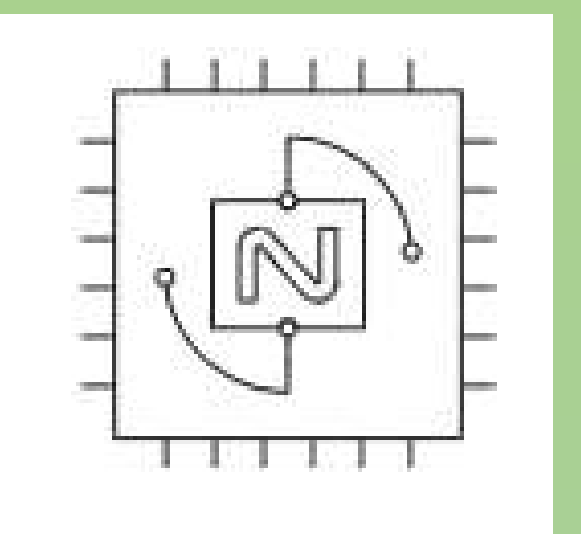


NIST on a Chip – Redefining Dissemination



<https://www.nist.gov/noac>

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Background

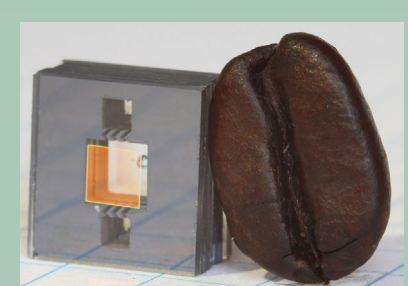
Quantum-based measurements are revolutionizing sensor technologies. The redefinition of units opened the door for new ways to realize fundamental units, laying the foundation for a new generation of sensors that are fit-for-purpose, intrinsically accurate, self-calibrating/self-validating, low-cost and manufacturable. The NIST on a Chip program (NOAC) is developing field-deployable devices for primary and derived units, including pressure, temperature, force, mass, torque, voltage and more. Together with its partners in industry and the US Department of Defense, several of these technologies are being commercialized and deployed.

The Vision & the Portfolio

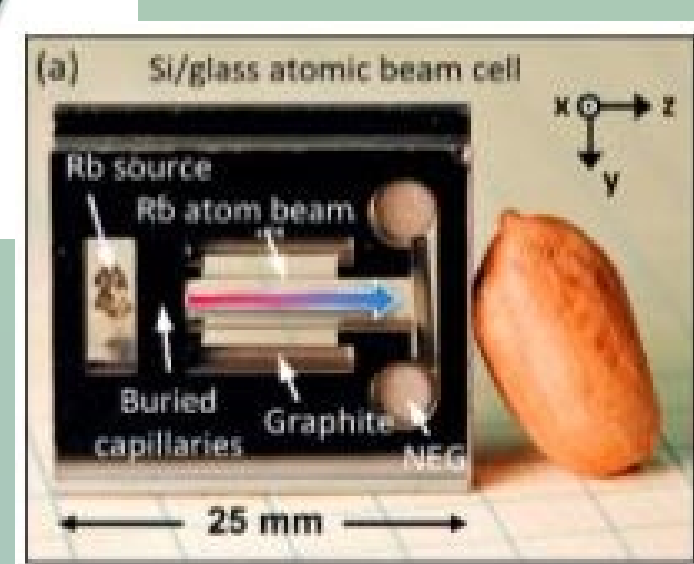
Commercialized!



Chip-scale Atomic Clocks



Vapor cell used in next-gen miniature optical atomic clocks



2023: World's first chip-scale atomic beam clock

<https://www.nist.gov/noac/technology/time-and-frequency>

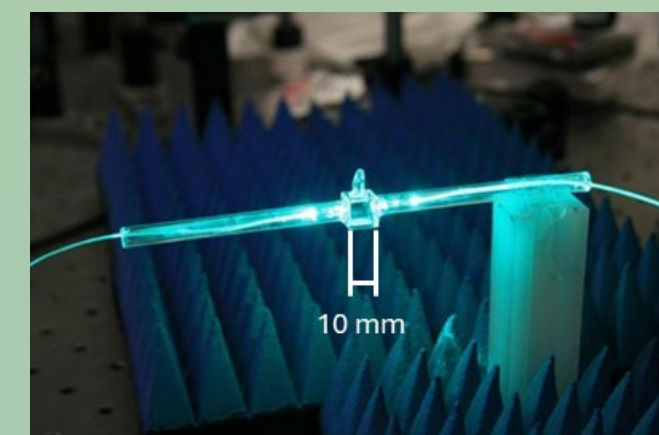
- Over 120,000 chip-scale atomic clocks sold by commercial partners
- Collaborations with 5 companies on patented vapor cell technology.
- World's first chip-scale beam clock demonstrated in 2023.

Commercial Collaborations!

Electric Field Sensing with Rydberg Atoms

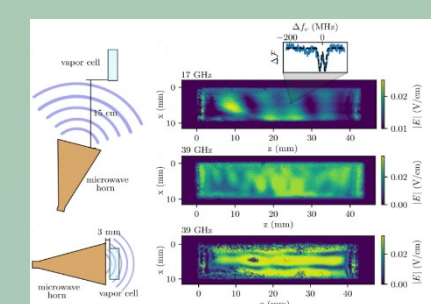


Reception of communications signals



Compact dielectric electric field probes

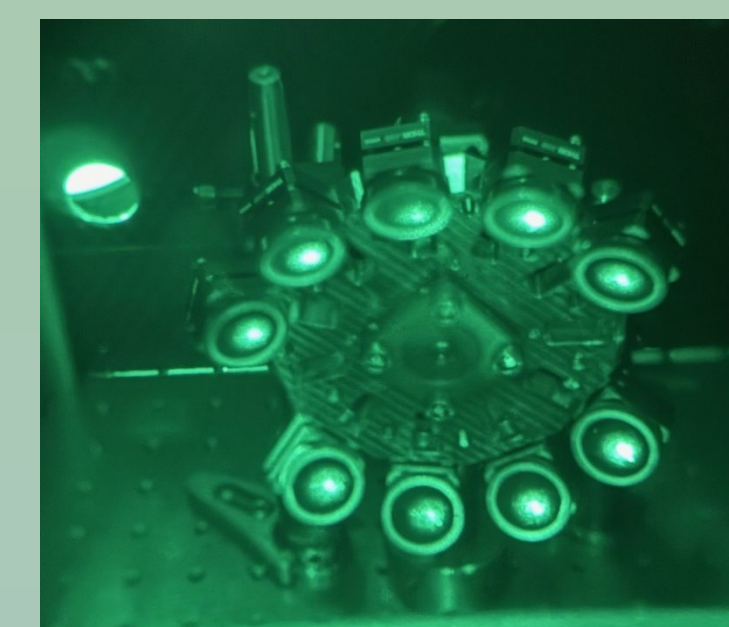
2D electric field imaging



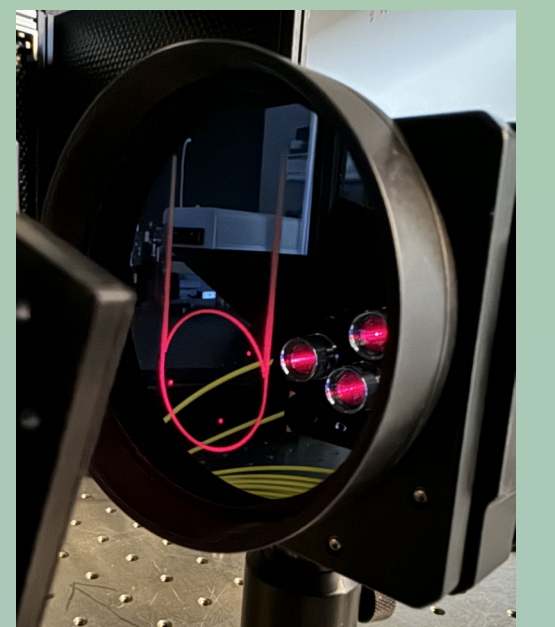
- Calibration-free electric field and RF power measurements, capability of determining phase and angle of arrival.
- Atomic sensing provides direct calibration.
- Recent demonstration of calibration-free temperature measurement.
- Over 20 companies making Rydberg sensors and field probes.

<https://www.nist.gov/noac/technology/magnetic-and-electric-fields/electric-field-metrology>

Portable Primary Standards for Laser Power and Pulse Energy



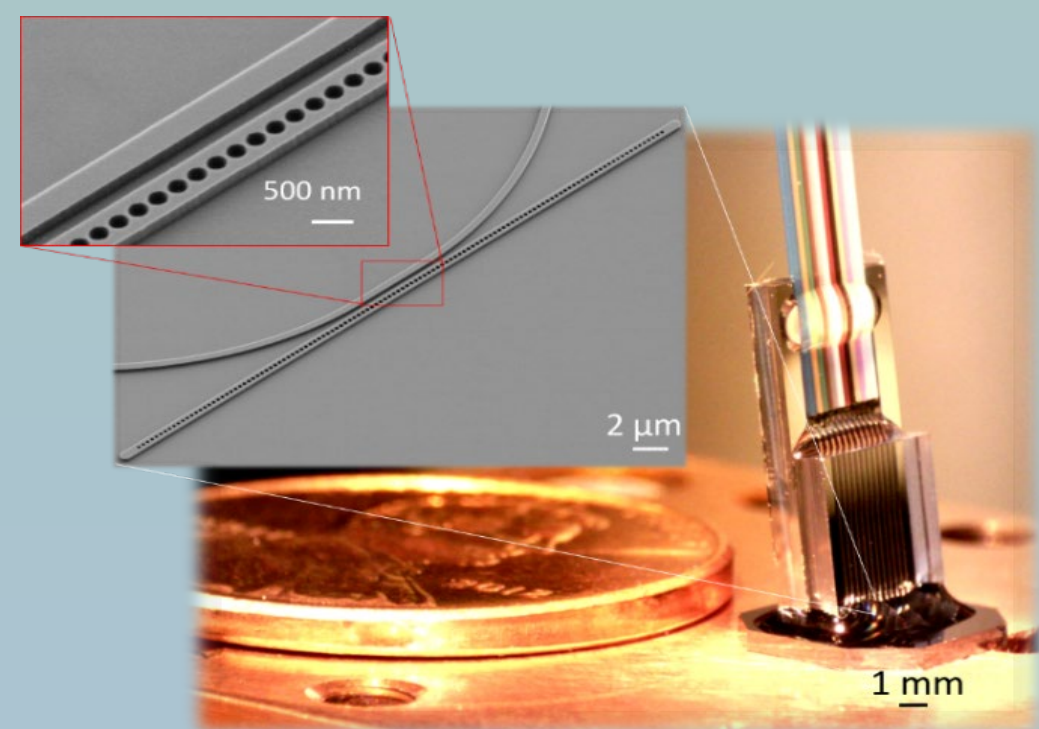
Multiplying the force of light for measurements at 10x lower powers



Measuring the momentum of laser light with a pendulum for pulse energy measurements

<https://www.nist.gov/noac/technology/quantum-optics-and-radiometry/photonic-power-metrology>

Photonic Thermometer to replace SPRTs



NIST photonic thermometer

Photonic temperature sensor

- Temperature is sensed through changes in the optical properties of materials
- Potential to replace the entire thermometry infrastructure

<https://www.nist.gov/thermodynamics/temperature>

Delivering NIST's precision metrology through a suite of chip-scale, quantum-based sensors, deployed at point-of use through commercial products

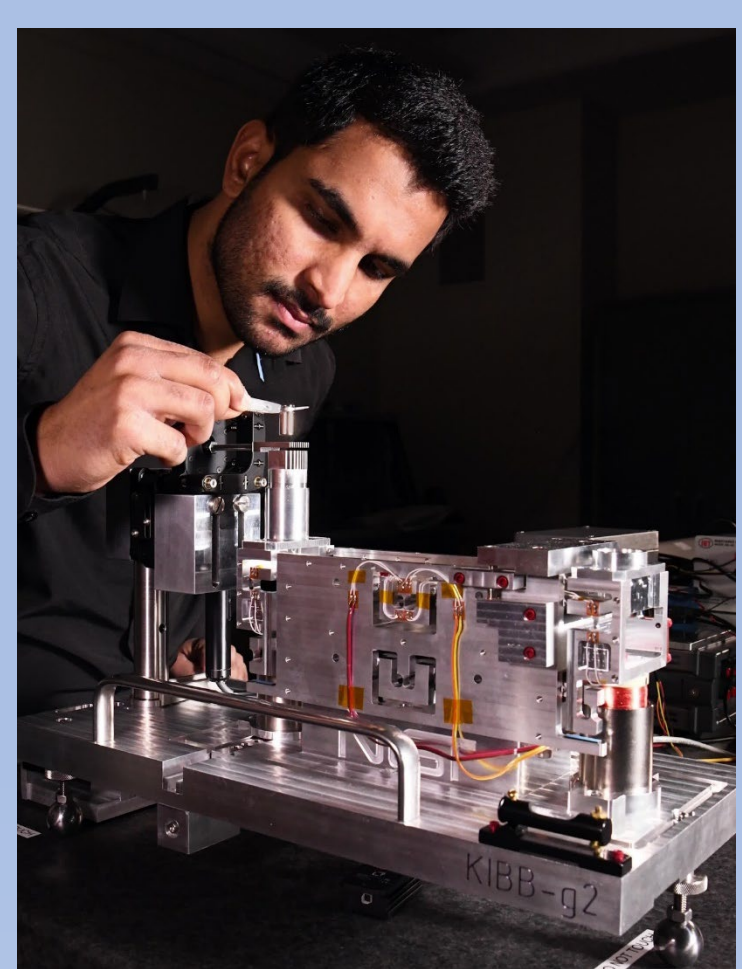
Prototypes Deployed!

Using the Kibble Principle for Mass & Torque



- NIST has partnered with Snap-on Inc. to create an accessible and user-friendly tabletop system to calibrate torque wrenches.
- Prototype Electronic NIST Torque Realizer (ENTR) delivered to U.S. Air Force.
- Prototype tabletop Kibble balance delivered to U.S. Army.

<https://www.nist.gov/noac/technology/mass-force-and-acceleration/torque-realization>



NIST engineer Kumar Arumugam examines the tabletop Kibble balance before its delivery to the U.S. Army. Credit: J. Lee/NIST

<https://www.nist.gov/noac/technology/mass-force-and-acceleration/tabletop-kibble-balance-gram-level-mass-realization>

Deployed!

Portable Josephson Voltage Standards



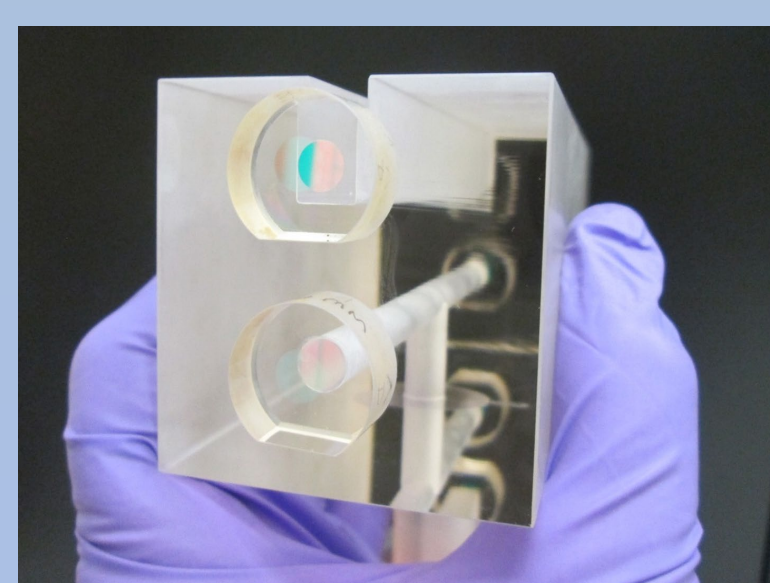
SRI 6000 Series Programmable Josephson Voltage Standard (PJVS)

<https://www.nist.gov/noac/technology/current-and-voltage>

- The Josephson voltage standard (JVS) precisely converts frequency to voltage.
- NIST has delivered over 100 primary JVS systems to metrology institutes around the world.
- In partnership with the US Air Force, NIST is pushing the frontiers of voltage metrology to make systems that are drastically more deployable and easier to operate.

Prototype Demonstrated!

Portable Pressure Standard to Replace Mercury Manometers



- Quantum-based pressure realization
- Eliminates need for mercury manometers
- Portable device demonstrated
- Critical for air data measurements for airspeed and altitude
- Commercial partnership (CRADA)

<https://www.nist.gov/programs-projects/quantum-pascal-fixed-length-optical-cavity-floc-pressure-standards>



U.S. Air Force

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U.S. DEPARTMENT OF COMMERCE