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High-resolution laser-based detection for magnetic tweezers

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Magnetic tweezers are a versatile and powerful single-molecule manipulation technique capable of applying force and torque on single bio-molecules. They afford several unique advantages over other single-molecule manipulation techniques such as optical tweezers or atomic force microscopy. The hallmark of magnetic tweezers is the ability to twist bio-molecules without the need for complex optical instrumentation. Perhaps less known but of equal significance, magnetic tweezers rely on a slowly decaying magnetic field gradient (1 mm) to impose force so they are intrinsically configured in a passive force clamp mode. These features make magnetic tweezers particularly well suited for the study of nucleic acid structure, DNA topology, and protein-nucleic acid interactions. The one downside to most magnetic tweezers to date is that they rely on video tracking methods to determine the position of the particle. Despite recent progress, the spatial and temporal resolution and accuracy are fundamentally limited by image tracking techniques. I will describe recent improvements utilizing laser-based detection to overcome these limitations. We implemented back-scattered laser-based detection combined with video image tracking to achieve high-resolution, high-bandwidth, three-dimensional position tracking.