For more information about this technology or any of AFRL New Mexico's Technologies, please contact:

Matt O'Brien, Program Manager
AFRL Tech Engagement
505-846-5028
matto@afrlnewmexico.com

THE AIR FORCE RESEARCH LABORATORY

Optical Rubidium Atomic Frequency Standard (ORAFS)

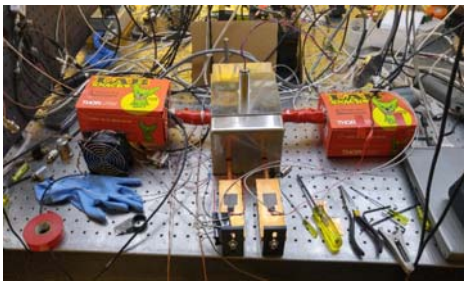
Inventors: John Burke, Nathan Lemke, Gretchen Phelps, Benjamin Stuhl, Kyle Martin

Background

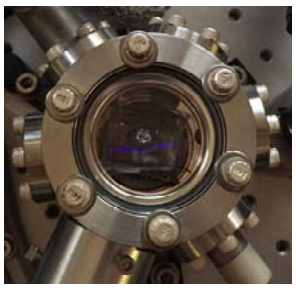
Extra-laboratory atomic clocks are necessary for a wide array of applications (e.g. satellite-based navigation and communication). Current GPS clock technologies tend to have high instabilities, due in large part to optical power fluctuations, as they are the most difficult clock instability mechanisms to suppress. This technology overcomes many of the limitations associated with current GPS clock technologies through several key innovative aspects.

Technology Summary

AFRL has developed an optical atomic clock, which is built largely upon existing vapor cell and laser technologies. The clock is designed around a simple and manufacturable architecture, which utilizes the 778 nm two-photon transition in rubidium and yields very low fractional frequency instabilities. The objective of this technology is to reach clock instabilities of less than 1×10^{-15} , a ten-fold decrease in instability over current GPS clock technologies.



The current experimental set-up. Previous ORAFS designs have fit in a 1 cubic foot volume.



Rubidium vapor cell locked to the two-photon transition.

The entire system is constructed primarily from commercially-available components, an attractive feature for commercialization purposes and deployment of optical frequency standards. A complete instability budget for this system has been explored, as well as the required conditions under which a fractional frequency instability of 1×10^{-15} can be maintained on long timescales. It was determined that optical power fluctuations are the most difficult clock instability mechanisms to suppress. In order to achieve instability levels of less than 1×10^{-15} , several key innovations were made to reduce effects of optical power fluctuations. These innovations include:

- Atomic fluorescence used as the power servo detector
- Multiple laser passes through the vapor cell
- Stark shift cancelation laser

Key Advantages

- Provides a cheaper, potentially more stable, Hydrogen maser alternative
- Potential state-of-the-art replacement for GPS clocks
- Reduced requirements of laser power stability in future designs
- Provides a stable reference laser at 1556 nm for offset lock telecom multiplexing