Measuring colloidal forces with TIRM

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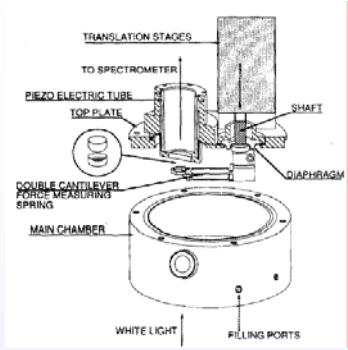
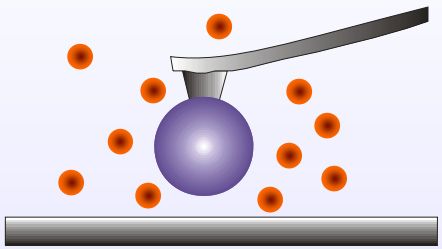
- Messmethoden
- Total Internal Reflection Microscopy (TIRM)
- Experimental set-up
- Force resolution

Direct measurements of colloidal forces

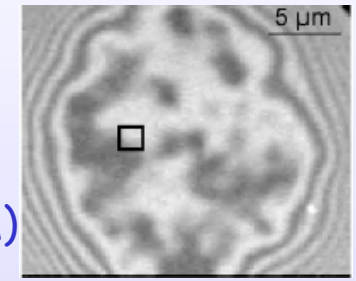
problem: typical forces in the nN to fN range

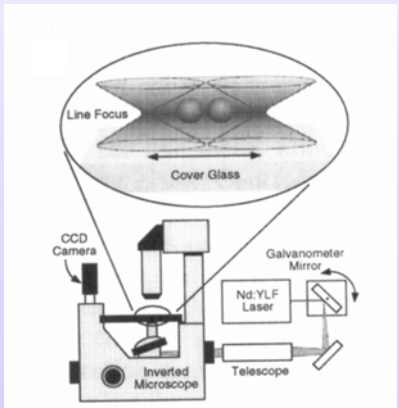




- Surface force apparatus (SFA)
  - J.N. Israelachvili, Intermolecular and surface forces, Academic Press (1991).

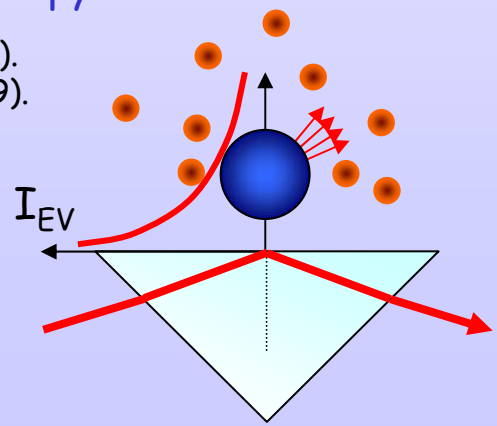
- Atomic force microscope (AFM)
  - Ducker, Senden, Pashley, Nature, **353**, 239 (1991).
  - Milling,Vincent, J. Chem. Soc., Faraday Trans. **93**, 3179 (1997).





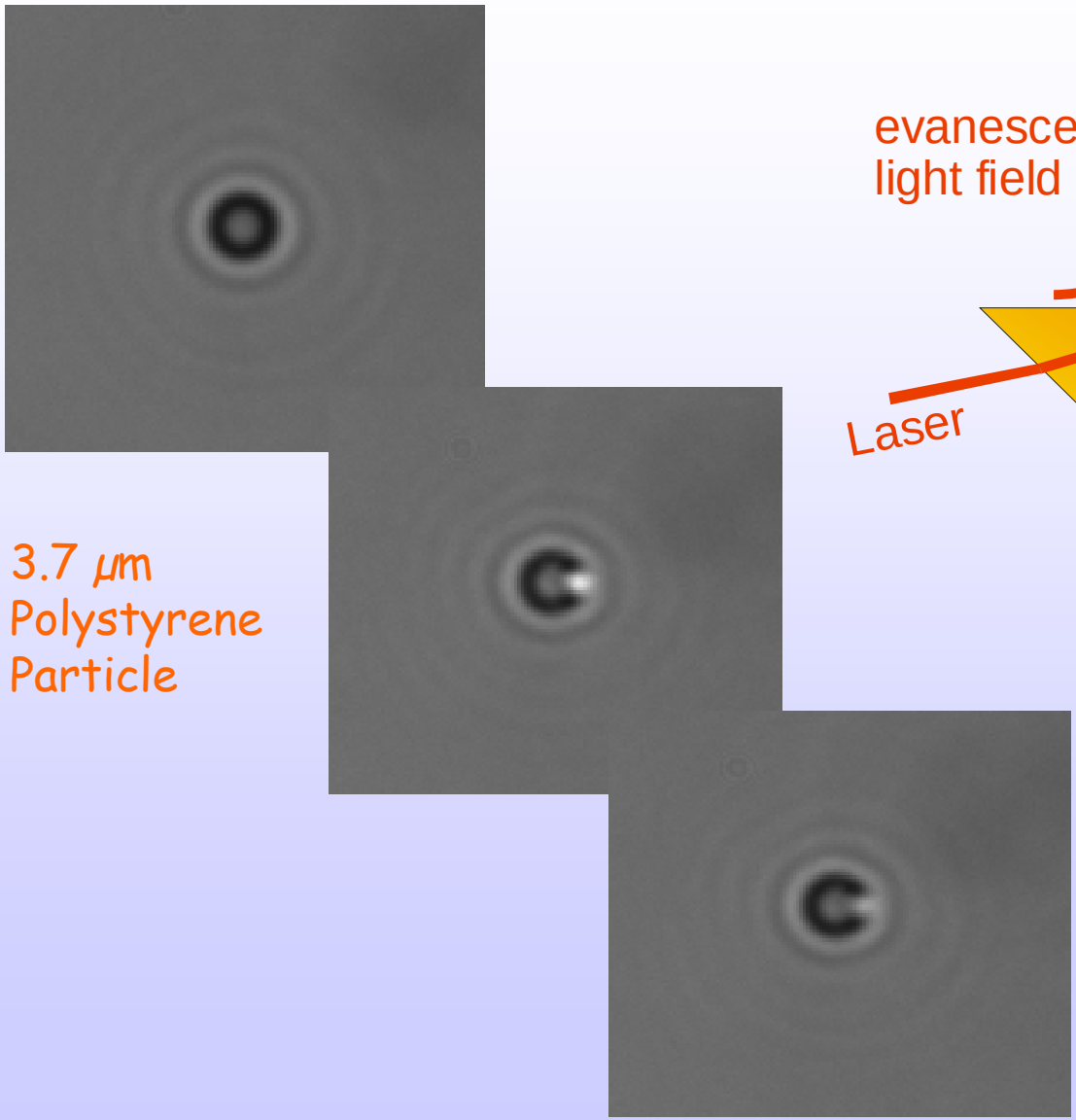
- Reflection Interference Contrast Microscopy (RICM)
  - Rädler, Sackmann, J. Phys. II France, **3**, 727 (1993).
  - Schilling, Sengupta, Goennenwein, Bausch, Sackmann, PRE **69**, 021901 (2004).

- Scanning optical tweezer and videomicroscopy
  - Verma, Crocker, Lubensky, Yodh, PRL **81**, 4004 (1998).
  - Crocker, Matteo, Dinsmore, Yodh, PRL **82**, 4352 (1999).

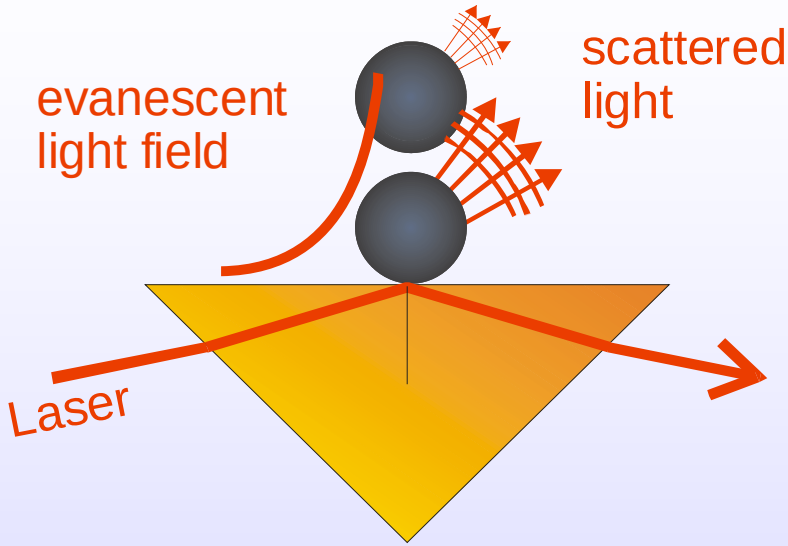


- Total internal reflection microscopy (TIRM)
  - Walz, Curr. Op. Coll. Interf. Sci. **2**, 600 (1997).
  - Prieve, Adv. Coll. Interf. Sci. **82**, 93-125 (1999).
  - Bike, Curr. Op. Coll. Interf. Sci. **5**, 144 (2000)

Single particle evanescent light scattering



3.7 μm
Polystyrene
Particle



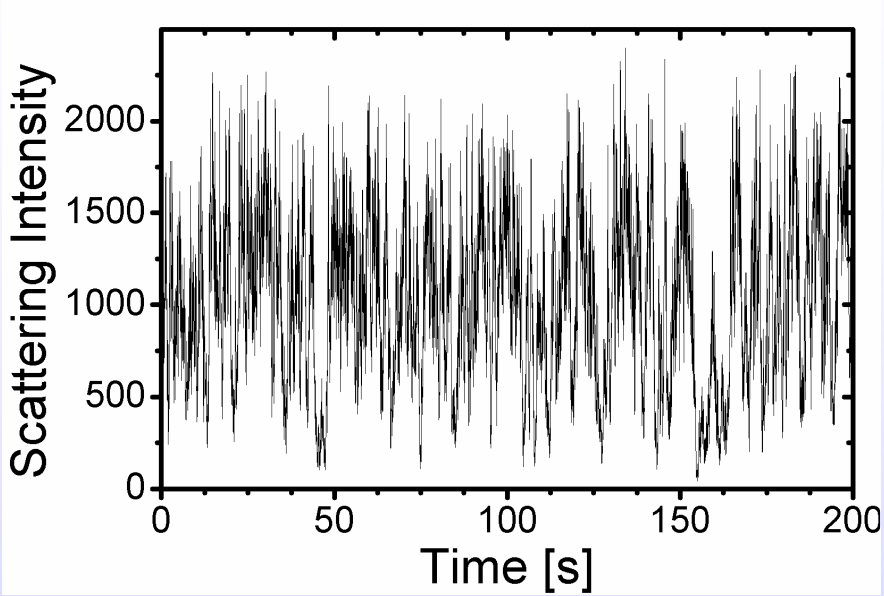
$I_{sc} \sim I_{ev} \sim \exp\{-\beta z\}$

Scattering intensity
⇔
Particle-Wall Distance

Details on evanescent scattering: Helden et al. Applied Optics, in Press, (October 2006)

The TIRM-Method

TIRM: Total Internal Reflection Microscopy



Scattering intensity reflects Brownian motion perpendicular to the substrate

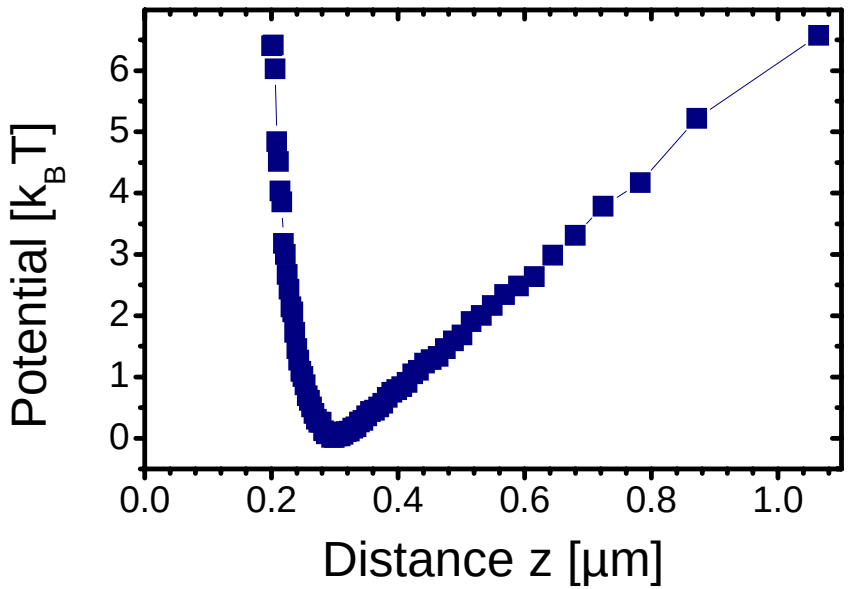
Boltzmann-Equation:

$$P(z) = A \exp[-\Phi(z)/k_B T]$$

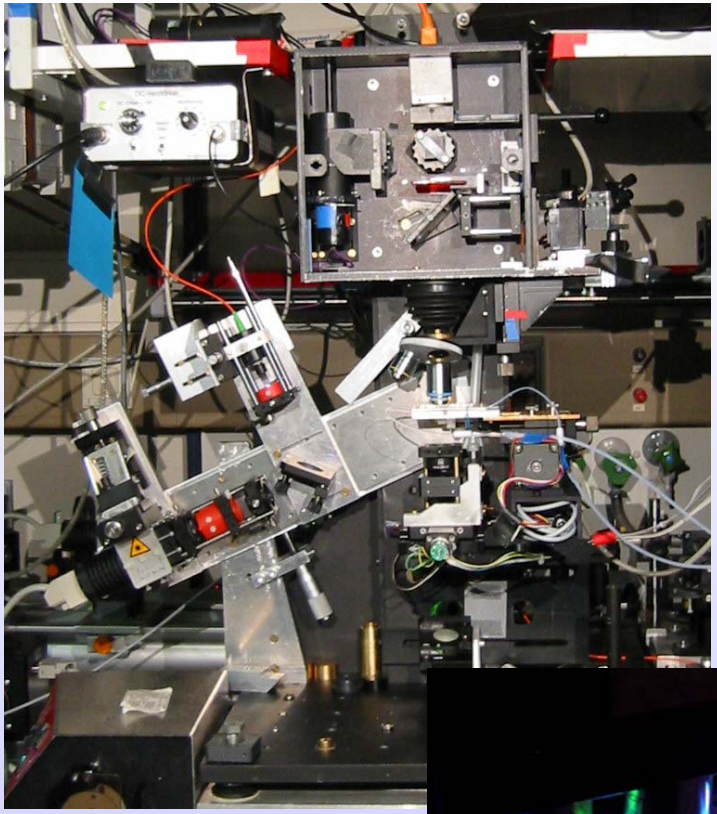
Probability ⇔ Potential

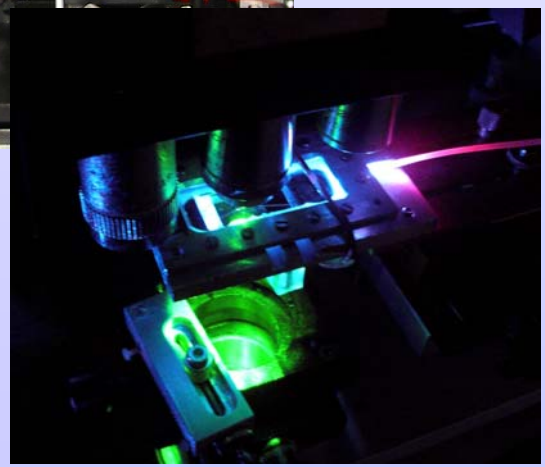
Interaction potential with femtonewton resolution!

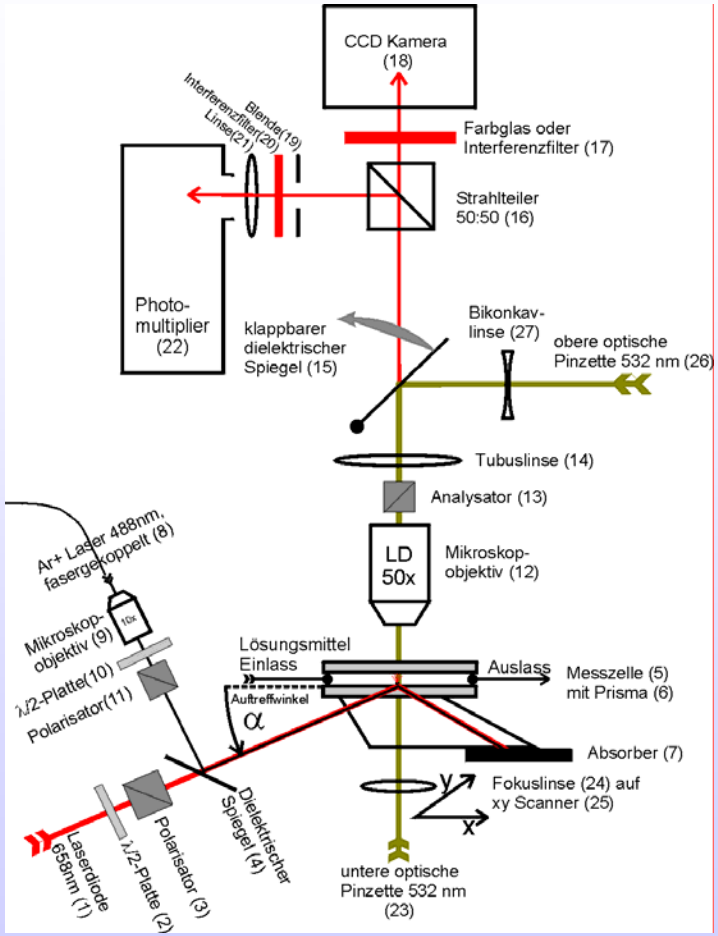
Here: electrostatic repulsion + gravity



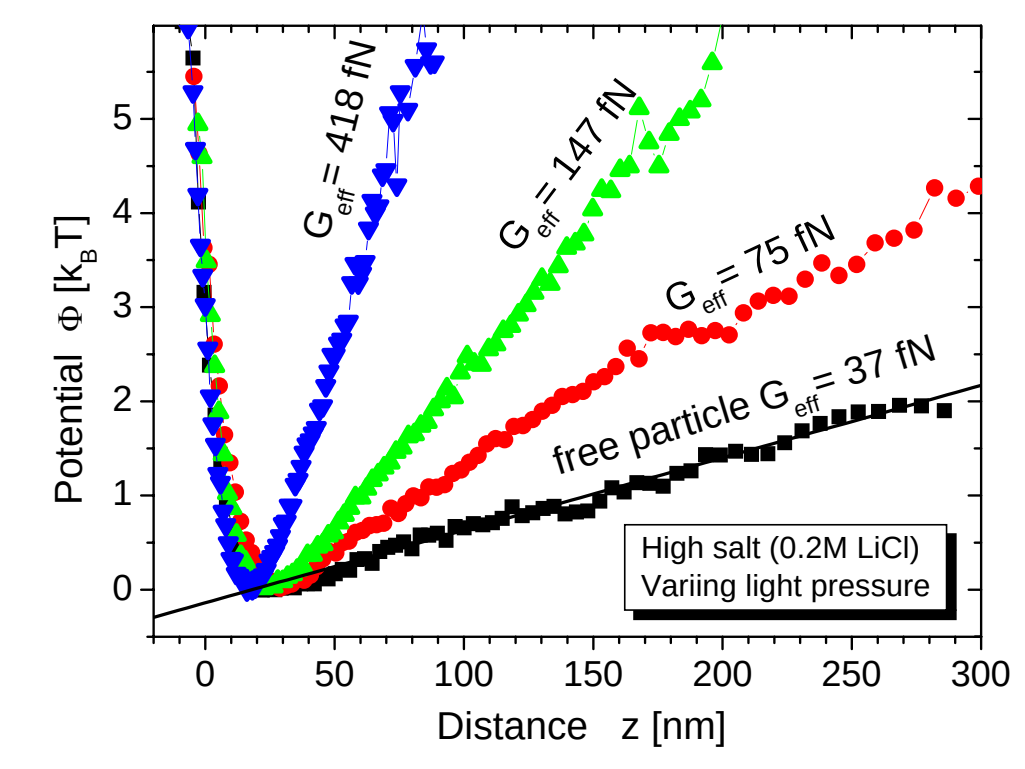
Experimental set-up

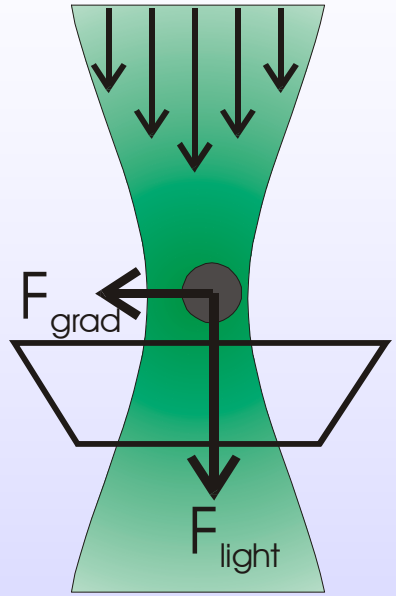






Tuning interaction potentials by light forces- Force resolution of TIRM





Light pressure (F_{light})

Gradient force (F_{grad})

$$\Phi(z) = B\exp(-\kappa z) + \underbrace{(G - F_{Light})}_{G_{eff}} z$$