Trapping of Microscopic Particles in a Laser Beam *via* Photophoresis

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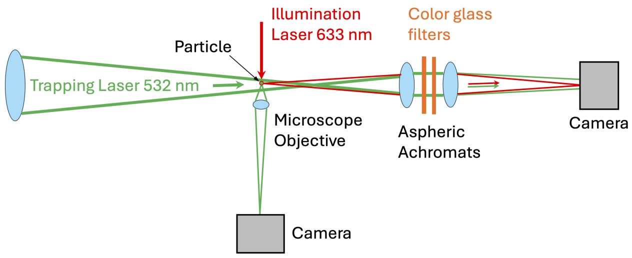

Figure 1: Setup for imaging a trapped dust particle radially and axially

For decades it has been known that microscopic dust particles can become trapped near the focus of a continuous laser beam when surrounded by ambient gas such as air. The laser heats particles, which in turn interact differently with the surrounding air molecules. This phenomenon is called photophoresis. Trapped particles typically scatter a significant amount of laser light as they 'levitate' in midair while being held by the laser beam. One can draw centimeter-scale 3-D patterns by sweeping a particle through a volume of space, relying on visual persistence while forming a 3-D pattern. The potential interest in 3-D displays based on photophoresis provides strong motivation to try to increase the sweep speed for particles as they remain stably trapped in the laser beam. While it clear that photophoresis can impart forces to particles, it is less obvious how this leads to stable trapping at specific locations in a unidirectional beam, even if there are local intensity minima or maxima present. If particles flee regions of high intensity, why would they not be continually pushed downstream in the beam, in spite of diffractive structures, for example, arising from spherical aberration. Nevertheless, when offered to the beam, self-selected particles become trapped in locally preferred regions. We report on measured images of trapped particles together with the surrounding trapping-beam profile. The experimental setup is depicted in Fig. 1. The radial structure of the beam is recorded with 1:1 imaging, where the ~ 1 W beam is attenuated with filters by many orders of magnitude. Meanwhile the particle is weakly illuminated using a different wavelength, which transmits through the filters. This allows for the particle to be seen relative to adjacent intensity features in the trapping beam.