Dual Etalon Frequency Comb Spectrometer

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A new concept for time-resolved Fourier-transform spectroscopy has been demonstrated. This spectrometer is based on the interference between two transient frequency combs and has many potential uses including time-resolved, "broad-band" spectroscopy with a nanosecond time scale, high-resolution spectroscopy and remote sensing. The Dual Etalon Frequency Comb (DEFCOM) spectrometer utilizes two independent etalons to generate two frequency combs. The bandwidth of the combs is set by the bandwidth of the laser beam used to excite the etalons. The etalon lengths are set such that the free spectral ranges (~300 MHz) of the two etalons are slightly different, approximately 250 kHz apart in our initial demonstration. An atom or molecule placed inside of one or both of the etalons possessing an optical transition resonant with some of the frequencies present within the etalons will absorb some of the light associated with some of the frequency-comb teeth. In order to quantitatively determine the intensity of each of the frequency comb teeth, the outputs of the etalons are combined onto a single photo detector. At the detector the outputs interfere producing a transient interferogram. The spectrum is retrieved by Fourier transforming the interference pattern. As the light "rings down" from the etalons for over 100 micoseconds, and every time segment of the interferogram contains the entire spectrum, one may obtain sequential spectra with a time resolution that one chooses by selectively Fourier transforming segments of the interferogram. We demonstrate this by Fourier transforming 5 microseconds time segments sequentially for approximately 100 microseconds. In the first demonstration the (1,1,3) overtone spectrum of H_2O and the R(7) line of the weak gamma band of O_2 were recorded. A single laser pulse provided a 3 GHz spectrum across a transition with a frequency resolution of 300 MHz. This is a simultaneous multi-frequency cavity-ring-down spectrometer.