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Optical Frequency Synthesizer powered by Coherent Verdi Laser

Measuring the frequency of light using fs laser pulses

New ultrafast counting techniques have revolutionized metrology and are gaining significance in basic research applications. With femtosecond laser frequency comb techniques developed within the last two years, counting optical oscillations of more than 10^{15} cycles in one second has become a simple task. Bridging the gap from the radio frequency to the optical regime this technology has allowed the highest possible precision in optical spectroscopy. Taking the step in the other direction the technology has recently led to the construction of an all-optical atomic clock that is expected to eventually outperform current state of the art caesium clocks.

This frequency comb technology is now commercially available from **Menlo Systems** GmbH.
Menlo Systems GmbH was founded in 2001 as an outgrowth of Prof. T. W. Hänsch's optical measurement research at the Max Planck Institute for Quantum Optics in Munich, Germany.

The system »FC8003« delivered by Menlo Systems is a well designed compact **one box optical set-up** together with the **control electronics**.

It serves the needs for optical frequency measurements up to the 10^{-14} level. The system is based on the fact that a periodic pulse train of a fs laser can be seen in the Fourier domain as a comb of regularly spaced modes, a so called frequency comb.
The frequency comb can be described by two free parameters, the repetition frequency of the pulses which turns out to be the mode spacing and a general offset frequency from zero of the comb as a whole. >>>

FC8003

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The nth mode of the comb can in turn be written as

$$\omega_n = n\,\omega_\gamma + \omega_0$$

The repetition frequency ω_γ can be picked up easily with a fast photo diode. To gain access to the offset frequency ω_0 the set-up shown in Fig. 1 can be used. Modes from the infrared part of the spectrum are frequency doubled and a beat signal with modes in the blue is observed.

The beat note between the frequency doubled mode and the mode 2n directly yields the offset frequency $2(n\,\omega_\gamma + \omega_0) - (2\,n\,\omega_\gamma + \omega_0) = \omega_0$.

With these two free parameters stabilized the optical frequency of each mode of the comb is known to the same precision as the radio frequency reference controlling the free parameters (for a more detailed description please see refs 1–4).

To achieve an octave spanning spectrum a Coherent Verdi pumped high repetition rate fs laser (Gigaoptics GmbH) is focussed into a photonic crystal fibre (University of Bath). The Coherent Verdi is the ideal low noise pump source for this system. Absolutely essential parameters for fs frequency comb applications are high beam pointing stability, high beam quality and very low amplitude noise. Furthermore turn key operations makes live a lot easier.

The commercial availability of the FC8003 from Menlo Systems is a major step towards an exciting new period of ultra-precise physics that opens a new window to nature where we can expect new discoveries and phenomena.

References:

1. J. Reichert et al., Opt. Commun. **172**, 59 (1999).
2. S.A. Diddams et al., Phys. Rev. Lett. **84**, 5102 (2000).
3. R. Holzwarth et al., Phys. Rev. Lett. **85**, 2264 (2000).
4. Th. Udem et al. Nature **416**, 233 (2002)

Fig. 1:
Schematics of the octave spanning frequency comb and its stabilization

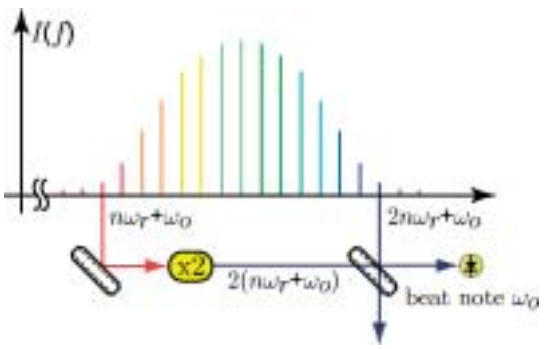
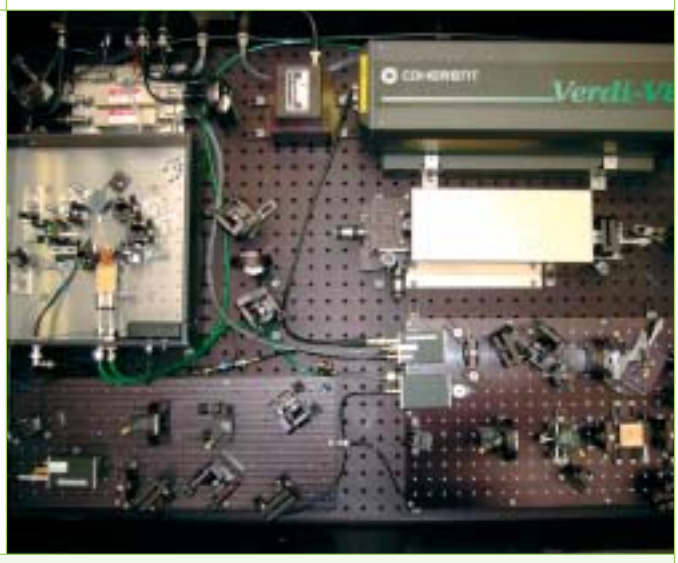


Fig. 2:
Optical set-up of the FC8003



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