

Optical frequency comb

Donnerstag, 20. Januar 2022 13:17

How do measure optical frequencies?

Too fast for electronic counting

↳ 100s of THz

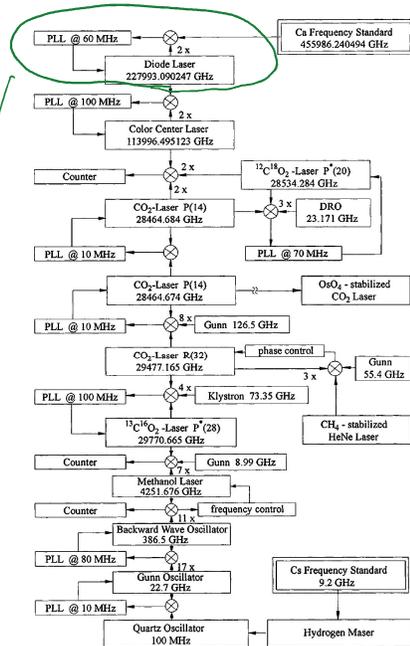
9.2 GHz in Cs
defines 1s

Before 2000: Optical frequency chains



Divider chains, needed lots of different steps

PTB Braunschweig



PTB chain to
measure Ca frequency
vs. Cs clock

each frequency to
be measured
needs another chain

FIG. 1. PTB's frequency chain to the Ca intercombination line (PLL = phase locked loop, details are given in the text).

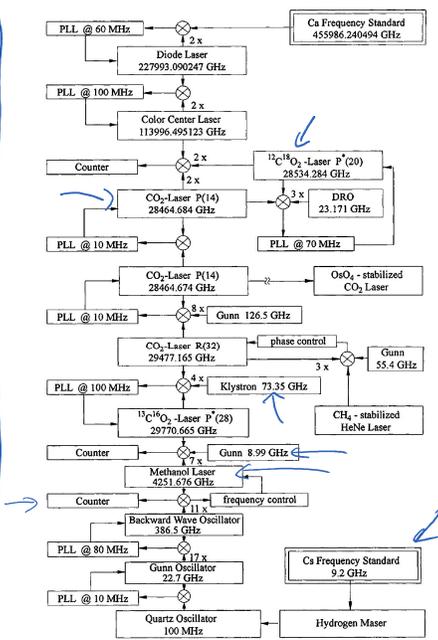
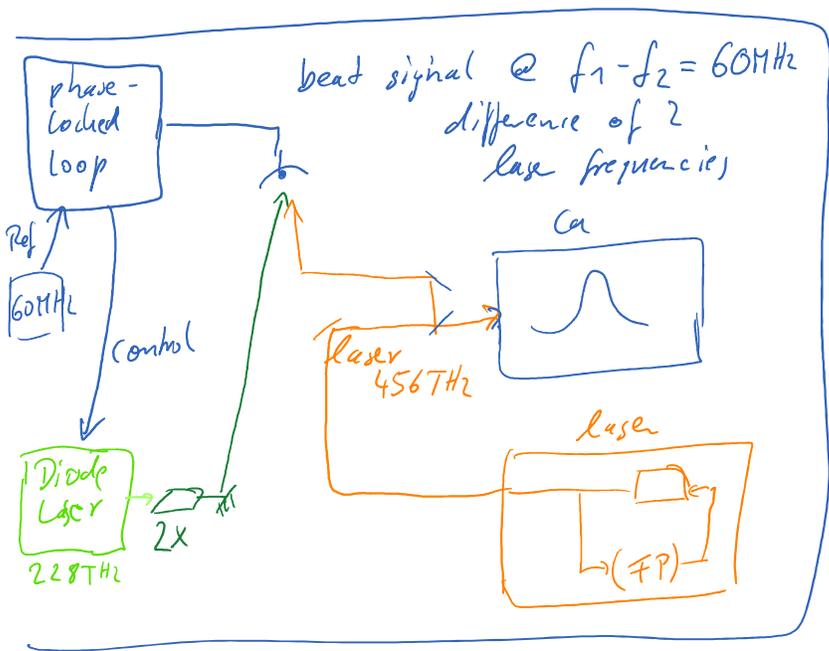
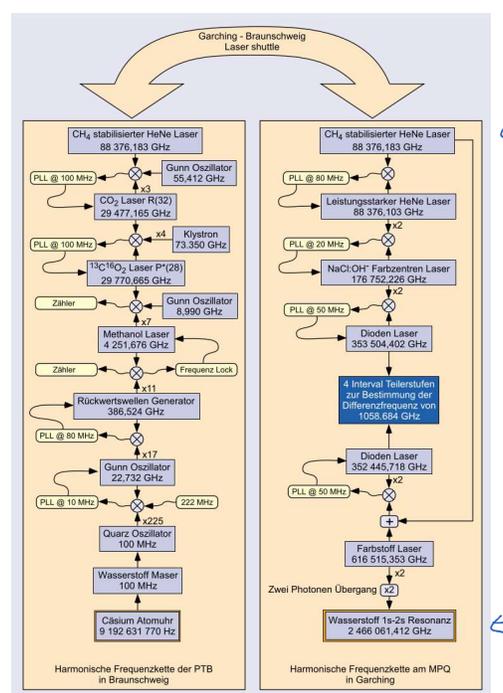


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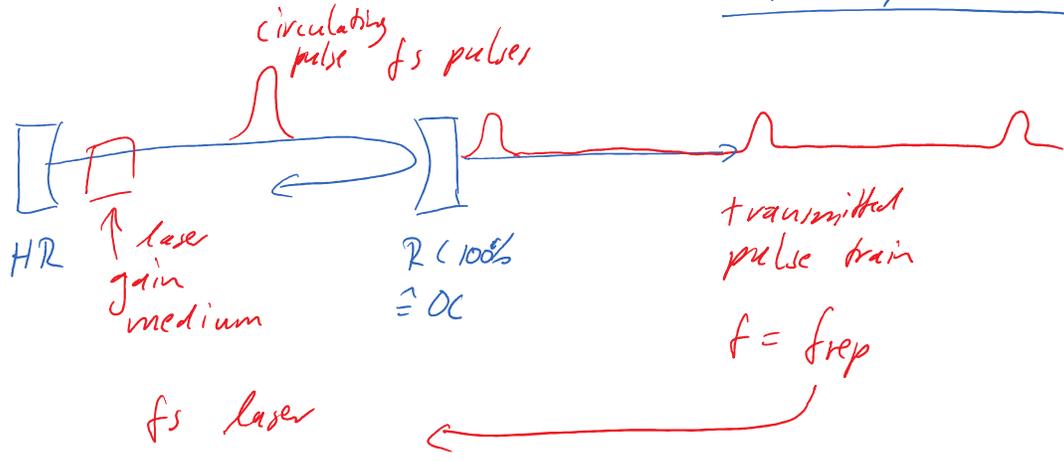
H(1S-2S) in Garching



← Reference laser transportable on truck

Tedious, complicated only 1 frequency

Solution T.W. Hänsch 1999 : Frequency comb

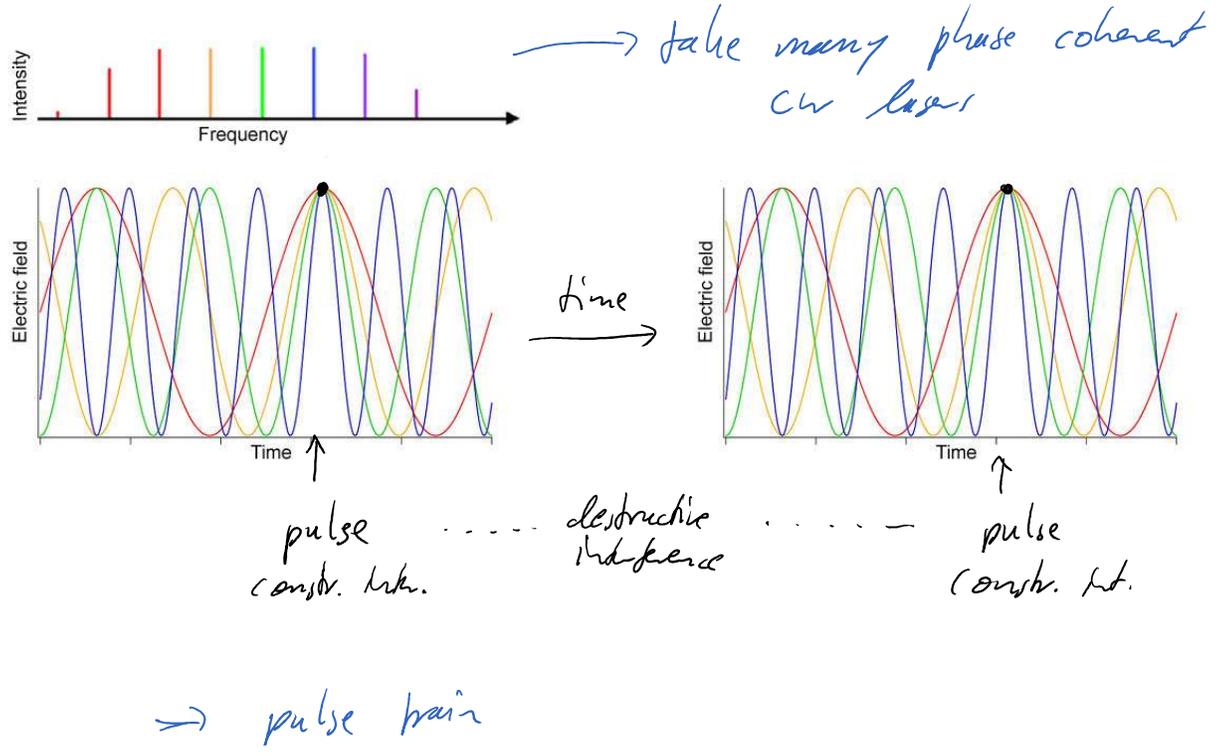


a regular "train" of phase-coherent pulses is

THE SAME

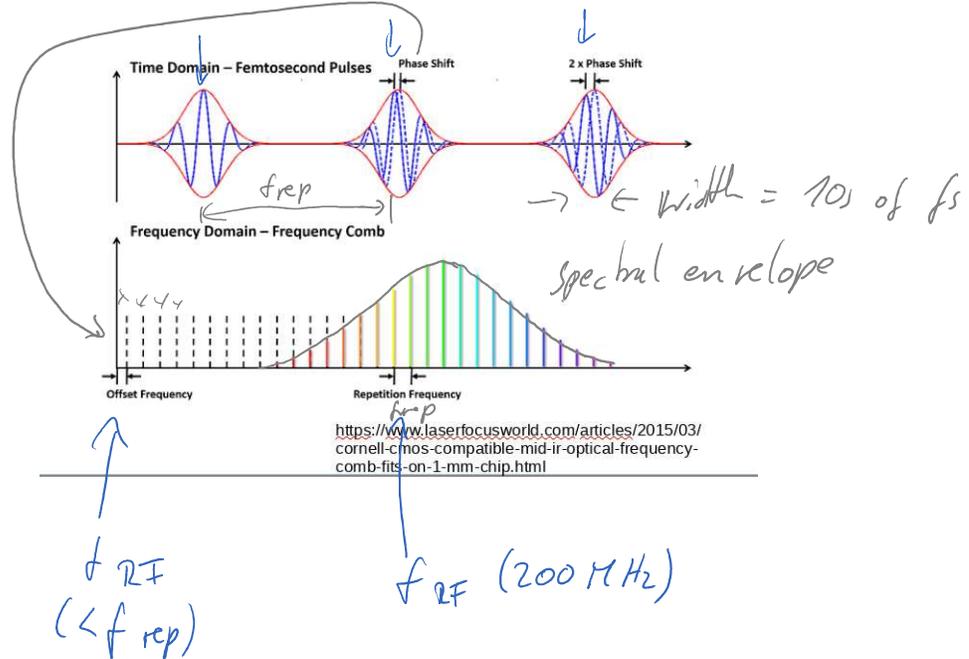
as a superposition of many continuous laser (cw lasers)
(These 2 are the Fourier transforms of each other)

Let's combine a few cw lasers :



→ pulse train

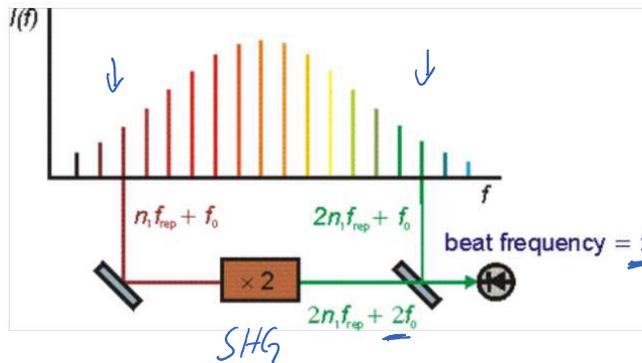
Fourier transform



2 RF frequencies define the whole comb!

$$f_{comb}(n) = f_{offset} + n \cdot f_{rep}$$

Self-referenced comb



this signal (RF) can be used to stabilize the comb

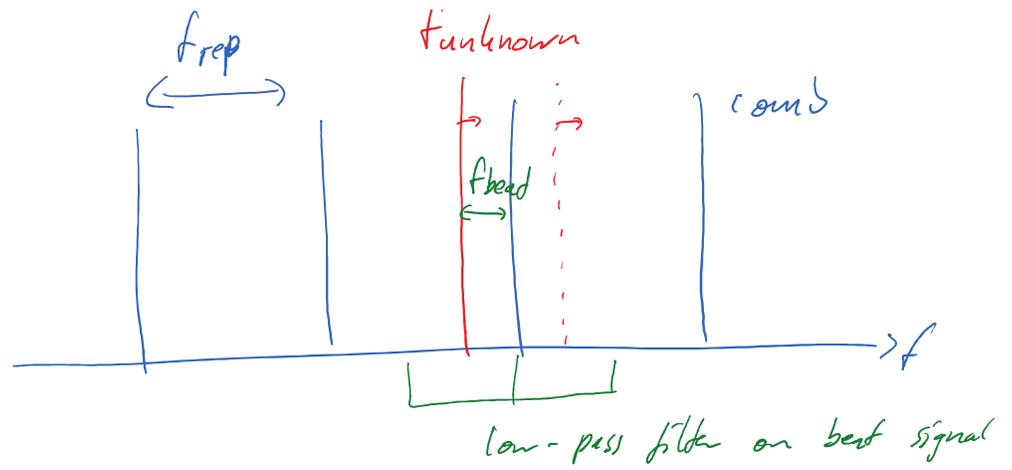
<http://www.npl.co.uk/science-technology/time-frequency/optical-frequency-standards-and-metrology/research/self-referencing-of-an-optical-frequency-comb>

f_{rep}

known

1 : 1

1 : 1



approx. meas. of $f_{unknown}$ with wave meter
 gives $f_{unk.}$ to $\sim 10\text{ MHz}$

\rightarrow this gives you $n_{comb} \in \text{integer}$

beat signal gives you offset from $f_{offset} + n_{comb} \cdot f_{rep}$

\swarrow \uparrow \nearrow

3 RF frequencies to be counted