communications
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MEETING REPORT

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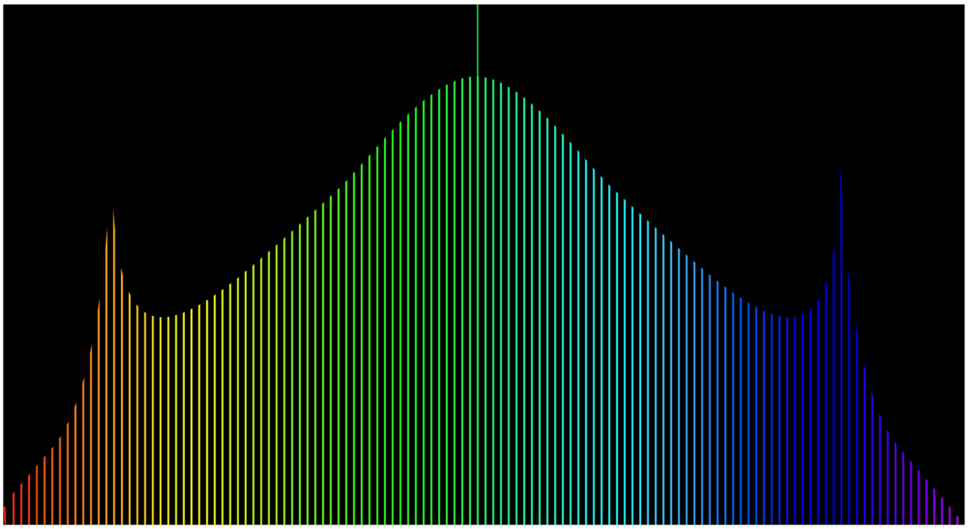
Moulding light on a ring

Drawing around 60 attendees and 20 presenters to a virtual lecture room, April's *CHI-2 Photonics in Microresonators and Beyond* conference explored recent progress in the use of microresonators and integrated photonic devices exhibiting second-order nonlinearity for optical frequency conversion.

The capability of photonic integrated circuits to convert incoming photons to new colours is a critical tool in modern-day information processing and precision spectroscopy. For light, microresonators act as racetracks with the photons looping around. A long path length and small footprint are the key advantages of on-chip frequency conversion. The material property enabling frequency conversion is called nonlinear susceptibility. The second-order, or chi-2, susceptibility is one of the best-known enablers of frequency conversion. It naturally doubles or halves the light frequency — a pretty large spectral leap on any practical account. Despite this, the majority of recent scientific and technological breakthroughs in microresonator-based frequency conversion have utilised the third-order, chi-3, nonlinear susceptibility. This is due to the challenges in making chi-2-based devices, such as the need to match both the phase and group velocities of photons across a broad spectral range.

Over the past few years, frequency conversion in chi-2 microresonators has gradually come out from beneath the shadow of chi-3 resonators. There are very good reasons for this. Primarily, dramatic improvements in fabrication capabilities using chi-2 materials have increased the options for device architecture. This in turn allowed reduced power requirements and the softening of numerous other constraints thanks to new resonator designs, material choices, and pumping arrangements.

The event opened with lectures describing recent work on non-monolithic resonators, aimed at generating relatively narrow frequency combs[1]. Frequency combs contain a regular and equally-spaced pattern of spectral lines, similar to the teeth on a comb. The regularity of these teeth allow them to be used for precision spectroscopy and other applications. Because the comb-teeth separation increases as the resonator radius decreases, the wavelength coverage of the generated spectra can be controlled.



Credit: D Puzyrev

Most of the following lectures considered smaller monolithic resonators, either fabricated mechanically from bulk crystals or lithographically from thin films. Many groups chose to work with lithium niobate as the microresonator material, as it combines one of the strongest chi-2 responses with good compatibility with established fabrication procedures, resulting in low-loss microresonators[2]. Low losses are associated with high quality factors, which is the main parameter boosting the efficiency of frequency conversion. One impressive result, announced at the meeting by Prof. Ya Cheng from the Chinese Academy of Sciences, was the realisation of on-chip lithium-niobate resonators with quality factors of 10^8[3]. Silicon[4] and aluminium[5] nitrides are less common choices for chi-2 platforms but are now generating growing interest, in part due to the existing use of these materials in electronic devices. Finally, Prof. Christoph Marquardt from the Max Planck Institute captured the attention of the audience with proposals of how to use chi-2 microresonators to generate quantum states of light[6] for secure communication on with satellite platforms.

The convergence of advanced fabrication methods and fundamental concepts leave no doubt about the continued growth of this research area, and demonstrate that its success is strongly dependent on international collaborations. A video record of the lectures is available online.

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Competing interests

The authors declare no competing interests.

Additional information

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