Spotlight on Optics

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Spotlight Summary by Paul Steinvurzel

Shaping the spectrum of a down-converted mid-infrared frequency comb

Campo et al. address an evergreen problem in laser spectroscopy: how to generate light with the appropriate spectrum for a given experiment. This is a particularly thorny issue in the mid-IR and UV, where there are far fewer materials and architectures that can provide performance approaching that of NIR or visible laser systems. Mid-IR photon energies match the rotational and vibrational energies of many molecules and molecular functional groups (molecular

Article Information

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G. Campo, A. Leshem, F. Cappelli, I. Galli, P. Cancio Pastor, A. Arie, P. De Natale, and D. Mazzotti

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fingerprint region), so mid-IR spectroscopy is among the best methods for identifying materials and probing their physical structure. This in itself is a boon for basic physical chemistry, but the applications of mid-IR sources are manifold, including in astronomy, atmospheric science, biomedical imaging and diagnosis, military surveillance, and non-proliferation.

Non-linear frequency conversion is the go-to method for generating colors not available from conventional laser systems. Recent work from Tel Aviv University has shown that, whereas crystals with uniform poling periods convert over only a narrow frequency band, computer generated holograms (CGHs) can be used to define a poling pattern that phase matches over a wide spectrum of wavelengths of one's choosing. They alternatively showed that, by appropriately tiling uniform quasi-phase-matched poling periods on top of one another, one can generate several discrete, widely spaced wavelengths simultaneously. Both these methods have been demonstrated in PP-KTP and PPLN to upconvert C-band light via SFG or SHG processes.

In this paper, a collaboration between the National Optical Institute in Florence, Italy, and the Israeli group, the authors experimentally show that both the CGH and quasi-periodic poling methods work for DFG in MgO:CLN to generate a variety of mid-IR spectra over <4.3 μm to 4.7 μm (a fingerprint region for several greenhouse gas isotopes). Using a CW Ti:sapphire pump, a 1 μm frequency comb signal (generated from a Ti:sapphire pumped PCF, spectrally spliced and amplified in Yb-doped fiber), and one of six poling patterns generated by either CGH or quasi-periodic tiling, the authors generate a variety of mid-IR spectra (broad continuum or pairs of discrete lines, both widely and closely spaced) that roughly match their designs. Preliminary measurements indicate that, when generating discrete lines, their beat note is narrow band, and so they maintain their phase relationship and are wellsuited for cavity-enhanced spectroscopy. The efficiency of the process is low (they use W's of pump and signal to generate μW's of idler, which can be improved), but their method shows a promising route to generating phase- and amplitude-tailored mid-IR spectra.

Article Reference

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G. Campo (/search.cfm?a=G Campo), **A. Leshem (/search.cfm?a=A Leshem)**, **F. Cappelli (/search.cfm?a=F Cappelli)**, **I. Galli (/search.cfm?a=I Galli)**, **P. Cancio Pastor (/search.cfm?a=P Cancio%20Pastor)**, **A. Arie (/search.cfm?a=A Arie)**, **P. De Natale (/search.cfm?a=P De%20Natale)**, and **D. Mazzotti (/search.cfm?a=D Mazzotti)**

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