Optical focusing of isolated particles for diffractive imaging experiments

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The short, intense, and coherent x-ray pulses produced by x-ray free-electron lasers (XFELs) have lead to major advances in macromolecular structure determination. Efforts are underway to extend the successful "serial femtosecond crystallography" paradigm to include *isolated* proteins, viruses or cells, without the need for growing well-ordered crystals (often the principal bottleneck to structure determination). This "single-particle imaging" scheme consists of directing a stream of randomly oriented bioparticles across the focus of the XFEL beam so that high-resolution three-dimensional electron density maps can be constructed from multiple diffraction patterns of identical particles.

Presently, the difficulty of efficiently delivering bioparticles to a sub-micrometer x-ray focus is a limiting factor in the development of single-particle imaging. For a 100 nm x-ray focus, current sample delivery efficiencies (fraction of particles that are intercepted by an x-ray pulse) are on the order of 10^{-7} on average, and hit fractions (fraction of x-ray pulses that intercept a particle) are below 0.1%. With such efficiencies, high-resolution experiments require samples prepared in large quantities and extended data collection times. In order to confront this problem, we are developing techniques for guiding aerosolized nanoparticles to the X-ray focus with specially shaped laser illumination [1, 2]. Our current experiments aim at transversely confining streams of aerosolized particles as they exit an aerosol injector [3] with a counter-propagating "hollow" quasi-Bessel beam. The experiment exploits radiation pressure and thermal (photophoretic) forces arising from the interaction of the particles with surrounding gas molecules.

References:

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