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**Precision measurement meets ultrafast science**[1]

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Phase control of a single-frequency continuous-wave laser and the electric field of a mode-locked femtosecond laser has now reached the same level of precision, resulting in sub-optical-cycle phase coherence being preserved over macroscopic observation times exceeding seconds. The subsequent merge of CW laser-based precision optical-frequency metrology and ultra-wide-bandwidth optical frequency combs has produced remarkable and unexpected progress in precision measurement and ultrafast science. A phase-stabilized optical frequency comb spanning an entire optical octave ($> 300$ THz) establishes millions of marks on an optical frequency "ruler" that are stable and accurate at the Hz level. Accurate phase connections among different parts of electromagnetic spectrum, including optical to radio frequency, are implemented. These capabilities have profoundly changed the optical frequency metrology, resulting in recent demonstrations of absolute optical frequency measurement, optical atomic clocks, and optical frequency synthesis. Combined with the use of ultracold atoms, optical spectroscopy and frequency metrology at the highest level of precision and resolution are being accomplished at this time. The parallel developments in the time domain applications have been equally revolutionary, with precise control of the pulse repetition rate and the carrier-envelope phase offset both reaching the sub-femtosecond regime. These developments have led to recent demonstrations of coherent synthesis of optical pulses from independent lasers, coherent control in nonlinear spectroscopy, coherent pulse addition without any optical gain, and coherent generation of frequency combs in the VUV and XUV spectral regions. Indeed, we now have the ability to perform completely arbitrary, optical, waveform synthesis, complement and rival the similar technologies developed in the radio frequency domain. With this unified approach on time and frequency domain controls, it is now possible to pursue simultaneously coherent control of quantum dynamics in the time domain and high precision measurements of global atomic and molecular structure in the frequency domain. These coherent light-based precision measurement capabilities may be extended to the XUV spectral region, where new possibilities and challenges lie for precise tests of fundamental physical principles.

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