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Atomic clocks based on adaptive phase measurements with entangled atoms AXEL ANDRE, Harvard University, ANDERS SORENSEN, Niels Bohr Institute, MIKHAIL LUKIN, Harvard University — We show that the frequency stability of atomic clocks limited by local oscillator frequency fluctuations [1] can be greatly improved by using an adaptive measurement strategy with entangled atoms. Our method uses multiple atomic sub-ensembles with various degrees of spin-squeezing and sequential adaptive measurements of the Ramsey phase. With properly optimized degree of squeezing, this method reaches the Heisenberg limit for phase measurements $\delta\phi \simeq 1/N$, where N is the number of atoms. In addition, we show that multiple interrogation times for these sub-ensembles can be used to improve the long-term stability of the clock. This method allows one to use a very long interrogation time, limited only by environmental fluctuations. The combination of the above two methods leads to an ultimate long-term frequency stability of the clock scaling as $\sigma_y(\tau) = \frac{\langle \delta\bar{\omega}(\tau)^2 \rangle^{1/2}}{\omega_0} \propto \frac{1}{N\tau}$, where τ is the averaging time, to be compared with the usual projection-noise limited clock stability scaling as $\sigma_y(\tau) \propto \frac{1}{\sqrt{N\tau}}$. [1] A. André, A. S. Sørensen, and M. D. Lukin, Phys. Rev. Lett. **92**, 230801 (2004).

Axel Andre
Harvard University

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