U.S. NAVAL RESEARCH LABORATORY

Quantum Position, Navigation, and Time (QPNT)

AT A GLANCE

What is it?

NRL is performing basic and applied research on methods to assure accurate long-term navigation and timekeeping in GPS-denied environments, based on accurate measurement of quantum systems.

How does it work?

QPNT measures transitions in atomic and atom-like quantum systems that are engineered to read out time, motion, fields, and gravity. Quantum interference provides ultraprecise readout of the state of quantum systems. Acceleration and rotation measurements enable inertial navigation while gravity and magnetic field measurement provide geophysical navigation capabilities.

Approaches

NRL is developing several types of quantum systems for QPNT:

- Matter-wave interferometry for acceleration, rotation, and gravity measurements
- Solid-state color centers in SiC for low-SWaP magnetometry and microwave timekeeping
- Continuous ultracoherent superradiant lasing in atomic strontium
- Dark-resonance spectrosopy in laser-cooled rubidium

Point(s) of Contact

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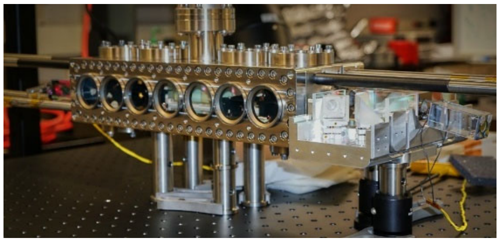
Quantum Atomic Beam Inertial Sensor

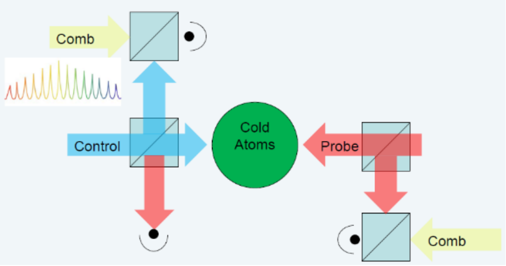


A new architecture for quantum inertial sensing based on matter-wave interference in a continuous beam of ultracold rubidium atoms. This system provides highly accurate measurements of rotation rates and accelerations while maintaining a measurement bandwidth over 100 Hz for inertial navigation.

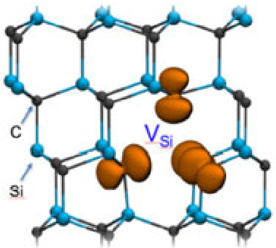
Superradiant Atomic Frequency Reference

Ultracoherent, superradiant emission from a laser-cooled strontium beam can provide absolute optical frequency stability. NRL is studying this system to form the foundation of a new generation of high-performance optical atomic clocks that eliminate the need for a prestabilized optical local oscillator.

Dark-Resonance Optical Clock



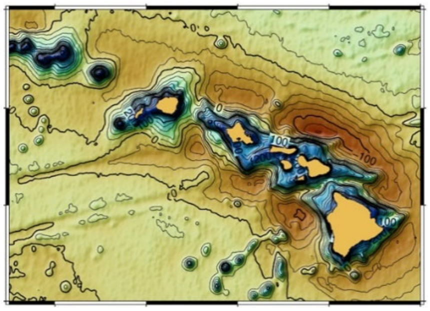
NRL seeks to improve the long-term stability of optical frequency reference technologies by interrogating laser-cooled rubidium. We are developing new methods of spectroscopy on narrow-linewidth two-photon transitions, leading toward an improvement in quality factor and reduced long-term drift.



Solid-State Quantum Sensor Platforms

Point defects in solid-state materials such as silicon carbide possess spin transitions with long coherence times at room temperature. These transitions can be used both for magnetometry and as a microwave frequency standard with ultra-low SWaP. NRL has improved quantum coherence times and demonstrated magnetic field and microwave frequency measurement in a strain-insensitive spin system.

Quantum Gravimetry



Atoms provide an ideal, absolute measurement of the strength of gravity. NRL has supported the design, modeling, and data analysis of quantum gravimeters for geophysical navigation applications. These efforts led to a successful demonstration of shipboard quantum gravimetry under a program led by the Office of Naval Research.