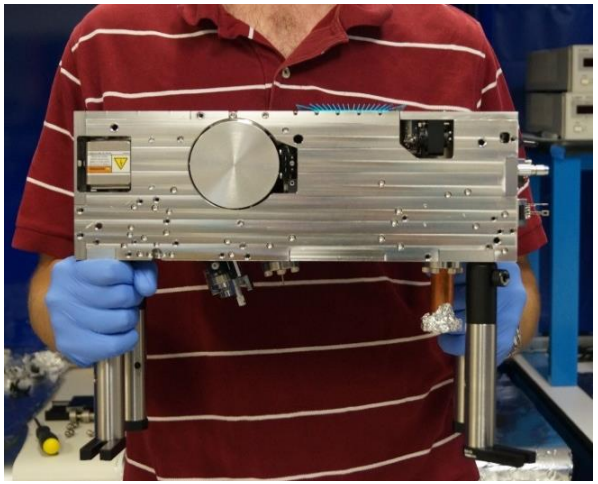
Delivering precision position, navigation, and timing solutions

- Founded in 2004 to spin-off work from Stanford University
- Core capability is design, fabrication, and testing of atomic clocks and inertial sensors
- 60k ft^2 R&D space located in Sunnyvale, CA.

- Staff of 52 (50/50 mix of physicists and engineers)
  - One of the world's largest atomic physics teams under one roof; 22 Ph.D.s trained under 7 Nobel laureates
  - Technical capabilities: Atomic physics, laser physics, vacuum engineering, packaging, optical and optomechanical engineering, precision manufacturing, electrical engineering, embedded systems, software engineering

Atom-optical devices set the standard for precision and accuracy



Sr lattice clock
$3\times10^{-16}/\tau^{1/2}$

10 m drop tower
1×10^{-11} g/Hz$^{1/2}$

"Chip-scale" accel/gyro
2×10^{-6} deg/hr$^{1/2}$

- Lab-based atomic sensors set the standard for measurement
  - e.g. Sr Lattice clock, 10 m drop tower, Thermal beam accel/gyro
- Current lab-based atomic sensors are impractical for deployment
  - Large overhead for preparing, addressing, and reading out atomic states; vacuum, lasers, low-noise electronics, grad students
- Solution: Partially trade performance for utility/simplicity
  - Identify practical/robust components; develop custom components, as necessary

Coherent imaging requires precise timing and location

- Physicist's perspective: Constructive/destructive interference requires temporal/spatial precision
  - Relative positioning between apertures/Stability over imaging time
    - Position $\Delta x \sim \lambda/10$; Jitter/Synchronization $\Delta t \sim 1/10\nu$
  - @ 1 GHz: $\Delta x \sim 30$ cm, $\Delta t \sim 100$ ps
  - @ 300 THz: $\Delta x \sim 100$ nm, $\Delta t \sim 0.3$ fs

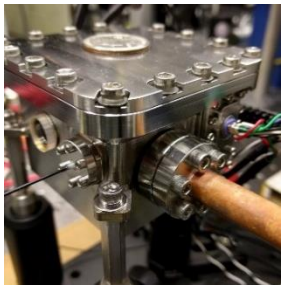
- Better clocks/synchronization support longer integration time
  - For higher frequencies, GPS is not good enough; $\Delta x \sim 10$ m, $\Delta t \sim 10$ ns

- IMU's can provide position/orientation updates when apertures are moving

AOSense can provide enabling hardware for coherent imaging

- For Amon-Hen, AOSense can provide prime contractors high-precision timing, synchronization, and positioning for coherent/distributed apertures.
  - Long-holdover/low-phase noise microwave and optical frequency standards

Microwave atomic clock



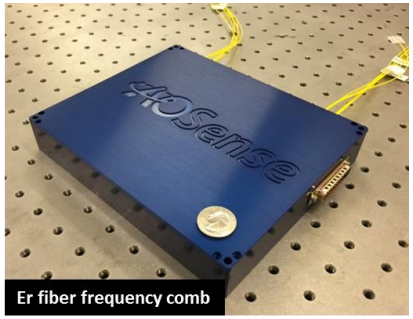
Integrated optical cavity

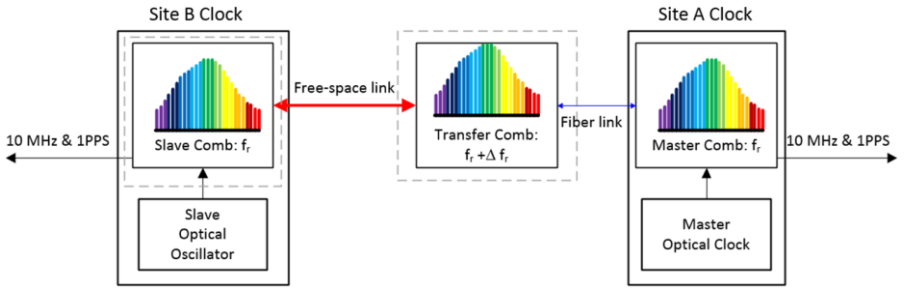
Fractional frequency stability

Microwave: $< 10^{-12}\ t^{1/2}$

Optical: $< 10^{-14}\ t^{1/2}$

  - fs-level synchronization via two-way optical time transfer using optical frequency combs





See NIST Scheme F. R. Giorgetta et. al, Nature Photonics 7, 434 (2013)

AOSense would love to join your team!

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