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# A Dazzling Show Inside a Laser, but a Vacuum of Light Outside

By HENRY FOUNTAIN

In an elegant melding of theoretical and experimental physics, scientists at Yale University have taken the basic function of a laser and flipped it around — producing a device that absorbs, rather than emits, a beam of light.

The device, which the scientists call a "coherent perfect absorber" or, more popularly, an anti-laser, may lead to the development of new kinds of switches, filters and other components that could be useful in hybrid optical-electronic computers under development, among other applications.

A. Douglas Stone, a theoretical physicist at Yale, developed the concept of a backward-running laser in a paper in Physical Review Letters last spring. The actual device, described in a paper published last week in Science, was created in the laboratory of a laser physicist, Hui Cao.

In a laser, energy is pumped into a medium — which can be a solid, liquid or gas — between two mirrors, stimulating the emission of photons that are coherent, or of the same frequency and phase. The photons reflect back and forth between the mirrors, resulting in amplification of the light.

"You put energy into it, and some of that energy gets converted into that beautiful coherent light beam," Dr. Stone said.

In his theoretical work, Dr. Stone said, he made use of the fact that the equations that describe how a laser works have certain symmetrical properties.

"If you can make a laser of a certain type, the equations say you can make a reverse device as well," he said.

An anti-laser uses mirrors, too, but the other components are the reverse of a laser. The medium that provides amplification is replaced with one that provides absorption, and the outgoing light beam is replaced with an incoming one. (This light needs to be coherent, so it

takes a laser to make an anti-laser.)

The incoming beam is split in two, and hits the medium from two sides. The photons bounce around between the mirrors and interfere with one another, eventually wiping themselves out in a flurry of electrons and heat.

The experimental device absorbed about 99.4 percent of the light. In theory, an anti-laser should be able to absorb 100 percent. “It’s a one-way trap for light,” Dr. Stone said.

Dr. Cao said the device they built was relatively simple, using silicon as the absorptive medium and a couple of “bad” mirrors.

“But we should be able to get coherent perfect absorption in more complicated systems,” she said. Eventually it may even be possible to make an “anti” version of a so-called random laser, in which the medium is highly disordered and there are no mirrors.

The experimental device works in the near-infrared, outside of the visible spectrum. But Dr. Stone said that in principle anti-lasers would not be limited in terms of frequency.

“We could move it into the visible, or the farther infrared,” he said. “It’s definitely possible to engineer this across the whole range.”

Stefano Longhi, a physicist at the Polytechnic Institute of Milan in Italy who was not involved in the work, said the anti-laser was an “important achievement” that was “exciting and surprising to the scientific community.”

He said one important characteristic of the device is that the absorption could be turned on or off. This might make anti-lasers extremely useful as optical switching devices.

A device that absorbs light perfectly might be considered ideal for solar energy applications, but Dr. Longhi said this is not the case. Sunlight is not coherent, and an anti-laser will not work with incoherent light, he said.

A physicist would describe the device as a “time-reversed” laser, since the symmetrical properties are related to the concept of time reversal.

But Dr. Stone said he thought the term anti-laser was a better description for nonscientists, so that no one would think the device had anything to do with time travel.

But even “anti-laser” is problematic, he noted. “I don’t want people to think this is some kind of laser shield,” he said. “If R2-D2 had our anti-lasers, it would be melted into a puddle.”