Lasers could make the Internet faster – and cleaner

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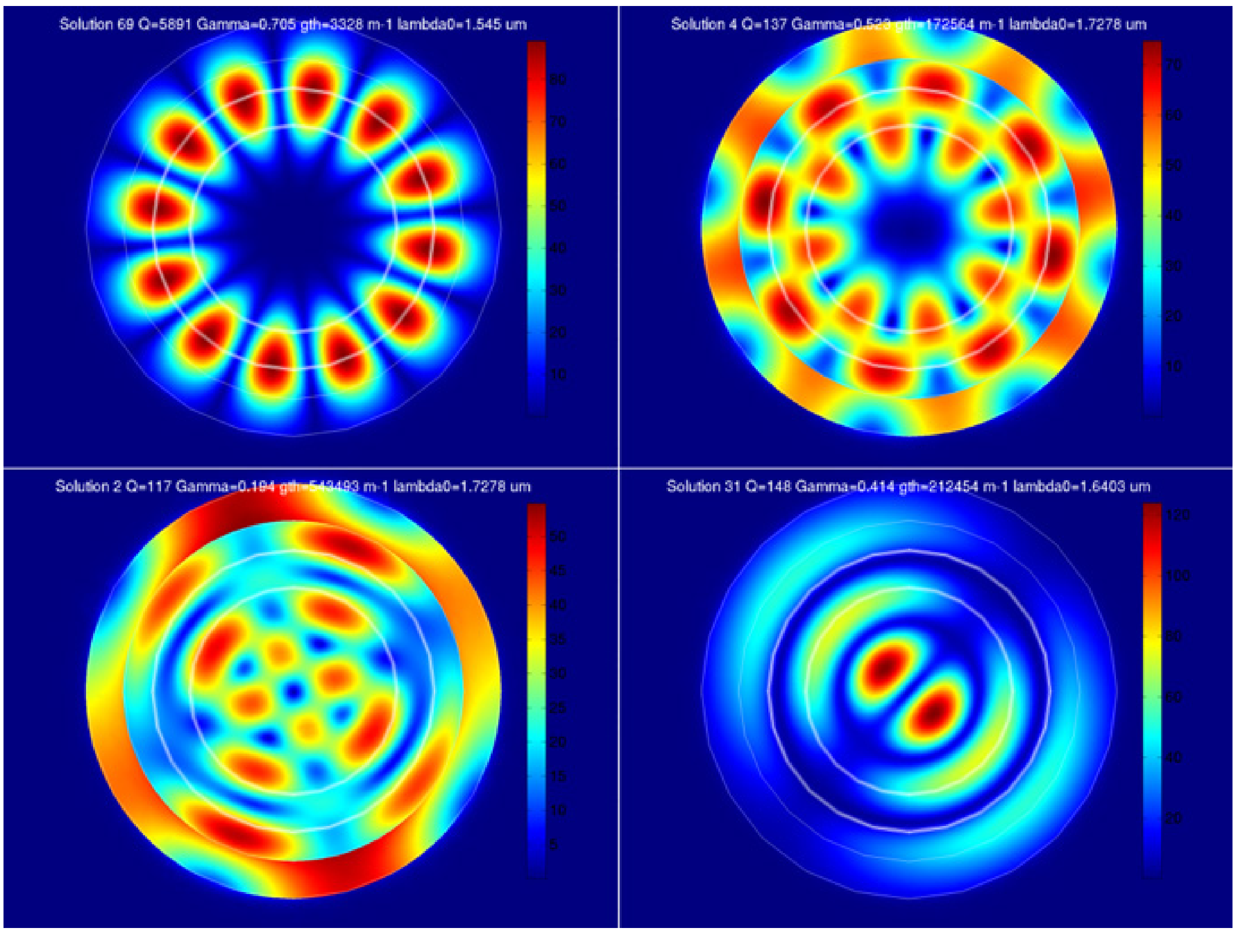

Wave patterns produced by whispering gallery lasers. Credit: Janelle Shane

If you're reading this, you probably have a fast Internet connection. In fact, there are better than even odds that you have a reasonably fast Internet connection on your cell phone.

But given the increasing amount of information online, the rate of data transfer on the Internet is about to hit some speed bumps. Fortunately, researchers at UC San Diego think they might have found the way to smooth the road ahead: lasers.

"As we are trying to fit more and more data on wires that we send from place to place, we are running up against the limit of what electricity can do," said Janelle Shane, an alumna of the Jacobs School of Engineering at UC San Diego.

More electricity flowing through wires makes the wires heat up and start to interfere with one another.

Shane specializes in photonics, the study of light and what can be done with it. Naturally, she has a brilliant answer to the challenge of transferring more data, faster: light.

"What we found is that, if we send data via light down fibers made out of glass that can transport light from one place to another, then suddenly we can fit a lot more information on one strand of glass than we ever could on a wire, because we can put different colors of light down the same wire," said Shane.

These fiber optic cables have other advantages over electrical wires: no interference and no heat problems.

The benefits aren't limited solely to transferring big data over long distances. The limitations of electrical wires are present even within a single electronic device, for example between your computer's processor and graphics card when you're watching the latest cat video.

"We want to try and use those same advantages that we got from fiber optics on a computer chip, for sending data not only between computers but now within computers as well," said Shane.

The information revolution's dirty secret

Your mobile phone may not take much power to fully charge, but its carbon footprint is much bigger than it seems.

All of those cat videos need to be stored somewhere – multiple places, in fact, so that you can access those cat videos on demand anywhere in the world.

The data centers that enabled the information revolution are an enormous and constantly proliferating power drain. By 2020, data centers in the U.S. alone are projected to consume 140 billion kilowatt-hours per year – roughly enough to power every household in New York City for eight years. A significant portion of this electricity is wasted when it is converted into excess heat, used for cooling systems to deal with the excess heat, or used to power multiple redundant backup systems. All of which wastes precious energy, and creates greenhouse gases in the process.

Take away the heat problem, and the energy consumption plummets.

"If we have more and more components on the same chip, then we don't have to convert signals to electricity so much, and that saves us energy there," said Shane. "The more information we can send via light, we also will save energy on heating up."

Tiny lasers, giant blimps

To take on a problem this big requires getting really small: computer chip small.

"We're trying to figure out how to make lasers that are so small that they fit well on computer chips," said Shane. "That means we want to make lasers that are about 100 times thinner than the diameter of a single human hair."

Shrinking the existing technology is no small feat.

"The lasers need to be small, switches need to be small, detectors need to be small, and the fiber optics themselves – we need to find a small equivalent that will fit on a computer chip," explained Shane.

If you succeed in shrinking a laser, tiny things become huge obstacles.

"When we try to shrink down lasers to the size that they are a hundred times smaller than a width of a single human hair that means they are also a hundred times smaller than your typical dust particle," explains Shane.

"In every breath of air that we take there are about a million particles of dust," said Shane. "Trying to build something that small where there are all these giant things floating around is approximately like trying to do chemistry in a lab when you've got blimps floating around in the room."

One particle of dust in the wrong place, and it's back to the drawing board.

Another challenge: As the semiconductor in a laser gets smaller, the less well it works.

"There is only so much it can amplify light. So we are fighting against that problem where we are trying to use a very small amount of semiconductor to do a lot of amplifying."

The whispering gallery laser

Fiber optic cables are made out of extremely pure glass. In a fiber optic cable, the properties of the glass force light to bounce off the sides of the fiber as it travels its length. Shane and her colleagues focused in on the challenge of optimizing the way that lasers could perform a similar feat on a computer-chip-sized scale, drawing inspiration from a property of sound first described over 200 years ago.

In buildings with large domes or circular rooms, like London's famed St. Paul's Cathedral, a whisper on one side of the dome can be heard by anyone else around the edge of the room. This is called a "whispering gallery" and the sound waves that bounce around the room are known as "whispering gallery waves."

"We've got the same thing set up inside of our lasers. They are 'whispering gallery' mode lasers. The light is bouncing around the outside of our laser and reaching its original point," Shane explained.

Shane and her colleagues hope that the optimal patterns of bouncing lasers found at larger scales can be replicated as the laser gets smaller and smaller, to make data transfer super fast and cool for future electronic devices.

"Looking at past trends, we can guess that we are going to be wanting to send more and more data at higher and higher rates," said Shane. "So, we've got to be ready."

Provided by University of California - San Diego