Optical Tweezers

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Overview

- Goal: to observe Brownian motion of magnetite microspheres through a controlled heating environment
- Success with stable trapping of silica microspheres with new laser of 1 μm
- Difficulty with trapping of magnetite microspheres with both new and previous laser

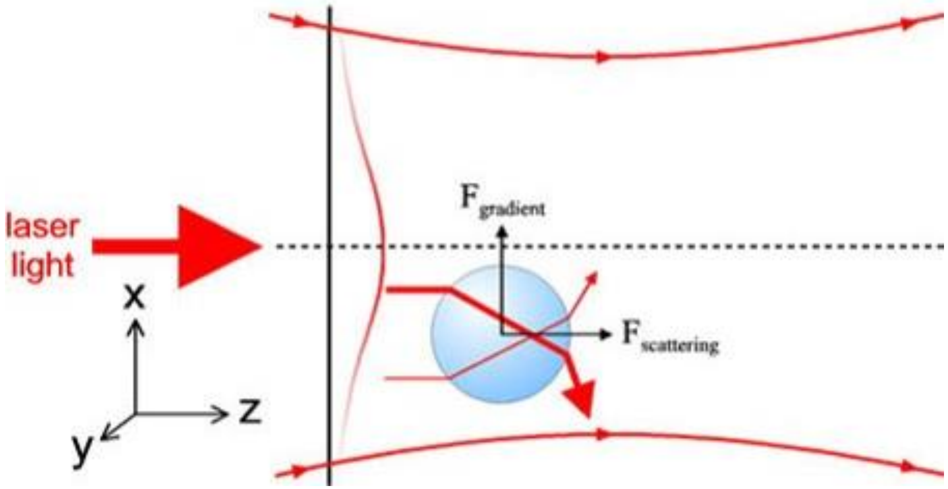
Theory

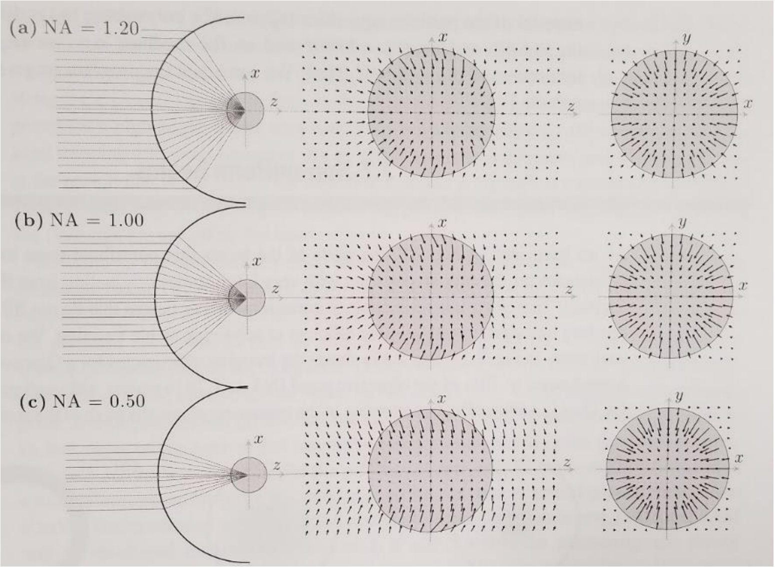
Two forces in the optical tweezers to trap particles:

- **Scattering force:** Photons carry momentum.

$$E^2 = (m_0c^2)^2 + p^2c^2$$

- **Gradient force:** Trapped particles move towards the higher intensity.



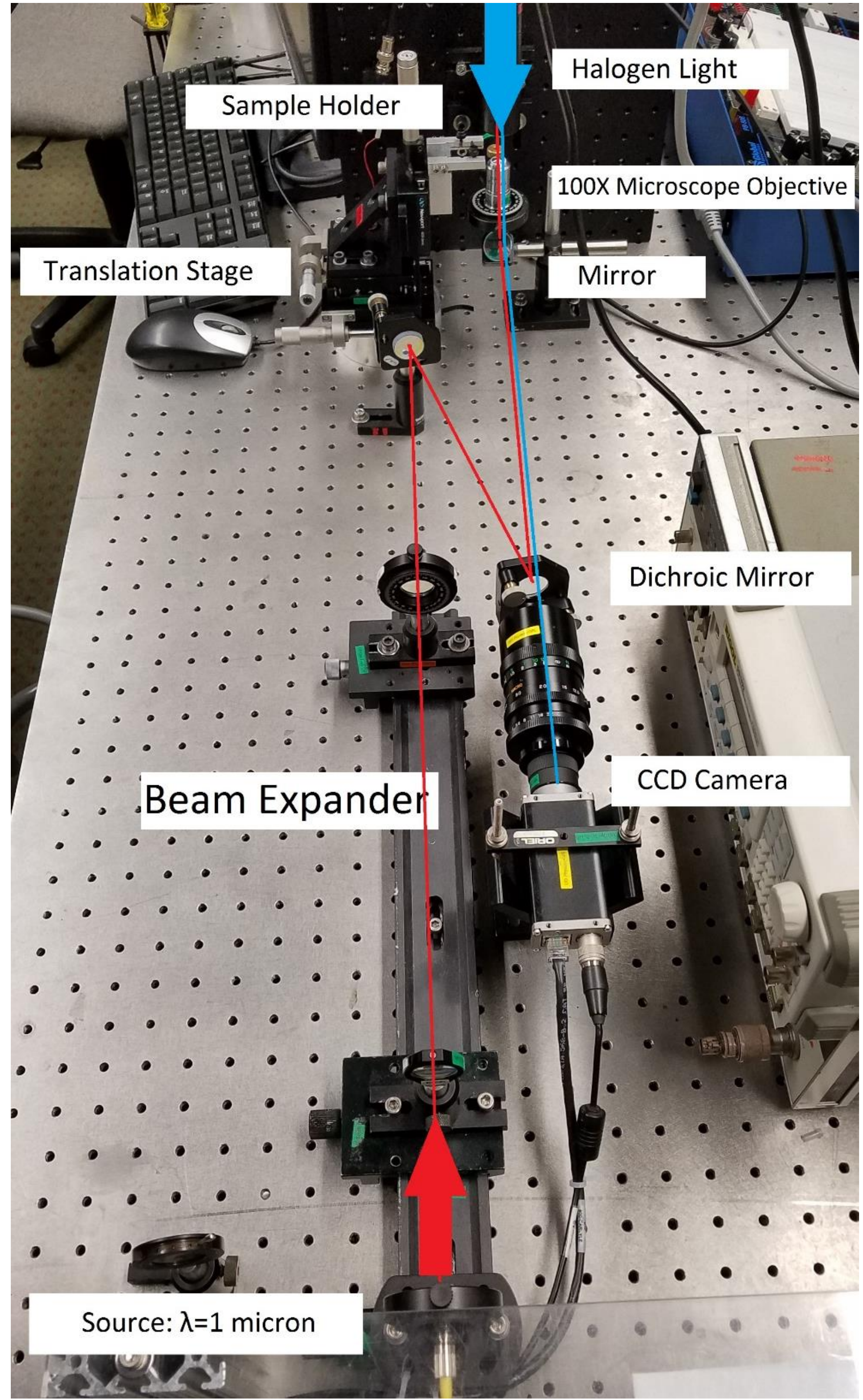


Theory

- Ray Optic and Rayleigh Regime
  - Dependent on wavelength and particle size
- New magnetic particles required us to switch from Ray Optic to Rayleigh Regime
- Went from 637nm laser to 1μm infrared laser
- Heating element is a coiled wire driven by a function generator at high frequency

Set Up

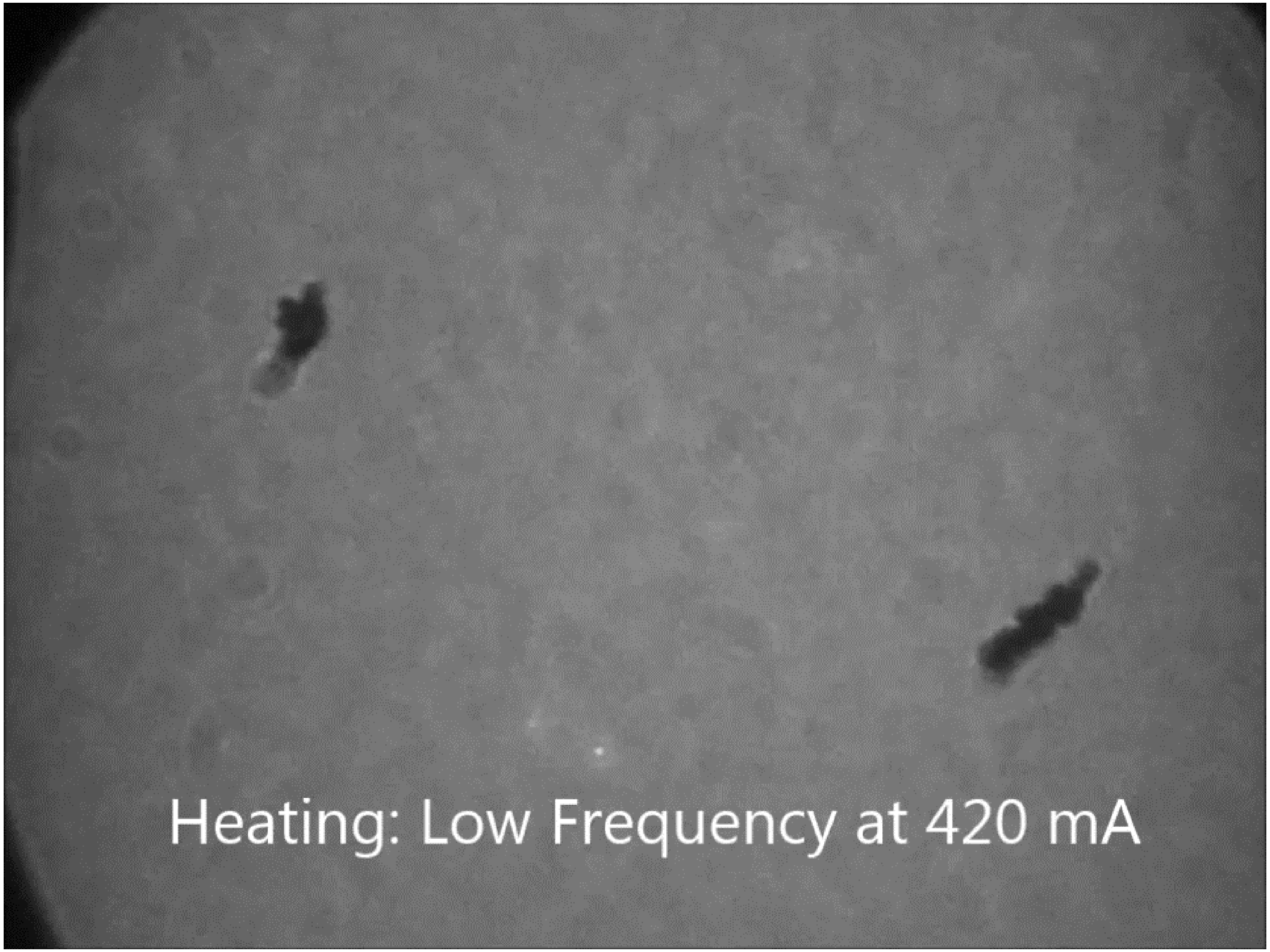
- Sample:
  - Deionized water with 0.1% of 1μm diameter microspheres
- Microscope Objective:
  - 100x
  - NA: 1.3 oil immersion

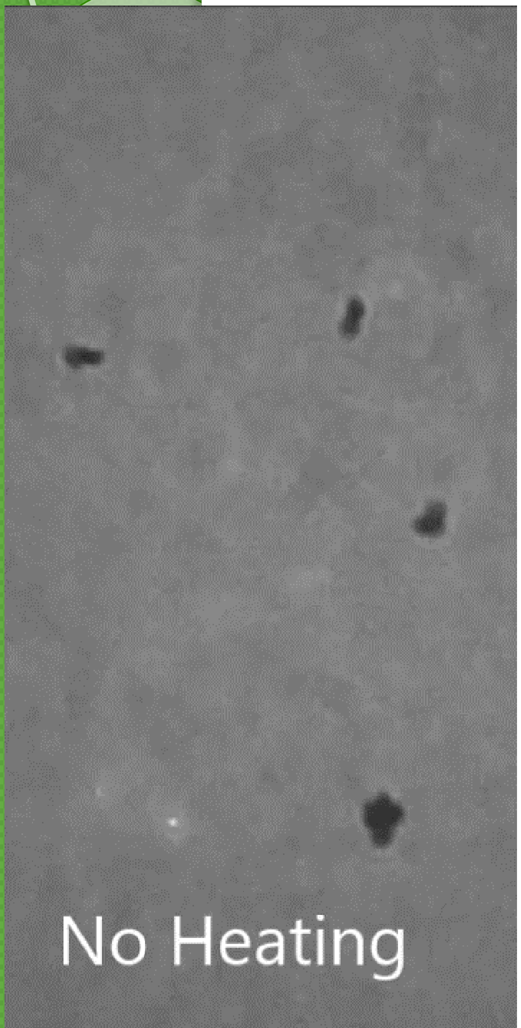
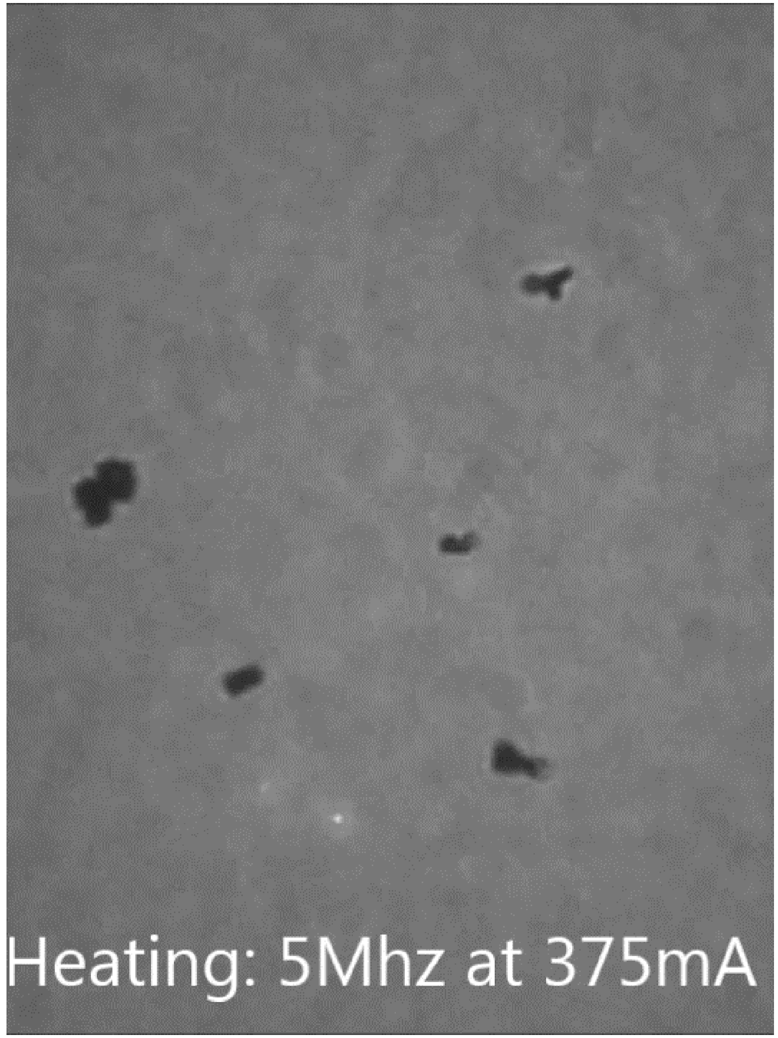


Ferromagnetic Spheres

- Magnetite core with silica coating
  - 95-98% Fe_3O_4
  - Saturation of Magnetization = 85 emu/g
- Approximately 1 μm diameter
- Index of refraction n=2.13
  - Much greater than the index of refraction of silica (n=1.45)

Low Frequency Heating




No Heating

Heating: 5Mhz at 375mA

Heating: 500Mhz

Qualitative Results

- Magnetic field applied influences magnetite microspheres
- Could not differentiate between low and high power/frequency heating
  - No observable change in Brownian motion
- Still unable to observe a stable trap

Roadblocks

- Magnetite versus silica microspheres
  - Conductive materials have a much larger reflection, absorption, and refractive index
  - Larger scattering force and trap instability
  - Magnetite tend to clump together
- Slide maintenance and shelf life
  - Bacteria growth, air bubbles, etc.
- Alignment of infrared laser
  - Not visible on CCD
- Metal sample holder/objective could be cause of distress regarding observations of a magnetic field at higher frequencies

Future Project Goals

- Heating element
  - Needs smaller diameter coil and less number of turns to reduce impedance
  - Quantitatively measure Brownian motion of heated particles
- Trapping efficiency
  - Increase laser optimization
  - Need to measure trap strength (Stoke's)