Physicists develop a metamaterial that can count

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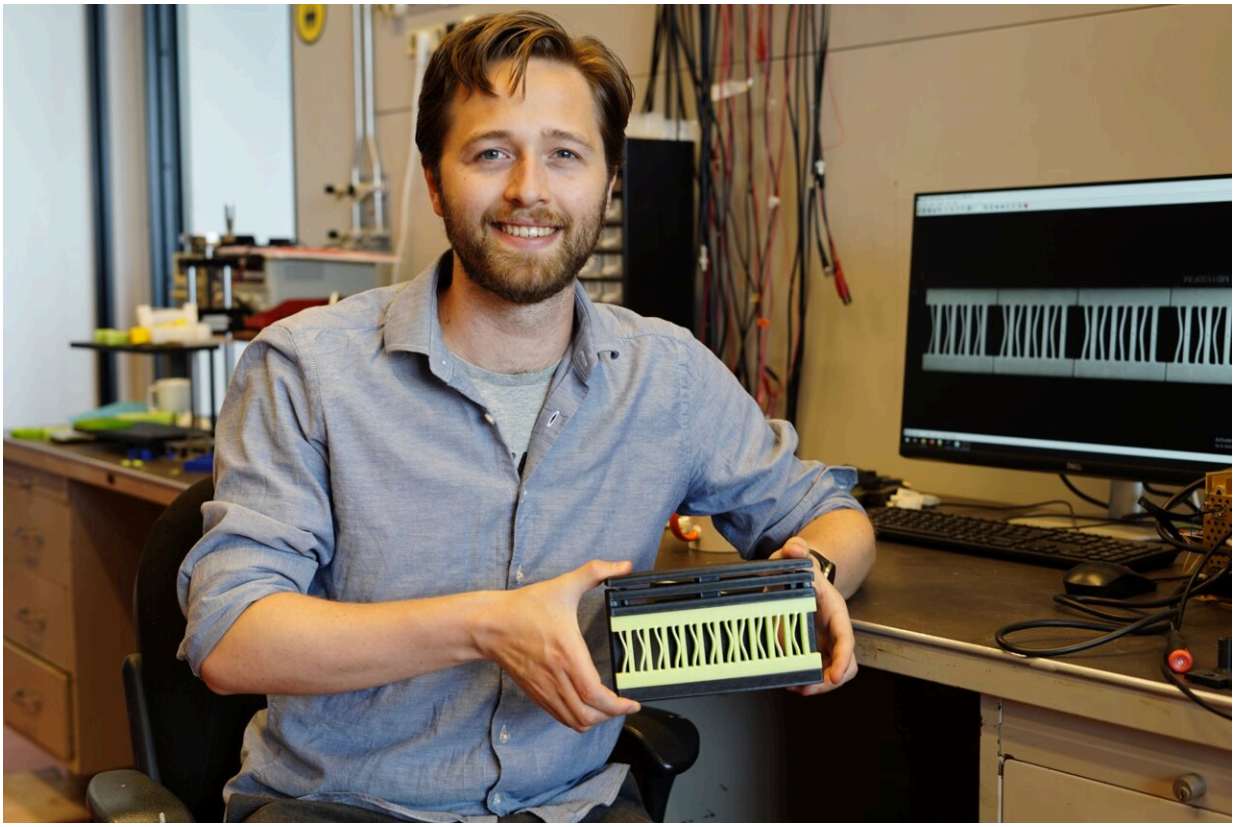


Lennard Kwakernaak. Credit: Leiden University

A block of rubber that can count to ten and even remember the order in which it is pressed—physicists Martin van Hecke and Lennard Kwakernaak (Leiden University and AMOLF Amsterdam) have

published about this latest metamaterial in the journal *Physical Review Letters*.

"I like finding complexity in simple things." With a big smile Ph.D. candidate Kwakernaak enters the room, the showpiece in his hands: a piece of soft rubber with 22 beams in pairs. "This is our beam counter. Push it," he says.

The result is unexpected. The bars all bend to the left except the first one, which bends to the right. "That first bar then pushes the next pair to the right and that moves along one position each time you push the material. That's how the material counts to ten."

Material with memory

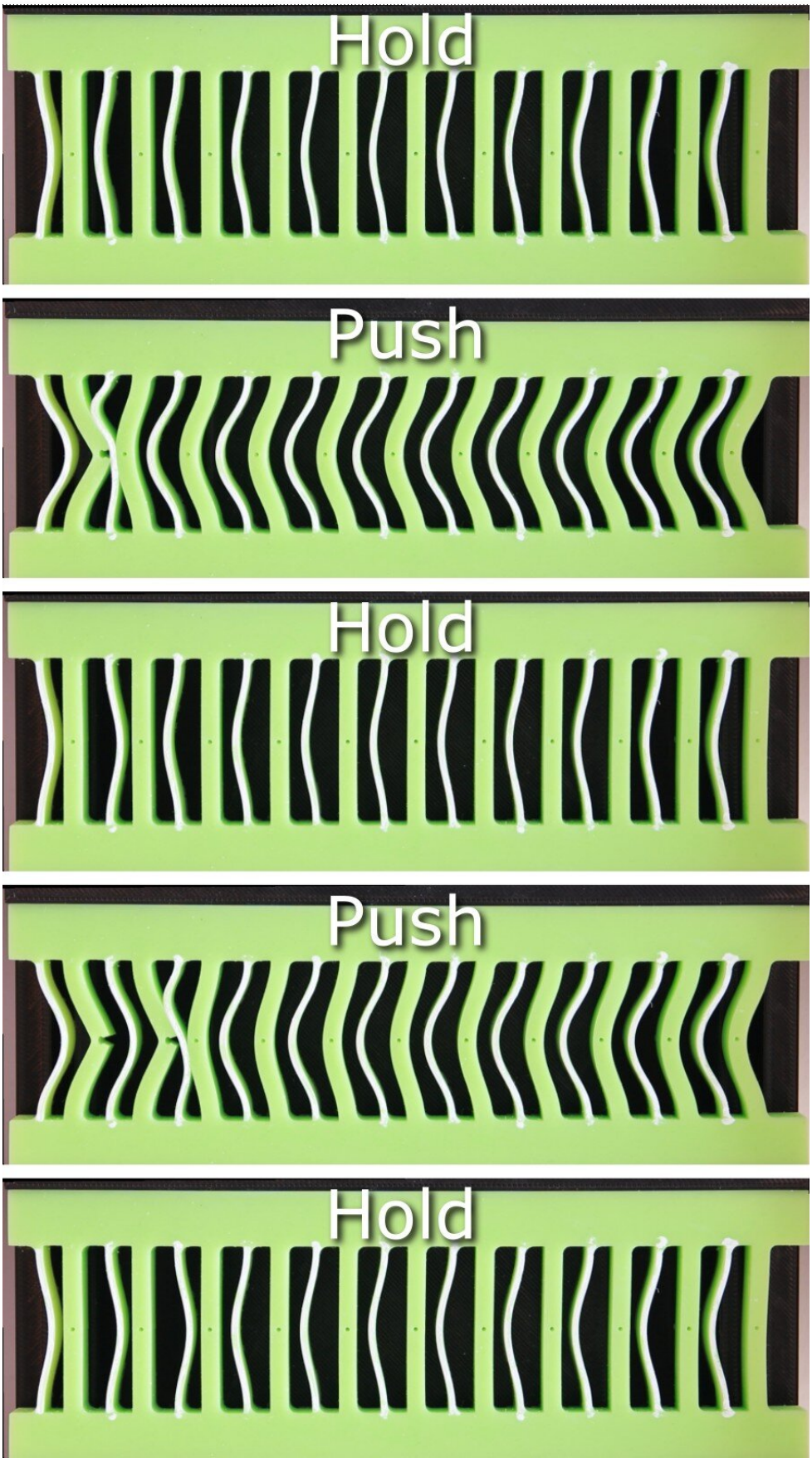
The rubber block is an example of a mechanical metamaterial: a material whose properties are determined not only by its composition but also by its structure. Van Hecke's group investigates how simple materials can be used to process information, a bit like a computer.

A bar that snaps from left to right can be compared to a computer bit that is either zero or one. "It's not easy to design the structure so that it responds the way we want," Kwakernaak explains. "Counting is the simplest computation we could come up with, so that was a logical starting point."

"When developing such a material, you try to discover the rules of the game," the Ph.D. candidate explains. "What are you allowed to do? The rule in this case is about the contact of a bar with its direct neighbors."

The researchers also went one step further than counting, he explains. "Along the way, I found out that you can cause different reactions in the rubber by pushing with different levels of force. By experimenting with

this, I was able to make a metamaterial that only counts to the end if you push on it in the right order, with the right amount of force. A kind of lock, in other words."


Hold
Push
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Counting metamaterial. Credit: AMOLF

Simple solutions to all kinds of problems

One possible use is counting cars from different weight classes driving over a bridge. Or a pedometer, for example, because you can make the metamaterial as big or small as you want. "The big advantage is that such mechanical metamaterials are cheap, robust and low-maintenance," Kwakernaak says.

"That makes them interesting for all kinds of applications. It's hard to say exactly what those will be, but we always find a purpose for new materials like this. For example, earlier research into a material that folds like origami inspired the folding of solar panels on a satellite."

Kwakernaak himself especially enjoys seeing how seemingly simple things can be very complex. "How such a thin beam bends exactly is much more complicated than you might think. A computer can barely even simulate it." He laughs, "Sometimes it almost feels like I'm a professional hobbyist."

Kwakernaak's next step is to come up with an even more complicated structure, where there is interaction between neighbors not just in one direction, but in a plane. "That would actually be a simple computer," he says.

More information: Lennard J. Kwakernaak et al, Counting and Sequential Information Processing in Mechanical Metamaterials, *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.130.268204

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