Opening a Window of Transparency

There's no invisible man lurking in the laboratory, but researchers have now discovered a way to make atoms of a gas transparent to light at wavelengths the gas would normally absorb. They achieve this surprising effect by using an intense laser beam to interfere with the usual, quantum-mechanical process by which an atom absorbs light.

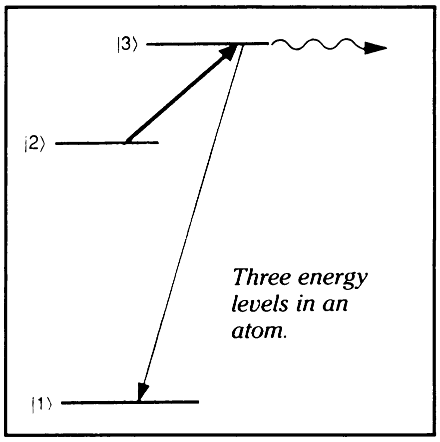
"We face the really exciting prospect of making opaque materials transparent at particular wavelengths," says physicist Stephen E. Harris of Stanford University.

Harris, Klaus-Jochen Boller and Atac Imamoğlu report the first observation of electromagnetically induced transparency, involving strontium vapor, in the May 20 PHYSICAL REVIEW LETTERS.

Atoms typically absorb light of wavelengths that correspond to the energies required for electrons to jump from one atomic energy level to another. To prevent absorption and induce transparency at one of these wavelengths (corresponding to the transition from energy level 1 to energy level 3 in the accompanying diagram), the idea is to apply an intense laser beam of a wavelength that would cause a transition between level 3 and another state, 2. Because of quantum-mechanical interference, a second laser beam normally capable of exciting the atom from level 1 to level 3 and applied at the same time as the first beam would pass right through without being absorbed.

Although the concept, in the guise of "population trapping," has been around for more than a decade, theorists failed to appreciate its significance when applied to a gas or a vapor instead of just to individual atoms. Harris changed that perception. "What we said is that you can use it to make an opaque material transparent," he says.

"All this had always been available to people, but we somehow never thought of it," adds laser expert Boris P. Stoicheff of the University of Toronto in Ontario.



Three energy levels in an atom.

Adapted from Harris

To demonstrate the technique for inducing transparency, the Stanford team used a heated cell containing strontium vapor. Green laser light at 570 nanometers created the transparency, preventing the vapor from absorbing ultraviolet light at 337 nanometers.

Encouraged by their success with strontium, the researchers tried another atomic gas, using a commercially available laser to induce transparency in lead vapor contained in a molybdenum cell heated to 1,150°C. They reported their positive result last month at the Quantum Electronics and Laser Science Conference, held in Baltimore.

The choice of strontium and lead for the initial experiments was largely a matter of convenience rather than necessity. The same technique for inducing transparency should work for any atomic gas.

"We have a formula for how to make atoms transparent," Harris says. "If you name a particular absorption line in an atom, I can devise a way to make that absorption line from reasonably to very transparent."

Indeed, Stoicheff and his collaborators have in the last few weeks managed to induce transparency in atomic hydrogen. "We're sticking with hydrogen because you can calculate all its properties," Stoicheff says. Such theoretical calculations afford useful insights into the experimental results.

Whether the technique could be applied to molecular gases, liquids and solids remains far from settled. "We are going to learn in the future how to extend transparency to more complicated things, but I don't know to what extent," Harris says. "I certainly don't want to say we know how to make light go through walls."

"There's no apparent reason it should be limited to gases," Stoicheff says. That leaves lots of room for exploration.

– I. Peterson

Antibodies pinpoint migrating mini-tumors

Approximately one in three breast cancer patients will eventually die from the disease even though her oncologist found no identifiable signs of distant malignant spread at the time of surgery. That grim statistic has driven researchers to seek out ever more sensitive techniques for detecting tiny "satellite" cancers, or micrometastases, spawned by the initial tumor.


Osborne

Unlike normal bone marrow cells, antibody-fingered breast cancer cells readily accept a distinguishing red stain.

Scientists at the Memorial Sloan-Kettering Cancer Center in New York City now report dramatic progress on the road to such tests. Their trials indicate that a trio of monoclonal antibodies may provide an "exquisitely sensitive" diagnostic tool, says Michael P. Osborne, who led the studies. When incubated with cells extracted from bone marrow, the antibodies could highlight even a single cancer cell among 1 million normal cells, he says. That's 100 times more sensitive than the most discriminating diagnostic technique available today, which relies solely on cultured bone marrow cells (SN: 6/2/90, p.341).

In the May 15 CANCER RESEARCH, Osborne and his co-workers report indirectly identifying breast cancer micrometastases among marrow cells that had been incubated with the monoclonal antibodies. The antibodies bind only to cells derived from epithelial tissue, allowing them to be stained a telltale red. Because bone marrow normally contains no epithelially derived cells, Osborne explains, oncologists interpret such cells as metastases from an epithelially derived breast tumor.

At last week's meeting of the American Society of Clinical Oncology in Houston, Osborne described using an earlier, fluorescent version of the same antibody cocktail, which highlighted breast cancer micrometastases in marrow samples from 31 percent of the 152 patients studied. A two-year follow-up of these women, he says, indicates that the presence of micrometastases – especially those involving 10 or more cells – may identify patients who face the greatest risk of early cancer recurrence, signaling the need for aggressive postsurgical chemotherapy.

– J. Raloff