Reconfiguring microwave photonic filters without an external device

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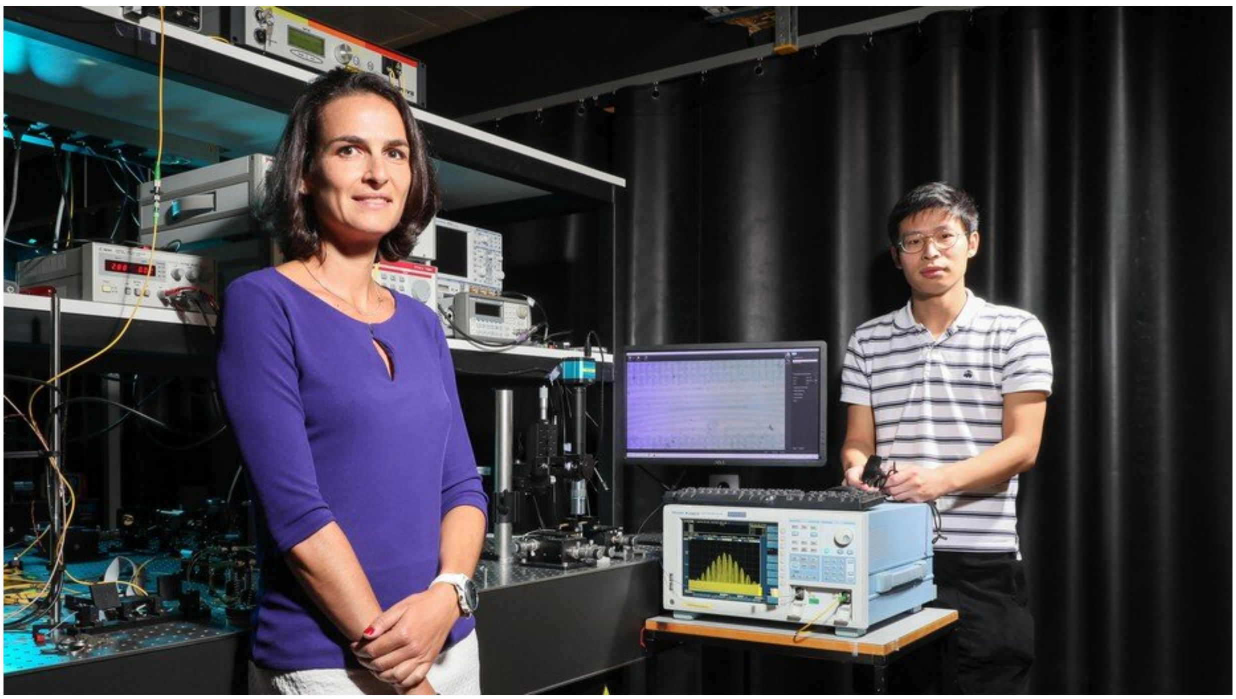

Camille Brès et Jianqi Hu, autors of the *Nature Communications* article. Credit: Alain Herzog

Researchers from EPFL's Photonics Systems Lab have come up with a way of reconfiguring microwave photonic filters without the need for an external device. This paves the way for more compact, environmentally friendly filters that will be more practical and cheaper to use. Potential applications include detection and communications systems. The researchers' findings have recently been published in *Nature Communications*.

Photons look set to replace electrons in countless tasks, since they move faster and consume less energy. These tiny light particles also have the added benefit of being surprisingly flexible—their frequency range is 1,000 to 10,000 times larger than that of electrons. So using light rather than electricity to manipulate microwaves gives you a much broader bandwidth to work with. Photonics comes in particularly useful in communications systems, the Internet of Things and beamforming, which is a signal processing method used in antenna systems. But for the moment, microwave photonic systems still can't generate light pulses on computer chips—a development that would make the chips more environmentally friendly, cheaper and more practical to use. Researchers at EPFL's Photonics Systems Lab have just made a major breakthrough in this area: they have developed reconfigurable radiofrequency filters that can produce high-quality microwaves without the need for a bulky external device. By creating interference between two pulses within a microcomb, they were able to accurately control the pulses in order to reconfigure the outgoing radiofrequency. The researchers' findings were recently published in *Nature Communications*.

Integrating a light source into a chip

A microwave photonic filter converts an incoming radiofrequency into an optical signal that can then processed by a photonic device in order to extract information. A photoreceptor than converts the signal back into a radiofrequency. Back in April, researchers in another EPFL laboratory, the K-Lab, managed to generate different types of microcombs on a silicon nitride chip, in order to produce high-quality soliton pulse signals. All that was left was to demonstrate that the pulse signals could be used to reconfigure the microwaves and that the system was just as flexible, linear, spectrally pure and noise-free as the previous, more bulky devices—exactly what the researchers in the Photonics Systems Lab optimized the chip to do.

The technology used in these chips, which are smaller than a coin, is based on how light interacts with the surrounding environment. The signal's wavelength can be modified by either varying the light source or by changing the shape or material of the optical channel it passes through. "Using a light source that can combine several wavelengths means that we can keep the filter's structure quite simple," explains Camille Brès, who runs the Photonics Systems Lab. "If we can reconfigure the frequency by altering the light pulse, we don't need to change the physical support." The researchers' main achievement was that they were able to replace the laptop-sized light generators with miniature on-chip optical resonators that use laser pulses to generate perfect solitons.

Altering the outgoing frequency

For these filters to be used in various applications, they also need to be capable of altering the outgoing radiofrequency. "Current filters require programmable pulse shapes to set the outgoing frequency and improve the wave quality, which makes the systems complex and hard to market," says Jianqi Hu, a Ph.D. student in the Photonics Systems Lab and the study's lead author. To overcome this obstacle, the researchers generated on-chip interference between two solitons—by modifying the angle between them, they were able to reconfigure the filter frequency. This breakthrough means that these systems can be made fully portable and used with 5G and terahertz waves.

More information: Jianqi Hu et al. Reconfigurable radiofrequency filters based on versatile soliton microcombs, *Nature Communications* (2020). DOI: 10.1038/s41467-020-18215-z