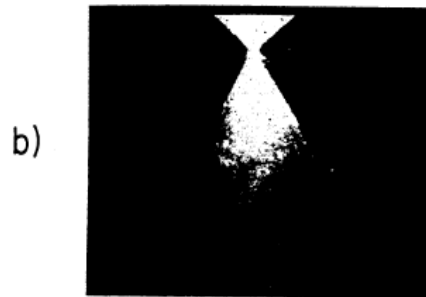
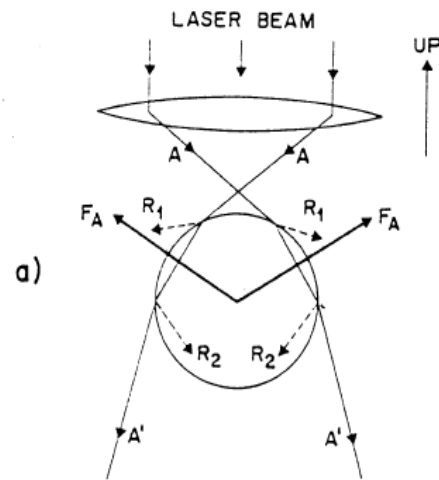
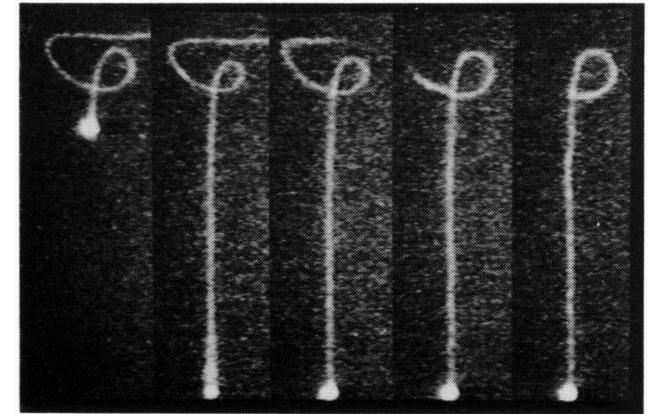
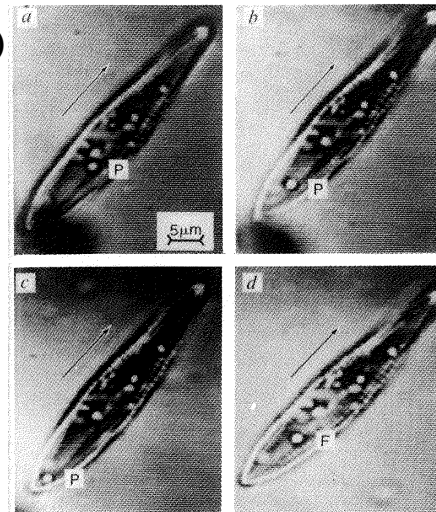
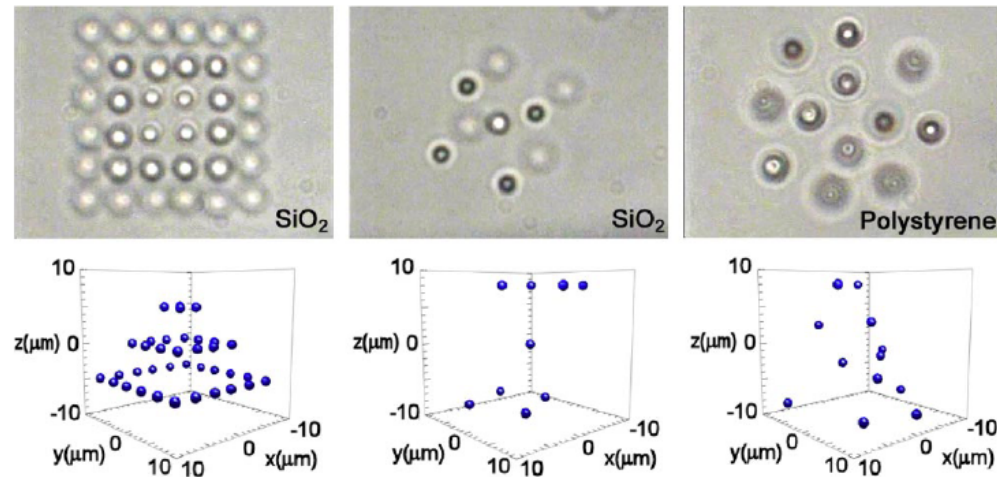


Fig. 1. a) Diagram showing the ray optics of a spherical Mie particle trapped in water by the highly convergent light of a single-beam gradient force trap. b) Photograph, taken in fluorescence, of a 10- μm sphere trapped in water, showing the paths of the incident and scattered light rays.



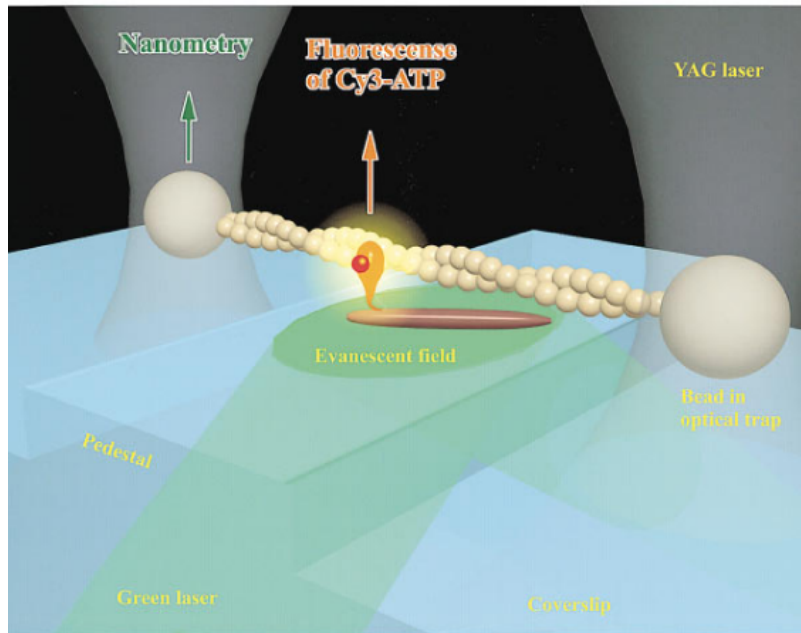
TT Perkins, et al., Science **264**,5160 (1994)

A. Ashkin et al., Nature **330**,769 (1987)

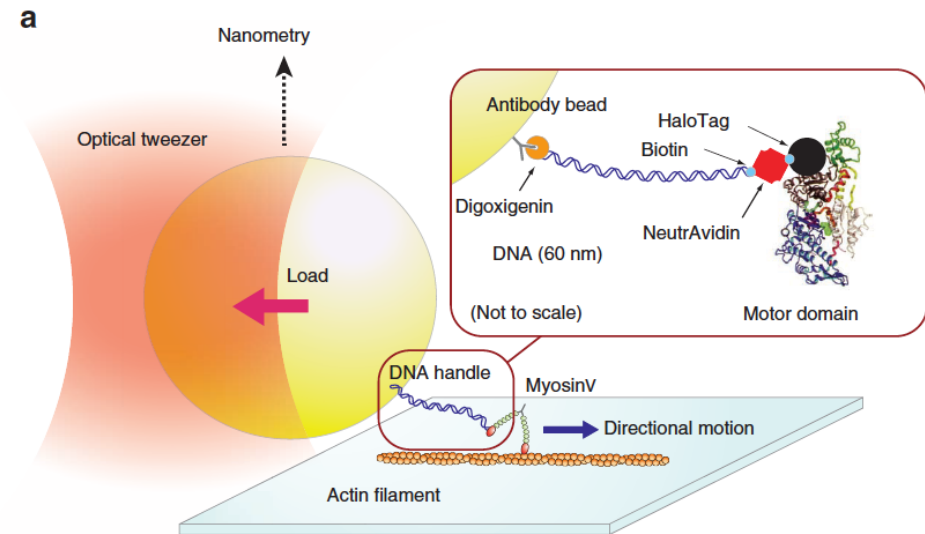


P. J. Rodrigo et al. Appl. Phys. Lett. **86**, 074103 (2005)

光トラッピングによる単分子計測



A. Ishijima et al, Cell, 92, 161-171 (1998)



K. Fujita, et al., Nat. Comm. 3, Article number: 956 (2012)

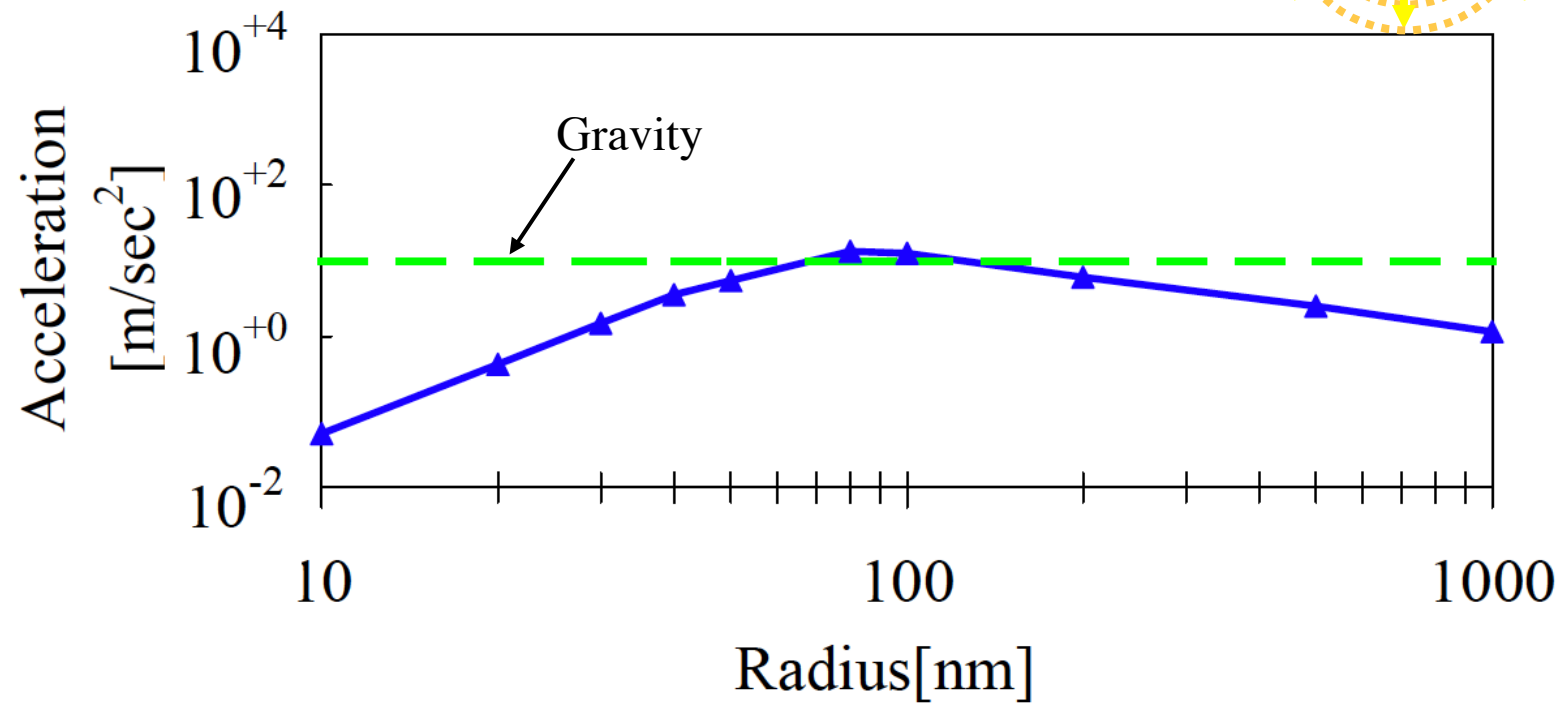
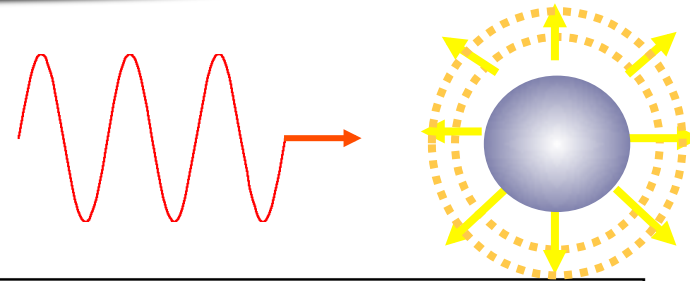
ナノ物質を光操作する試み

ナノ光マニピュレーションの困難

- 極端に小さな散乱断面積
 - 外乱
 - 如何に観測する？
-

微小物質に対する輻射圧のサイズ依存性

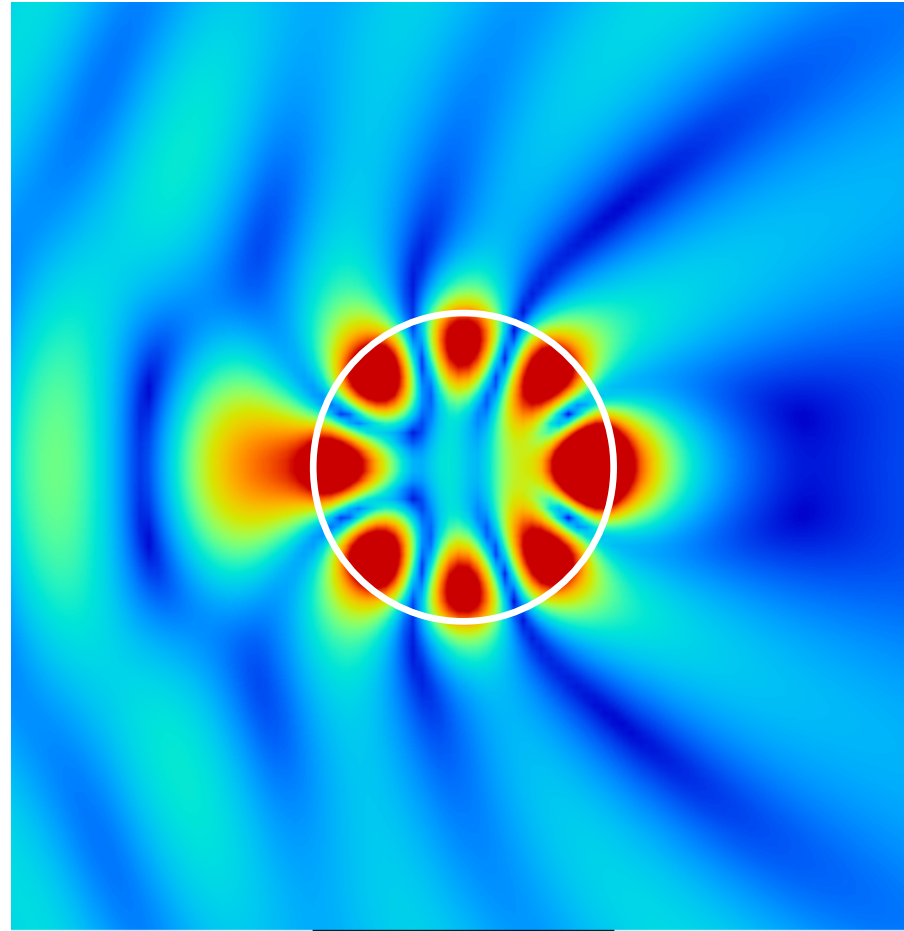
$$\varepsilon = 5.6, I = 50 \text{ W/cm}^2$$



ナノ物質の操作は可能か？

散乱電場の様子(マクロ、非共鳴)

光の方向

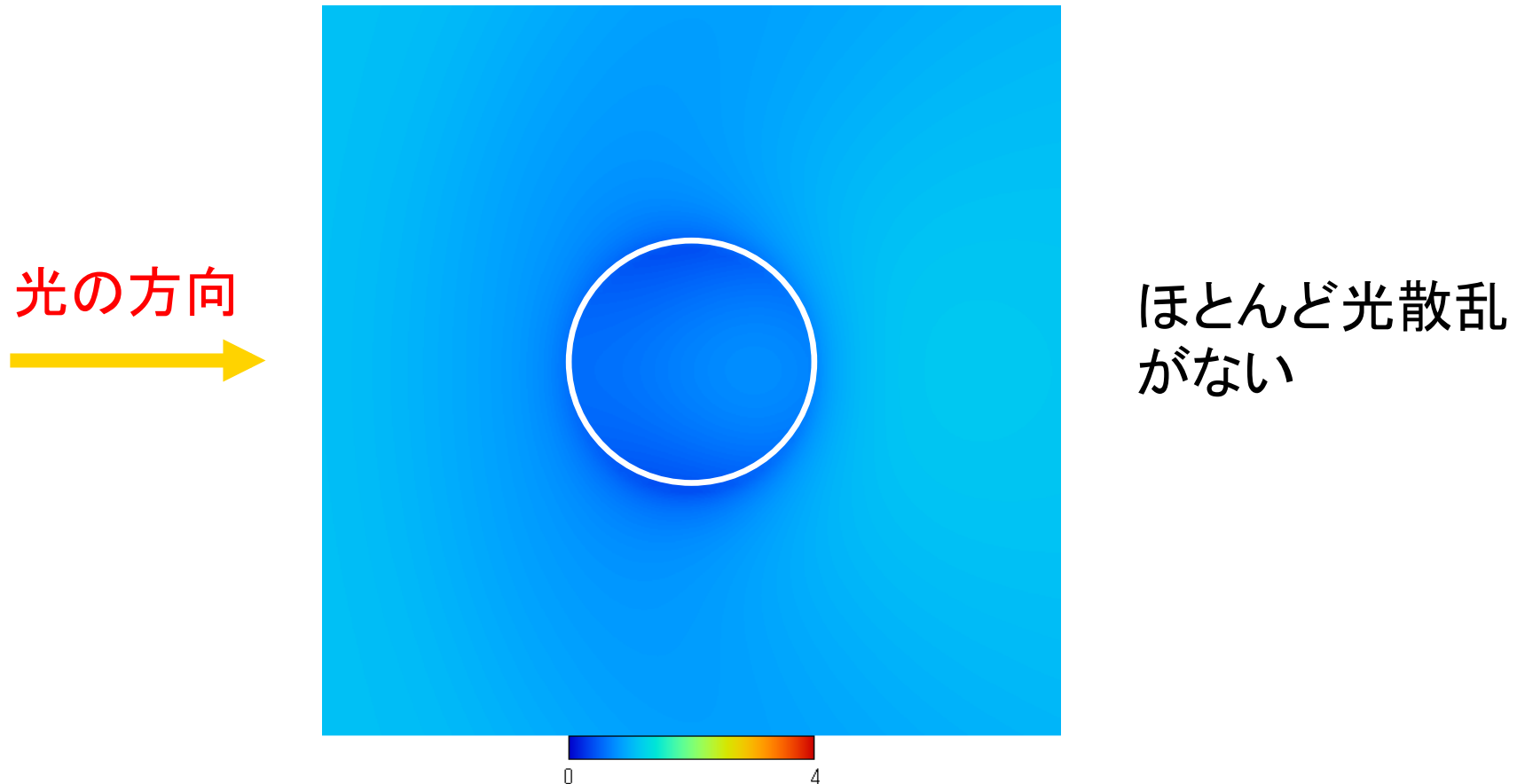


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半径1マイクロメートル (波長2205.7nm)

ナノ領域の操作は可能か？

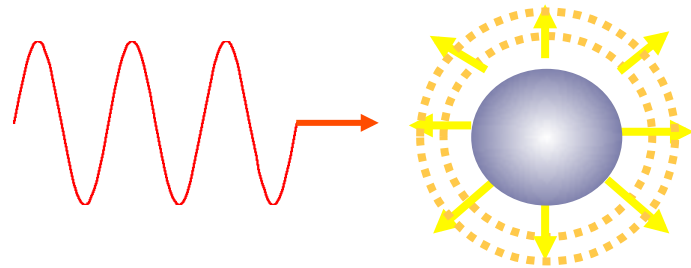
散乱電場の様子(ナノ、非共鳴)



半径50ナノメートル (波長390.75nm)

波長よりずっと小さなナノ物質に力を働かせる事は困難？

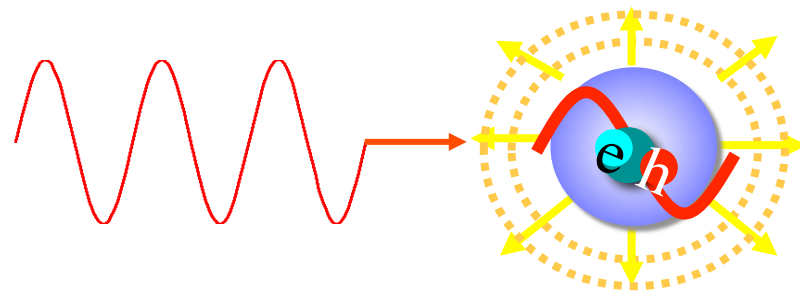
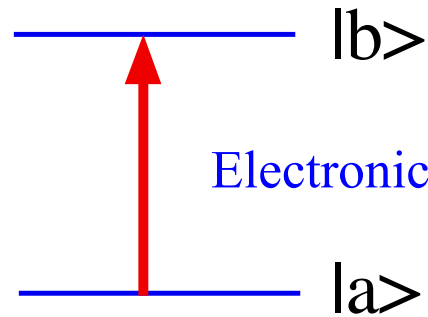
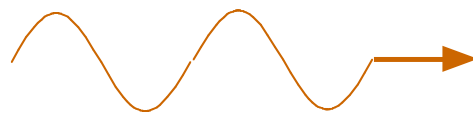
共鳴光マニピュレーション



T. Iida and H. Ishihara, Optics Lett. **27**, 754, (2002)

R. R. Agayan, F. Gittes, R. Kopelman and C. F. Schmidt, Appl. Opt. **41**, 2318 (2002)

Molecules, Nanostructures



Resonant enhancement of
the induced polarization



Enhancement of the radiation force