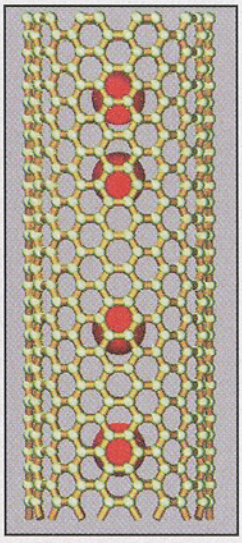
Two Lasers Pump Atoms Through Nanotubes

EAST LANSING, Mich. — Scanning tunneling microscopes can deposit individual atoms on surfaces, enabling researchers to study and modify nanostructures. Such microscopes do not have continuous capabilities, though, so are limited in transporting atoms, molecules or ions.

Carbon nanotubes could make excellent conduits for atoms, but a scanning tunneling microscope could not act as the pump mechanism. Instead, Petr Král of the University of Toronto and David Tománek of Michigan State University have proposed a laser-driven atomic pump.

Detailed in the June 28, 1999, issue of *Physical Review Letters*, their idea is to pump the tubes with two lasers, one with twice the frequency of the other. Adjusting the phase difference between their coherent radiation creates a net current that can selectively induce the flow of atoms in the desired direction.

Developers can control the tubes' diameters and electrical conductivity. Although nanotubes have found several applications, some have been limited. For example, an electric current passing through the structure creates a force that will push atoms and molecules through the center of the tube. But it is difficult to make electrical contacts to the nanotubes.



A schematic shows a carbon nanotube that is only 1.4 nm in diameter. Many atoms and molecules fit inside, as indicated by the red spheres, and could be pumped through these miniature pipes using two laser beams.

"A single laser will create hot electrons, but half would move left and half would move right in the nanotube," explained Tománek, a theoretical physicist at the university's Center for Fundamental Materials Research. "We propose the use of two lasers. And by adjusting the phase difference between them, we can drive the electrons to the right or to the left. Since we need no contacts, we can have 10,000 nanotubes in the laser spot, and in each of these nanotubes we will induce a current."

The tubes could deliver pharmaceutical molecules to individual cells, Tománek said. "The nanotubes are so small that the cell membrane is not damaged by the insertion of the nanotube." □

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