SELF-ASSEMBLY, TRAPPING AND MANIPULATION OF NONMAGNETIC MICROOBJECTS WITH MAGNETIC FIELDS

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Magnetic fields can manipulate non-magnetic/diamagnetic objects provided these objects are immersed in a medium of significantly higher magnetic susceptibility (e.g. solution of a paramagnetic salt or suspension of magnetic nanoparticles). Besides levitating a frog (for which an Ig-Nobel was once given to a future Nobel laureate), this phenomenon has been used in the assembly of macroscopic components as well as formation of colloidal arrays of various compositions. Along these lines, the first part of my talk will focus on the use of micropatterned static magnetic fields to drive formation of both mono-component and multi-component colloidal arrays, colloidal molecules, three-dimensional assemblies, and even arrays of bacteria and colloid-bacteria hybrids. These assemblies can comprise up to hundreds of millions of regularly positioned components. In the second part of the talk, I will focus on using magnetic fields to trap and manipulate individual non-magnetic microobjects. In the system we have recently developed, the microobjects (colloids or live cells) are immersed in a high-susceptibility solution (HoNO3 or Fe3O4/dextran nanoparticles, respectively) subject to a uniform magnetic field (~ 20 mT) produced by an external electromagnet. A sharp coaxial “pen” comprising tungsten core surrounded by a layer of Ni/Fe supermalloy is the working element of the system – when the external field is on, the pen creates a local minimum in the magnetic fluid beneath its tip, thus creating a trap for nonmagnetic objects; when the external filed is off, the trap vanishes. What is remarkable about this trapping mode is that the strength of the trap can be regulated by the electromagnet’s field, and its shape, by the cross-section of the magnetic pen. Capitalizing on these advantages, I will show how to address not only individual colloids or living cells, but also create traps with which entire colloidal formations (e.g., lines of particles) can be manipulated or traps in which colloidal clusters can be controllably crystallized. Many of the capabilities of our electromagnetic traps cannot be realized with optical trapping approaches.

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