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Phase stability in next-generation atomic frequency standards

Atomic clocks (or oscillators) form the basis of standard, everyday timekeeping. Separated, hi-accuracy clocks can maintain nanosecond-level autonomous synchronization for many days. The world's best Cs time standards are atomic fountains that use convenient RF quantum transition at 9,192,631,770 Hz and reach total frequency uncertainties of $2.7\text{--}4 \times 10^{-16}$ with many days of averaging time. A new class of optical atomic standards with quantum transitions having $\pm 1 \times 10^{-15}$ uncertainties drives an Optical Frequency-Comb Divider (OFD), thus providing exceptional phase stability, or Ultra-Low Phase Noise (ULPN), at convenient RF frequencies. In terms of time, this means that a 1 ns time difference wouldn't occur in a network of clocks for 15 days! I show how the combination of high atomic accuracy and low-phase noise coupled with reduced size, weight and power usage pushes certain limits of physics to unlock a new paradigm, creating networks of separated oscillators that maintain extended phase coherence, or a virtual lock, with no means of synchronization whatsoever except at the start. This single property elevates their usage to a vast array of applications that extend far beyond everyday timekeeping. The author show how such accurate oscillators with low-phase noise dramatically improves: (1) Position, navigation and timing; (2) high-speed communications, (3) private messaging and cryptology, (4) spectrum sharing, (5) relativity theory and (6) measurements of quantum consistency, i.e., α -dot. This talk outlines game-changing possibilities in these areas to the degree that clock properties are maintained in application and lab environments. I will show a summary of several ongoing US programs in which the commercial availability of such low-phase noise, atomic oscillators are now a real possibility.

Biography

David Allan Howe is a Research Advisor to the Time and Frequency Division of the National Institute of Standards and Technology (NIST) and Colorado University, Physics Department, Boulder, CO. His expertise includes time-series analysis, automated accuracy evaluation of primary cesium standards, reduction of oscillator acceleration sensitivity and precision spectral analysis. He has worked with David Wineland from 1973 to 1987 doing advanced research on NIST's primary cesium standard and compact hydrogen and ammonia standards. He has developed and built the first operating compact hydrogen masers in 1979, led and implemented global high-accuracy satellite-based time-synchronization among national laboratories in the maintenance of Universal Coordinated Time (UTC).

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