IIP PROJECT HIGHLIGHT

Rydberg Radar: A quantum architecture for multi-science signal of opportunity remote sensing

OVERVIEW

This radar instrument concept will use **quantum Rydberg atomic receiver technology** to achieve state-of-the-art sensitivity, low-noise, and ultra-broadband capabilities on a single compact detector with no antenna or RF front-end, which would make it lighter and more powerful than traditional radar instruments. While a CubeSat-ready Rydberg Radar would be beneficial to numerous Earth system studies, it will be especially useful as part of a coordinated, multi-satellite signal of opportunity (SoOp) system dedicated to addressing dynamics and transients in land surface hydrology.

SCIENCE AREA

Remote sensing of **soil moisture** from canopy to root zone soil moisture (RZSM) is critical for modeling of land surface hydrological processes and its application to water resource management, agriculture yield, and flood forecasts. Despite its importance, measuring vertical distribution of soil moisture over large regions or globally has had numerous challenges: current space radar technologies are generally expensive and large, and spectrum allocation in needed bands is minimal.

Rydberg Radar will help researchers better understand features of Earth's hydrosphere such as root zone soil moisture, which is crucial for developing better crop forecasts.

TECHNOLOGY

Quantum Rydberg radars utilize quantum states and energy levels of excited Rydberg atoms for remote sensing applications. The proposed Rydberg Radar concept features dual detectors positioned in the zenith and nadir directions to detect direct and ground reflected SoOps. It would operate across six radar bands between 137 MHz and 3.9 GHz, which are sensitive to variables including canopy water content, vegetation water content, as well as near-surface and root-zone soil moisture. In addition, this instrument could be dynamically tuned to frequency bands from 10 kHz-1 THz with no deployable antennas.

Advancements

- **Quantum Rydberg atomic detectors** collect radar signals with unparalleled sensitivity, paving the way for groundbreaking studies of Earth's surface topography and freshwater availaibility.
- **Dynamically tuned RF selection** allows for rapid tuning to target potential signals without an antenna, providing significant advantages in weight and power consumption compared to traditional radar systems.
- **Dual-polarization sensor** will enable measurements of direct and reflected SoOps, enabling superior measurements of RZSM from a compact instrument platform.

Contact Info

PI : Darmindra Arumugam / JPL
Email : darmindra.d.arumugam@jpl.nasa.gov
TRL : 3
Co-Is : R. Shah, X. Xu, P. Mao, D. Hawkins, J. Bush, JPL; C. Holloway, A. Artusio-Glimpse, M. Simons, NIST; K. Cox, D. Meyer, P. Kinz, ARL