DUAL COMB FOURIER TRANSFORM SPECTROSCOPY

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The advent of laser frequency combs a decade ago has already revolutionized optical frequency metrology and precision spectroscopy. Extensions of laser combs from the THz region to the extreme ultraviolet and soft x-ray frequencies are now under exploration. Such laser combs have become enabling tools for a growing tree of applications, from optical atomic clocks to attosecond science.

Recently, the millions of precisely controlled laser comb lines that can be produced with a train of ultrashort laser pulses have been harnessed for highly multiplexed molecular spectroscopy. Fourier multi-heterodyne spectroscopy, dual comb spectroscopy, or asynchronous optical sampling spectroscopy with frequency combs are emerging as powerful new spectroscopic tools. Even the first proof-of-principle experiments have demonstrated a very exciting potential for ultra-rapid and ultra-sensitive recording of complex molecular spectra. Compared to conventional Fourier transform spectroscopy, recording times could be shortened from seconds to microseconds, with intriguing prospects for spectroscopy of short lived transient species. Longer recording times allow high resolution spectroscopy of molecules with extreme precision, since the absolute frequency of each laser comb line can be known with the accuracy of an atomic clock.

The spectral structure of sharp lines of a laser comb can be very useful even in the recording of broadband spectra without sharp features, as they are e.g. encountered for molecular gases or in the liquid phase. A second frequency comb of different line spacing permits the generation of a comb of radio frequency beat notes, which effectively map the optical spectrum into the radio frequency regime, so that it can be recorded with a single fast photodetector, followed by digital signal analysis. In the time domain, a pulse train of a mode-locked femtosecond laser excites some molecular medium at regular time intervals. A second pulse train of different repetition frequency interferometrically samples the transient response or free induction decay of the medium, akin to an optical sampling oscilloscope.