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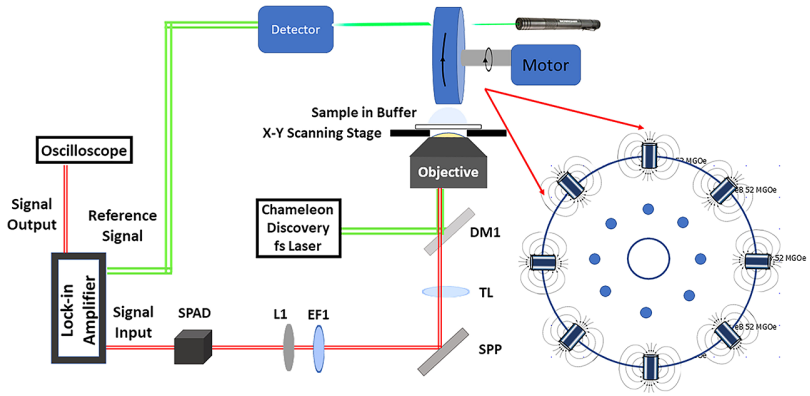
Ultrasensitive magnetic tweezers allow for exploration of the fluctuation dynamics among biomolecules.



Specialized biological systems, such as living cells, DNA, proteins, and other biomolecular complexes, often require manipulation without physical or chemical contact.

Magnetic tweezers are ideal for these dynamic studies, since they produce no photon or thermal damage, induce no optical background into the targeted molecules, and can exert either a static or oscillatory magnetic force. Lock-in amplifiers are also useful. Amplifiers enhance signal readout and are capable of accurately measuring ultrafast, time-resolved fluorescent properties.

Meiling Wu and H. Peter Lu have successfully designed and built a set of oscillating magnetic tweezers coupled with a lock-in amplifier. The device simultaneously reports the frequency of the oscillating magnetic field and reveals the exact conformational and functional response of proteins subjected to piconewton force manipulation.

Rhodamine 6G stained super-paramagnetic beads were used to demonstrate this technology. The researchers were able to monitor weak signals produced from nanometer scale oscillatory motions of the beads under the changing magnetic fields at specific frequencies.

“In this work, we use the lock-in amplifier to lock on the force manipulation, and the new technique can detect the signals buried under the thermal noise environment,” said Lu. “Also, the force field can be regulated in oscillatory amplitude frequency that can change the protein reactive energy landscape, reaction pathways, and activities.”

The researchers anticipate their device will be used to explore the mechanical force impact on biological macromolecules while promoting understanding and insight into the protein structure-dynamics-function relationship.

Source: “Ultra-sensitive lock-in amplifier coupled oscillatory magnetic tweezers for piconewton force manipulation applications,” by Meiling Wu and H. Peter Lu, *Journal of Applied Physics*, (2021). The article can be accessed at https://doi.org/10.1063/5.0048701.