'Optical Matter' Emerges Under Laser

There definitely is something new under the sun, or at least under a laser. For several years, researchers have known that a laser beam can push bacterium-sized particles in the direction the light is traveling. But the beam can also induce a previously undetected attraction between the laser-soaked particles, three physicists report.

The group describes the first, simple examples of "optical matter" — tiny spheres stuck together under laser light — in the Sept. 18 PHYSICAL REVIEW LETTERS.

"A consequence is that light waves can serve to bind matter in new organized forms," say Michael M. Burns and Jean-Marc Fournier of the Rowland Institute for Science in Cambridge, Mass., and Harvard physicist Jene A. Golovchenko, who also works at the Rowland Institute. With further development, "optical binding" could join the small club of chemical and physical interactions that govern how molecules and larger material building blocks organize into increasingly larger-scale structures, Golovchenko says.

"The atoms that come together to make up the various forms of organized matter around us are bound together by forces that can be viewed as originating from the exchange of electrons between atoms," he notes. "Our group has been studying the possibility that new forms of matter might exist, which we think of as optical matter, in which that [electronic] binding is replaced by the exchange of photons."

"I'm struck by its novelty," comments Arthur Ashkin, a physicist at AT&T Bell Laboratories in Holmdel, N.J., who uses lasers to manipulate cells and other microscopic objects. Physicist Noel A. Clark of the University of Colorado at Boulder suggests the newly described interaction might prove useful for getting bacteria to stick together or for aligning particles in preferred configurations before chemically bonding them. "It's important work," Ashkin says, but he thinks talking about applications is premature.

In their experiments, Golovchenko and his colleagues inject a solution containing polystyrene mini-spheres (1.43 microns in diameter) between two closely spaced glass plates, then shine an intense laser beam through the plates. Radiation pressure from the beam traps a few spheres against the top plate. The researchers also observe the effects of an optical binding force among the trapped spheres.

In the simplest example of the force's effects, pairs of spheres that start out roughly 5 microns apart take discrete, wavelength-sized steps (0.387 microns in this example) toward one another until they touch. At room temperature, switching off the laser enables Brownian, or thermally induced, motion to separate the spheres, but the scientists note that freezing the sample solution preserves the optical matter.

Golovchenko told SCIENCE NEWS his group already has seen the spheres form into much more complex optical matter. He declined to discuss these observations until the work is published in a journal article.

How does optical binding work? Like sunlight, radio signals and other forms of electromagnetic energy, laser light consists of oscillating electric and magnetic fields. The light induces oscillating electrical currents within the spheres, turning them into minuscule antennas that respond by also emitting radiation — a process called light scattering.

The electric and magnetic fields from the laser interfere with those from the light scattering off the spheres, creating a busy electromagnetic landscape pocked with energy wells. The spheres "hop" from well to well until they settle into a pair of deeper wells separated by a distance equal to a sphere's diameter. That's when the spheres make physical contact and stick together. *— I. Amato*

Greenery filters out indoor air pollution

Perhaps because they're so easy to grow, spider plants have seldom shared the cachet of such other houseplants as the African violet, amaryllis or asparagus fern. But preliminary NASA research a few years ago raised the spider plant's prestige when it showed these hanging plants could filter toxic organic pollutants from indoor air. Indeed, "we thought there was something magic about the spider plant," recalls Bill C. Wolverton at NASA's John C. Stennis Space Center in Bay Saint Louis, Miss. But the two-year study he described at a press conference this week in Washington, D.C., suggests most houseplants can remove indoor air pollutants — whether at home or in a space station. In fact, Wolverton says, compared with the Gerbera daisy, potted mum and banana (*Musa oriana*), the spider plant is only second-rate.

The new study, funded by NASA and the Associated Landscape Contractors of America, tested the ability of 14 houseplants to remove three volatile organic chemicals: the carcinogen benzene, trichloroethylene (TCE) and formaldehyde. Researchers chose these three not only because they represent a wide range of chemicals found to taint indoor air but also because of suspicions that they contribute to "sick building syndrome" — the human respiratory complaints and fatigue sometimes associated with occupation of new and newly renovated buildings (SN: 9/23/89, p.206).

Each plant spent a day in a sealed chamber containing air tainted with one of the chemicals. Pollutant concentrations in the air ranged from 20 or 30 parts per million (ppm) to less than 1 ppm — concentrations "one might find in a home," Wolverton says. While all plants scavenged the pollutants to some extent, their efficacy varied widely. English ivy, for example, removed 90 percent of the benzene in one test but just 11 percent of the TCE in another. And *Ficus* removed 50 percent of the formaldehyde but filtered out only about 10 percent of the TCE. Potted mums proved more consistent. In one set of tests they scavenged 61 percent of the formaldehyde, 53 percent of the benzene and 41 percent of the TCE.

In the case of *Dracaena, Sansevieria* and other plants requiring low light, NASA data indicate leaves accounted for at most 20 percent of the observed pollutant scavenging. Roots and soil microbes, which apparently feed on the pollutants, accounted for the rest, Wolverton says. This may explain why air cleaning proved most efficient when a plant's soil was unshielded by rocks or low-hanging leaves.

Though preliminary, these data suggest that one 10- to 12-inch potted plant per 100 square feet of floor space could dramatically reduce low-level pollution from organic chemicals, Wolverton says. When it doesn't, he suggests supplementing the greenery with fan-driven plant filters he developed at NASA several years ago. The filters root plants directly into activated carbon, supplemented with a little potting soil. A small fan draws room air through the carbon, which collects and holds organic pollutants until microbes and plant roots can degrade them. Commercial versions should be marketed widely within a year, he says.

While the NASA data are "interesting," says Betsy Agle with EPA's indoor-air division in Washington, D.C., they still leave some important questions unanswered — such as how much pollution a plant can filter out before getting sick itself. But EPA's greatest concern, she says, is that people may be tempted to rely on such systems instead of focusing on removing the sources of unhealthy contaminants. *— J. Raloff*