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Sensing Methods with Undetected Mid-Infrared Photons

Mid-infrared (MIR) sensing holds significant promise across many industries due to its capability to accurately identify samples from their molecular vibrations which are revealed in their MIR absorption. Nevertheless, the wider adoption of MIR sensing is often hindered by the limitations of current MIR detection technologies, which are plagued by large noise, inefficiency, and high costs and cooling requirements in comparison to silicon-based detectors. Additionally, broadband MIR sources are typically complex and expensive, further restricting the widespread use of this technology.

In the colloquium, I want to give a comprehensive overview of our research on various implementations of ‘sensing with undetected photons’ [1], aimed at overcoming these challenges. This technique leverages nonlinear interferometry to separate the probe and detection wavelengths, thereby allowing samples to be examined in the MIR range while utilizing silicon-based technology to detect shorter wavelengths. This approach can significantly reduce the size, weight, power, and cost of MIR sensing by eliminating the need for traditional MIR detectors and sources.

In our research we sofar demonstrated the application of this method to perform a variety of sensing tasks in the MIR range, including the spectroscopy of plastics and gases [2], optical coherence tomography (OCT) of highly scattering layered structures [3], and microscopy of biological specimens [4,5] which I will discuss in addition to our progress towards translating these proof-of-principle experiments into real-world industrial applications in environmental monitoring of microplastics and non-destructive testing of ceramics.

References

[1] G. B. Lemos, M. Lahiri, S. Ramelow, R. Lapkiewicz, and W. N. Plick, “Quantum imaging and metrology with undetected photons: tutorial”, J. Opt. Soc. Am. B **39**(8), 2200-2228 (20 22).

[2] P. Kaufmann, H. M. Chrzanowksi, A. Vanselow, and S. Ramelow. “Mid-IR spectroscopy with NIR grating spectrometers”, Opt. Express **30**(4), 5926-5936 (2022).

[3] A. Vanselow, P. Kaufmann, I. Zorin, B. Heise, H. M. Chrzanowksi, and S. Ramelow. “Frequency-domain optical coherence tomography with undetected mid-infrared photons”, Optica **7**(12), 1729-1736 (2020).

[4] I. Kviatkovsky, H. M. Chrzanowski, E. G. Avery, H. Bartolomaeus, and S. Ramelow, “Microscopy with undetected photons in the mid-infrared”, Sci. Adv. **6**(42), eabd0264 (2020).

[5] I. Kviatkovsky, H. M. Chrzanowski, and S. Ramelow, “Mid-infrared microscopy via position correlations of undetected photons”, Opt. Express **30**(4), 5916-5925 (2022).