# Coherent frequency combs and spectroscopy – from far IR to XUV

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Phase-stabilized optical frequency combs can now maintain long-term (> 1 s) temporal phase coherence across the entire visible spectrum. This unprecedented spectral and temporal precision of optical fields has profoundly changed optical frequency metrology and ultrafast science, with breakthrough developments in optical atomic clocks, optical frequency synthesis, united time-frequency spectroscopy, high-resolution quantum control, coherent pulse synthesis and amplification, and control of sub-femtosecond electron dynamics in atoms and molecules.

Beyond the visible spectrum, development of frequency combs in the far infrared opens the door to a wealth of fundamental molecular transitions, allowing direct frequency comb spectroscopy to simultaneously provide ultrahigh detection sensitivity, massively parallel monitoring channels, broad spectral coverage, and real-time and quantitative measurement capabilities.

The other exciting frontier naturally turns to the production of VUV and XUV frequency combs; laser-like sources with a high degree of temporal coherence in the vacuum and extreme ultraviolet spectral regions. This can be viewed as a development of the attosecond spectroscopy in the frequency domain. A strong motivation is to extend high precision laser spectroscopy and high-resolution quantum control techniques to VUV and XUV, which would allow measurement of many ground state transitions of atoms and molecules with revolutionary precision. These experiments might allow for some of the most stringent tests of quantum electrodynamics. Meanwhile, the production of VUV and XUV frequency combs provides an important platform to study extreme nonlinear dynamics with unprecedented precision. We will report the first detection of comb structure in high harmonic generations.