Terahertz laser frequency combs

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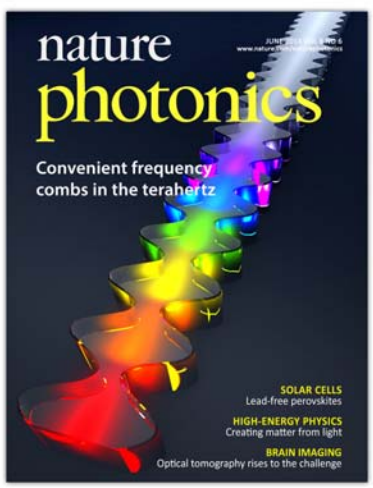
The development of optical frequency combs has had a revolutionary impact on high-precision metrology and spectroscopy, and the development was recognized with a Nobel Prize in 2005. At visible and near-infrared frequencies, the combs are often formed based on mode-locked lasers whose periodic pulse trains in the time domain naturally lead to frequency combs from the duality relation in Fourier transform. More recently, a new type of frequency comb was developed using nonlinear optical sideband generation based on four-wave mixing (FWM) [1]. In these devices, a coherent *cw* laser source is used to pump a microresonator with high quality factor and equally spaced cavity modes. When the pump lasing frequency coincides with a cavity mode, the cavity-enhanced FWM generates multiple sidebands in a bifurcate fashion at other cavity modes.

In 2012, a mid-infrared frequency comb was developed based on FWM in a quantum cascade structure [2]. A straightforward implementation of this scheme will likely fail at THz frequencies because of the much stronger group-velocity dispersion due to the proximity to the *Reststrahlen* band. By using a carefully designed and fabricated integrated dispersion compensator, we were able to develop laser frequency combs at THz [3]. This breakthrough will enable the creation of compact terahertz spectrometers that replace the bulky systems currently in use. With comb-based spectrometers, we can achieve the high resolution (~kHz) and S/N ratios of laser spectroscopy, the broadband capabilities of FTIR (>1 THz), all with no mechanical moving parts. This development will enable a wide range of applications not currently possible.



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