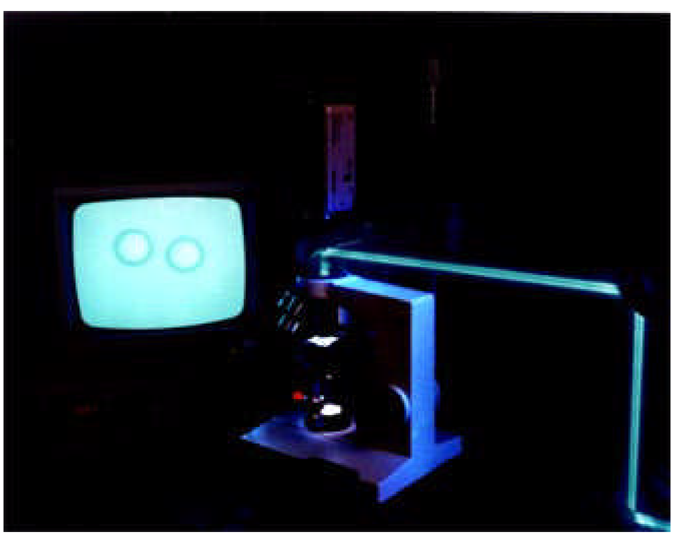
Interferometer-Controlled Optical Tweezers Constructed for Nanotechnology and Biotechnology

A new method to control microparticles was developed in-house at the NASA Glenn Research Center in support of the nanotechnology project under NASA's Aerospace Propulsion and Power Base Research Program. A prototype interferometer-controlled optical tweezers was constructed to manipulate scanning probe microscope (SPM) tips. A laser beam passed through a Mach-Zehnder interferometer, and a microscope objective then produced an optical trap from the coaxial beams. The trap levitated and generated the coarse motion of a 10-μm polystyrene sphere used to simulate a SPM tip. The interference between the beams provided fine control of the forces and moments on the sphere. The interferometer included a piezoelectric-scanned mirror to modulate the interference pattern. The 10-μm sphere was observed to oscillate about 1 μm as the mirror and fringe pattern oscillated.

The prototype tweezers proved the feasibility of constructing a more sophisticated interferometer tweezers to hold and manipulate SPM tips. The SPM tips are intended to interrogate and manipulate nanostructures. A more powerful laser will be used to generate multiple traps to hold nanostructures and SPM tips. The vibrating mirror in the interferometer will be replaced with a spatial light modulator. The modulator will allow the optical phase distribution in one leg of the interferometer to be programmed independently at 640 by 480 points for detailed control of the forces and moments. The interference patterns will be monitored to measure the motion of the SPM tips. Neural-network technology will provide fast analysis of the interference patterns for diagnostic purposes and for local or remote feedback control of the tips. This effort also requires theoretical and modeling support in the form of scattering calculations for twin coherent beams from nonspherical particles.



The output of a Mach-Zehnder interferometer is used to form laser tweezers that can move particles by interference phase control.

Long description: Laser light is directed though an interferometer to generate an interference pattern that functions as a conventional laser tweezers. The fringe-containing laser light is shown reflecting off of mirrors to form the optical tweezers, and trapped particles are shown on a video monitor.

Glenn contact: Dr. Arthur J. Decker, 216-433-3639, Arthur.J.Decker@grc.nasa.gov
Author: Dr. Arthur J. Decker
Headquarters program office: OAT
Programs/Projects: Aerospace Propulsion and Power Base Research, Microgravity Science