DARPA Selects Research Teams to Enable Quantum Shift in Spectrum Sensing

Program aims to bring quantum techniques to radio frequency sensing to enable new levels of sensitivity, agility for defense applications

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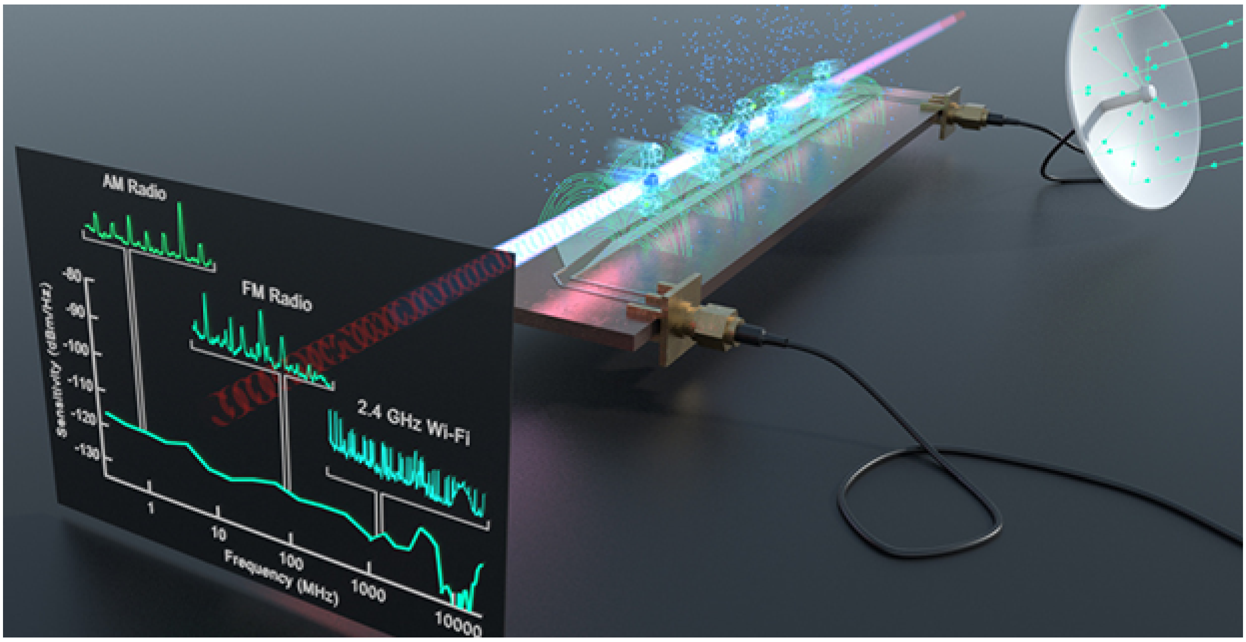

DARPA today announced the research teams selected for the Quantum Apertures (QA) program, which seeks to develop a fundamentally new way of receiving radio frequency (RF) waveforms to improve both sensitivity and frequency agility for defense applications. The selected teams will be led by Honeywell, Northrop Grumman, ColdQuanta, and SRI International.

The QA program aims to develop RF antennas, or apertures, that use quantum techniques to alter the way the RF spectrum is accessed.

The goal is to develop portable and directional RF receivers with significantly greater sensitivity, bandwidth, and dynamic range than any classical receiver available today.

“Today, commercial wireless infrastructure, the construct of spectrum use, and beyond have been dictated by a hundred years’ worth of antenna theory, originally developed by German physicist Heinrich Hertz,” said John Burke, the program manager leading the QA program. “With the introduction of quantum, we have the ability to replace the existing fundamental limits placed on antenna technology with a whole new set of rules. Quantum Apertures seeks to create a paradigm shift in the way we access and use the spectrum.”

The research teams selected to the program will endeavor to address today’s antenna limitations by advancing the current state-of-the art in quantum RF sensors – the Rydberg sensor. DARPA’s former Quantum-Assisted Sensing and Readout (QuASAR) program realized the potential to sense electronic fields using highly excited Rydberg quantum states. These quantum states have a high quantum number (n) (in this case, approximately 100). High-n states have electrons that orbit ~10,000x further away from the proton than a ground-state atom, making them highly sensitive to electric fields – effectively acting like small antennae. More recently, the U.S. Army Research Laboratory (ARL) harnessed this sensing capability to develop a super wideband radio receiver – now known as a Rydberg sensor – further demonstrating the technology’s potential.

Ryberg sensors have several advantages over classic antenna-based receivers. They are not plagued with the same sensitivity challenges, largely because Ryberg sensors do not have to contend with thermal noise. Further, the performance of classic receivers is greatly impacted by the size and shape of the antenna. Ryberg sensors have no such size limitations with respect to the received RF frequency wavelength. This decoupling of the aperture shape and RF frequency enables a Rydberg sensor to be programmed over a large frequency range – from MHz to THz.

Despite these advantages, there are still significant technical challenges that must be overcome to realize the Rydberg sensor's potential in relevant defense applications. The QA program aims to address these challenges. Researchers will employ quantum and electro-mechanical-systems engineering to demonstrate the utility of Rydberg sensors as part of a portable RF receiver system. The target system will be able to directionally receive low intensity, modulated RF signals and operate over a very large spectral range – from 10 MHz to 40 GHz, or more. This will enable a user to see a large swath of the spectrum with one antenna, particularly the portions that are relevant to military applications. The researchers will also endeavor to develop a sensor element and its associated electronics in a one cubic centimeter package that can successfully operate across various frequencies. This will break the tradeoff between frequency range and size that exists with classic antennas. Further, the QA sensor will utilize lasers instead of cable for wiring, making it more resilient to high-power effects and tolerant of microwave radiation. This is a critical capability should the sensors be used near high-power calibrators or transmitters.

The final goal of the program is to demonstrate an ability to detect and process some commonly used waveforms (GPS, digital television, and a frequency hopping waveform) as well as develop novel waveforms that can take advantage of the unique RF sensing characteristics of Rydberg receivers for future defense applications.

"Recent demonstrations of Rydberg atomic sensors have shown that it's possible to access large portions of the RF spectrum, but QA aims to go beyond those efforts by continuously connecting these demonstrations across the spectrum," noted Burke. "We're going from simple demonstrations of one functionality to a device that can be programmed to do almost anything and do most of it better than a classical receiver could. This includes speeding up the time to tune the sensor, improving sensitivity to small signals, enhancing dynamic range, and expanding compatibility with modern signals."

The Quantum Apertures program is expected to run for 56-months, with four phases. Research will kick off in the Fall of 2021.

Image Caption: *A Rydberg receiver and spectrum analyzer detects a wide range of real-world radio frequency signals above a microwave circuit including AM radio, FM radio, Wi-Fi and Bluetooth. (U.S. Army illustration)*