



Apr 21st, 1:15 PM - 2:15 PM

Lensless Optical Tweezing

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Rau, '02, Ileana G. and Spalding, Faculty Advisor, Gabriel C., "Lensless Optical Tweezing" (2002). *John Wesley Powell Student Research Conference*. 5.
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Poster Presentation P44

LENSLESS OPTICAL TWEEZING

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Optical trapping of a single particle can be accomplished by tightly focusing a laser beam with a microscope objective lens. By incorporating a diffractive optical element in the light path, a large number of particles can be controlled and assembled into a structure of interest. We are studying an alternative way of achieving the same goal: to organize micro- and nanostructures into larger assemblies using evanescent field laser tweezers.

Evanescent fields can be produced by total internal reflection due to the fact that boundary conditions require finite amplitudes in the second medium. This type of wave propagates parallel to the surface and decays exponentially in the direction normal to the interface over a distance of a few wavelengths. Under certain conditions an orders of magnitude enhancement in the intensity of the evanescent field can occur by coupling to surface plasmons. The resulting gradient forces are [we argue] large enough to trap particles. This technique should offer a significant improvement compared to the approach described above. Due to the large field enhancement the same laser has an orders of magnitude larger effective power that enables the trapping of a much larger number of particles. Moreover, because of interference effects, the spacing between the particles being trapped can be smaller than the wavelength of light that is used.

We are investigating the theoretical aspect of lensless optical tweezing by developing a simple mathematical model that describes this "light sculpting" technique and we are using these calculation to guide the experimental work. Some of the topics explored include studying surface plasmon resonances and establishing the limits imposed by both experimental considerations and theoretical predictions on lensless optical tweezing using evanescent fields.