QUANTUM TECHNOLOGIES, METAMATERIALS, AND THE FUTURE OF CB SENSING

Ultrasensitive, High Sensitivity, High-throughput, Quantum Sensing Of CB Agents

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An ideal diagnostic modality should be fast, sensitive, specific, reagentless, and high-throughput. Emerging techniques of “quantum sensing” promise new approaches to realizing this vision in practice. These techniques rely on the inherent fragility of quantum systems (e.g., single spins) to discern tiny changes in their environment, relying on quantum mechanical properties of superposition and entanglement.

In this talk, I will describe a new approach for highly sensitive, high-throughput, and label-free identification of CB analytes that combines quantum sensing with droplet microfluidics. Our approach utilizes nanoparticles of diamond (NDs) hosting Nitrogen-Vacancy centers as quantum chemical sensors for proximal analyzing molecules in their surroundings. These sensors are incorporated within monodispersed phase-separated droplets, serving as picoliter containers for both the sensors and analytes of interest. Pairing controlled droplet flow with microwave control of NV electronic spins, we introduce a new noise-suppressed mode of Optically Detected Magnetic Resonance (ODMR) that is sensitive to chemical analytes while resilient against experimental variations, achieving low-limit-detection sensing with low analyte volumes, about an order of magnitude better than existing methods. Simultaneously, the approach utilizes minimal sensor volumes and incurs low ND costs, <$0.70 for an hour of operation and hundreds of thousands of droplets. The method works in both clear (buffers) and complex (blood) matrices and in a reagent-free manner, and can ultimately potentially provide Nuclear Magnetic Resonance (NMR) information of CB analytes, allowing their agnostic identification with little or no prior information. This technology has the potential to open exciting new opportunities for point-of-need analysis for bioassays for warfighter support, identification and screening of analytes and infectious diseases towards developing countermeasures, topics of broad relevance to the DTRA JSTO.

References:
A. Sarkar, Z. Jones, M. Parashar, …, A. Ajoy. “High-Precision Chemical Quantum Sensing in Flowing Monodisperse Microdroplets.” arXiv Preprint arXiv:2404.19313. (Sci. Adv. Under review)

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