The various paths to nanoscale 3D microscopy

Christian Degen
Department of Chemistry
Massachusetts Institute of Technology
Cambridge, MA 02139

Just looking at it can tell you a lot about an object. Over the years people have developed tools that allow visualizing "things" from galaxies to atoms, spanning almost 30 orders of magnitude. A particularly "tough" lengthscale is the range between 1 and 100 nm – things are too big for atomistic techniques like X-ray crystallography or NMR spectroscopy, but too small for classical tools like the optical microscope. Yet exactly this lengthscale covers some of the most interesting biological complexes and is a key area for technological development; for example, the ribosome is 20 nm in diameter and the smallest structures on a computer chip are in the 30-40-nm range.

Discerning small features is not the only demand posed on modern microscopy. The ultimate microscope should also possess sophisticated image contrast, be non-invasive, work under a variety of conditions and with all kinds of samples, and deliver images within a reasonable amount of time.

In this talk we will survey established and more recent efforts in nanoscale, three-dimensional microscopy. We will try to highlight successes and limitations of the various techniques, and point out some of the more recent developments, like atom-probe tomography. Finally, we will attempt to make a comparison and put these efforts into context with the recent advances in nanoscale MRFM and diamond-based magnetometry.