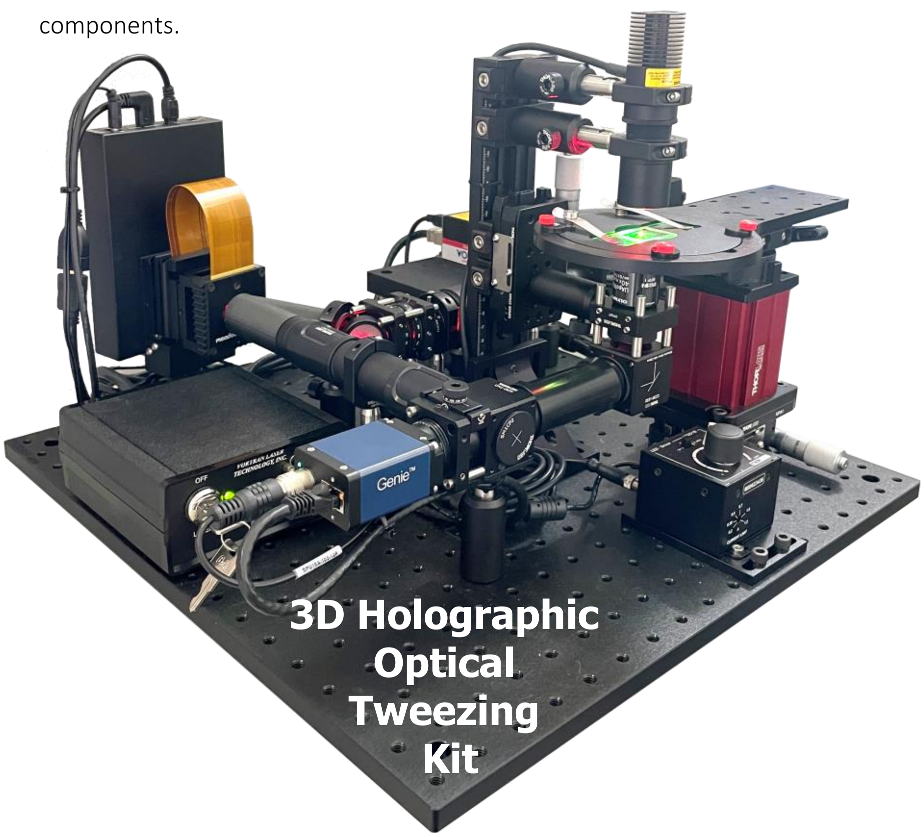
meadowlark optics

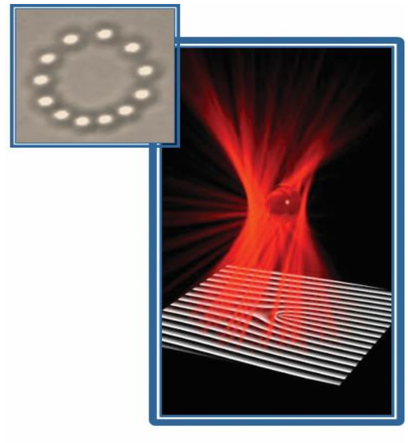
Spatial Light Modulator
3D Holographic Optical Tweezing Kit

Introduction

Optical tweezing can be used to manipulate objects ranging in size from 10's of nanometers to 10's of microns and objects with a variety of material characteristics. Trapping examples include cellular organisms, dielectric spheres, metallic spheres, metallic nanoshells, carbon nanotubes, air bubbles, and even water droplets in air.

The Meadowlark Optics' Optical Tweezing Kit provides researchers with a portable, stand-alone, optical tweezing platform as well as a simple to use graphical user interface (GUI) and software development kit to enable customization, calibration, and computations without requiring in-depth knowledge of tweezing theory. Thus, the default configuration allows a user to quickly and easily manipulate microscopic objects in three dimensions (3D) using the provided GUI and pre-built optical system. The accessible design allows for hassle-free customization allowing users to easily add or remove components.





Key Features

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Complete Optical Tweezing Kit using high resolution 1920 x 1200 SLM

Custom software to create Holographic Optical Traps

3D Particle Manipulation using Holographic Beam Control

High Temporal Trap Stability

Spatially Uniform Trapping across 312 x 312-micron field of view

Optical Components

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1920 x 1200 Spatial Light Modulator

Camera

Laser

Translation Stage

Oil immersion objective

Breadboard

Lenses

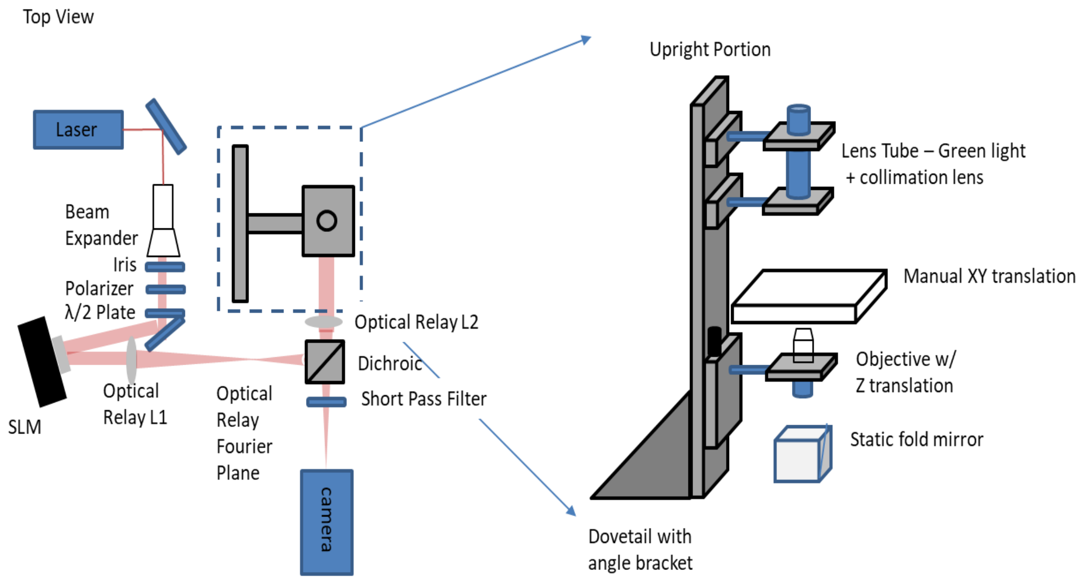
Mirrors

Polarizers

All mounting hardware

KEY TRAPPING FEATURES

- Traps can be moved interactively and independently in 3 dimensions
- High-speed Spatial Light Modulator operation increases closed-loop trapping and tracking stability.
- Clearly defined optical design, and accessible implementation make the system ideal for customization.
- Enclosed lens tubes with side ports allow a user to check how light is propagating through the optical system, while simultaneously keeping optics dust-free and the system eye-safe.

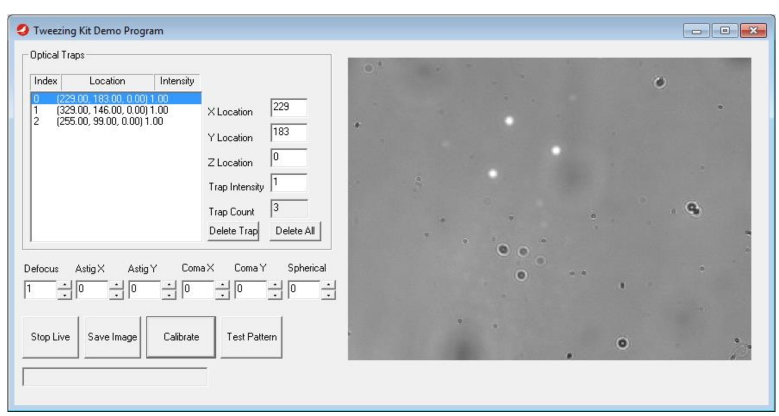


IMAGING

- Bright-field imaging over a large field of view (FOV) of 120 x 90 µm, effective pixel size of 200 nm (depends on microscope objective/camera).
- Magnification and image size optimized to camera chip size with interchangeable relay optics.
- 640 x 480 camera images at 300 frames per second (fps) full-field, up to 3000 fps for one or two beads.

TWEEZING SOFTWARE FEATURES

- GUI with dynamic control of trap number, size, position
- Aberration correction included
- Included SDK functions enable custom software development by computing holograms, as well as computing and applying Affine transformations to co-align camera and tweezing coordinates. SDK functions are compatible with C++, LabVIEW, Matlab, and Python



OPTICAL DESIGN

- 1920 x 1200 Spatial Light Modulator
- Laser, 160 mW at 639 nm
- High NA (1.35) 40x oil immersion microscope objective
- Dichroic beamsplitter directs >90% of 400-870 nm light to camera port
- Minimal moving parts to maximize stability (no floating table required)

PORTABILITY

- Fully enclosed laser beam path allows its use outside of laser labs
- All alignment controls are accessible with laser shielding in place
- Optics come mounted on an 18 x 18-inch breadboard

1920 x 1200 SLM SYSTEM

We recognize researchers may want to use the SLM in multiple experiments. The 3D Holographic Optical Tweezing platform was designed with this in mind. Users can simply remove the SLM from it's post and add it to any other optical setup.

1920 x 1200 SLM System
for Optical Tweezing Kit

1920 x 1200 Analog Spatial Light Modulator Specifications

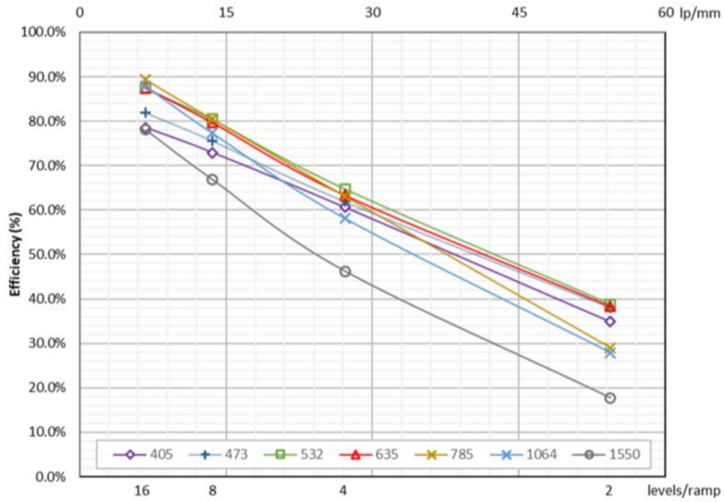
Resolution: 1920 x 1200 | **Array Size:** 15.36 x 9.60 mm | **Phase Ripple:** 0.10 – 0.30% (custom as low as 0.025%)

Fill Factor: 95.6% | **Pixel Pitch**: 8.0 x 8.0 µm | **Controller:** HDMI 8-bit

Standard Speed System - Standard Liquid Crystal with HDMI Controller

Specify Calibration Wavelength	Wavefront Distortion	LC Response Time / System Frame Rate	AR Coatings (Ravg <1%)	0^{th}-order Diffraction Efficiency (varies with pixel value)	Reference this Model Number when Ordering
405 nm	λ/3	13.4 ms / 60 Hz	400 – 850 nm	83 – 90%	
473 nm	λ/4	13.7 ms / 60 Hz	400 – 850 nm	84 – 90%	
532 nm	λ/5	14.0 ms / 60 Hz	400 – 850 nm	80 – 88%	**Model E19x12-400-700-HDMI**
635 nm	λ/6	14.5 ms / 60 Hz	400 – 850 nm or 500 – 1200 nm	84 – 89%	
785 nm	λ/7	20.5 ms / 30 Hz	500 – 1200 nm	76 – 79%	**Model E19x12-500-1200-HDMI**
1064 nm	λ/10	25 ms / 30 Hz	500 – 1200 nm or 850 – 1650 nm	85 – 88%	**Model E19x12-850-1650-HDMI**
1550 nm	λ/12	45 ms / 15 Hz	850 – 1650 nm	85 – 91%	

Diffraction Efficiency (1st-order) - This is the percentage of light measured in the 1st-order when writing a linear repeating phase ramp to the SLM as compared to the light in the 0th order when no pattern is written to the SLM. Diffraction efficiency varies as a function of the number of phase levels in the phase ramp. The plot to the right shows sample 1st order diffraction efficiency measurements, as a function of the phase ramp period, taken at various wavelengths.



Software - Meadowlark Optics' SLMs are supplied with a Graphical User Interface and software development kits that support LabVIEW, Matlab, Python and C++. The software allows the user to generate images, to correct aberrations, to calibrate the global and/or regional optical response over 'n' waves of modulation, to sequence at a user defined frame rate, and to monitor the SLM temperature.

Global or Regional Calibrations - Regional calibrations provide the highest spatial phase fidelity commercially available by regionally characterizing the phase response to voltage and calibrating on a pixel-by-pixel basis.

Image Generation Capabilities

Bessel Beams: Spiral Phase, Fork, Concentric Rings, Axicons

Lens Functions: Cylindrical, Spherical

Gratings: Blazed, Sinusoid

Diffraction Patterns: Stripes, Checkerboard, Solid, Random Phase, Holograms, Zernike Polynomials, Superimpose Images