Creating a nanoscale laser

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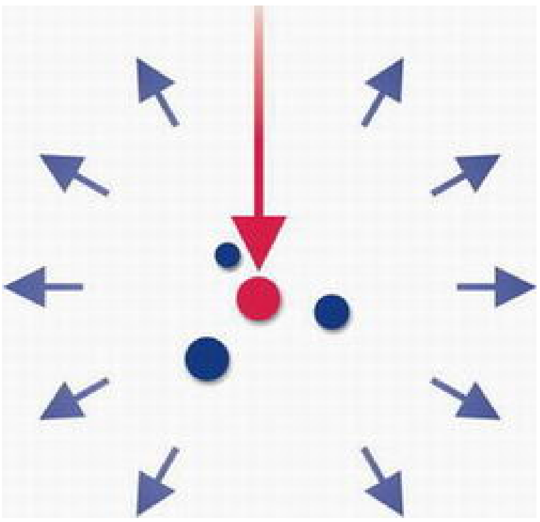

This image shows how a micro laser would work. The red dot represents the pumped atom, and the blue dots represent other atoms, which then send out light in a variety of directions. Credit: Tom Savels

“Nowadays, people and companies want to try to make smaller and smaller integrated circuits. In order to do this, low-power optical devices, like lasers, are needed,” Tom Savels tells *PhysOrg.com*. Savels, a scientist at the FOM Institute for Atomic and Molecular Physics in Amsterdam, and his colleagues, Allard Mosk and Ad Lagendijk at the MESA Research Institute at the University of Twente in Enschede, The Netherlands, set about asking themselves this question: *how small can we make a laser*?

“The answer,” says Savels, “is quite small — only two atoms are necessary.” Savels and his peers explain their findings in a Letter titled “Gain Narrowing in Few-Atom Systems” in *Physical Review Letters*. “It is really a race to see who can build these small lasers, and we have drawn the finish line,” Savels says, explaining that right now the microscopic laser is a theory. “But it is applicable for a huge range of experiments, and already there are groups interested in working on this idea.”

Savels points out that microscopic lasers with two atoms are actually smaller than some of the lasers that make use of only one ion. “Those lasers need cavities and mirrors to create the laser effect,” he says. “We show that you don’t need mirrors. All you need is another atom. Ours is the smallest and simplest system we know of that is an exactly solvable way to get laser oscillation.”

One atom is pumped, and at least one other atom nearby provides optical feedback. It is possible to introduce more atoms into the clustered system, and the team from The Netherlands posits clusters with up to five atoms in their Letter. “The more atoms we have, the better the effect,” says Savels, “but the fact remains that you only need one other atom besides the one that is pumped.”

This laser theory is fundamental, Savels explains, and can be used for particles other than atoms. “Amazingly, this laser effect applies to a wide range of objects including molecules, gold particles attached to DNA, and even to quantum dots.”

“Our theory also touches on discussions of what lasers are,” Savels continues. “As you get smaller, things get fuzzy and people tend to disagree about what defines a laser. We’ve talk to a lot of other scientists, and what we have found is that by and large, a laser has what is called gain narrowing.”

Gain narrowing is a term that refers to the fact that the bandwidth of light can be reduced to a point where the frequency only allows one color in the light spectrum, such as blue for a DVD player or red in other devices. “When you put little energy into the system, only one color survives,” Savels explains, “and this is the very thing we looked for in our system. We found that two atoms together can do the same thing that one ion with a cavity and mirrors can do.”

Savels is certain that the project will move toward the experimental realization of this system. “It really is widely applicable, and can be used to form nanoscale laser systems for a variety of uses in the future.”

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