Confinement and Manipulation of Single Molecules, Particles or Cells using Fluid Flow

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Recognized by several Nobel prizes, fine-scale control of atoms and particles has led to key advances in many fields of science and engineering. Particle trapping is a pervasive technology with a rich scientific toolbox and many important applications. To date, a wide array of confinement techniques has been developed using various force fields (e.g. electric, magnetic, optical) to achieve exquisite control over the position and velocity of micro- and nanoscale particles in solution.

In this talk, I will introduce two new methods for particle trapping based on the sole action of hydrodynamic forces in microfluidic devices. First, I will provide a brief overview of the current trapping methods for micro- and nanoscale particles. Next, I will discuss two new flow-based methods, the ***hydrodynamic trap*** and the ***microfluidic Wheatstone bridge***, which we recently developed. I will present results demonstrating two-dimensional free-solution confinement and manipulation of individual particles and cells using these techniques.

Importantly, these new flow-based trapping methods offer a new platform for observing single particles, macromolecules or live cells without the need for surface immobilization. Moreover, the hydrodynamic trap enables confinement of particles with no specific requirements on material composition (optical, magnetic, surface charge) of the trapped object. The hydrodynamic trap confines particles using the gentle action of fluid flow, thereby enabling non-perturbative trapping of single live cells and allowing for the exchange of surrounding growth medium in real time. Unlike existing trapping methods such as optical or magnetic traps (where the trapping force scales with particle volume), the hydrodynamic trapping force scales linearly with particle radius, which promises to facilitate trapping of single molecules and small nanoparticles (<50 nm) in free solution. Overall, we expect that these new methods will enable a wide array of fundamental research in many fields, including nanoscience, polymer physics, catalysis, and systems biology.

Short Bio

Dr. Melikhan Tanyeri received his Ph.D. in Physics from University of California, Davis where he developed chemical and biological sensor platforms based on optical resonances in microcavities. He is currently a postdoctoral researcher in the department of Chemical & Biomolecular Engineering at the University of Illinois at Urbana-Champaign, where he is developing a new class of microfluidic tools based on single particle and cell manipulation for applications in nano- and biotechnology. His research interests include microfluidics, chemical and biomolecular sensors, and single molecule biophysics.