QUANTUM TECHNOLOGIES, METAMATERIALS, AND THE FUTURE OF CB SENSING

Improving Swap In Thz Detection Using A Laser-cooled Rydberg Atomic Sensor On A Photonic Integrated Circuit

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Accurate and timely identification of both organic compounds and biological substances (OCBS's) is critical to assessing threats to human health and public safety. This necessitates high-fidelity metrology in diverse environments, where reducing device SWaP is fundamentally important, and an ongoing challenge.

A promising candidate for identifying OCBS's, THz spectroscopy offers SWaP improvements and other advantages over a present industry standard, IR spectroscopy. THz spectroscopy reduces SWaP relative to IR spectroscopy by alleviating the bulky cooling systems required for IR detectors. Furthermore, unlike the IR domain, many fabric or cloth materials are transparent to THz radiation, allowing for sensing to be performed in more diverse situations. However, a significant challenge in THz spectroscopy is the difficulty of detecting radiation in the relevant frequency range.

At Leidos, we overcome this challenge with a Rydberg atomic sensor that is sensitive to the THz domain and offers reduced-SWaP over traditional methods. Developed as an internal research effort, we use laser-cooled Rb atoms to surpass the sensitivities achievable by hot-vapor sensors, while avoiding reliance on bulky traditional cryogenic cooling apparatus. The SWaP of our sensor is further reduced by miniaturization on to a photonic integrated circuit (PIC), which is compatible with conventional chip fabrication techniques. In our PIC-based Rydberg sensor, we use splitters and an array of photonic ring resonators to convert an incident laser into several output channels of tunable frequency. Each channel prepares optically-trapped Rb atoms in states that are sensitive to a particular THz frequency. By measuring across these channels, we can simultaneously monitor incident THz radiation over a range of frequencies, resulting in a spectrometery-capable sensor that is only a few cm2 in size. In combining these exciting advances, Leidos delivers a THz sensor that improves measurement sensitivity and reduces SWaP over conventional sensors, further developing THz spectroscopy as an option for in-the-field detection of OCBSs.

We hope to present our developments to the CBD S&T community to share current advances in quantum metrology and provide an outlook on the readiness of such devices for implementation.

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