Interferometry and spectroscopy with laser frequency combs

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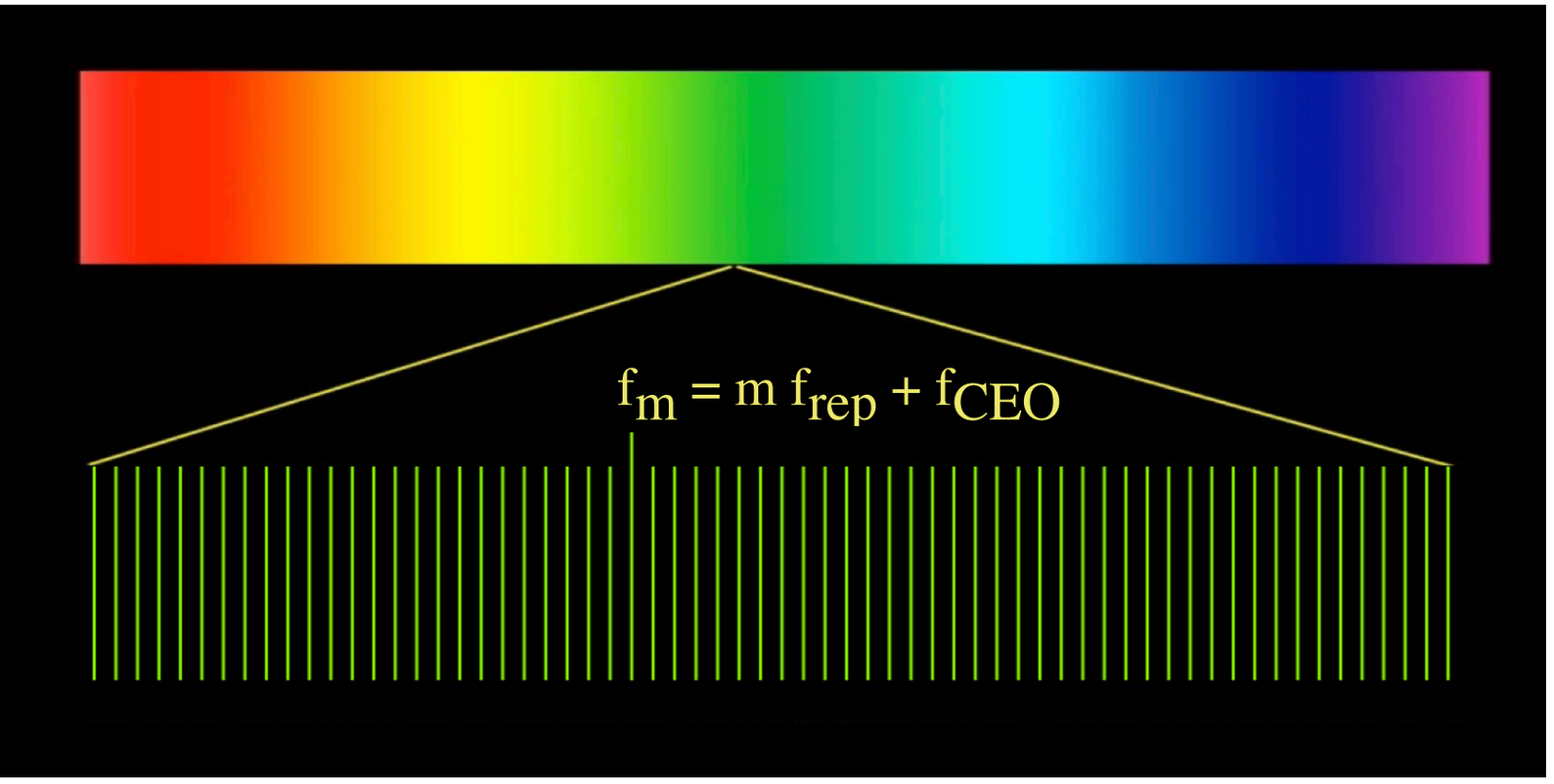
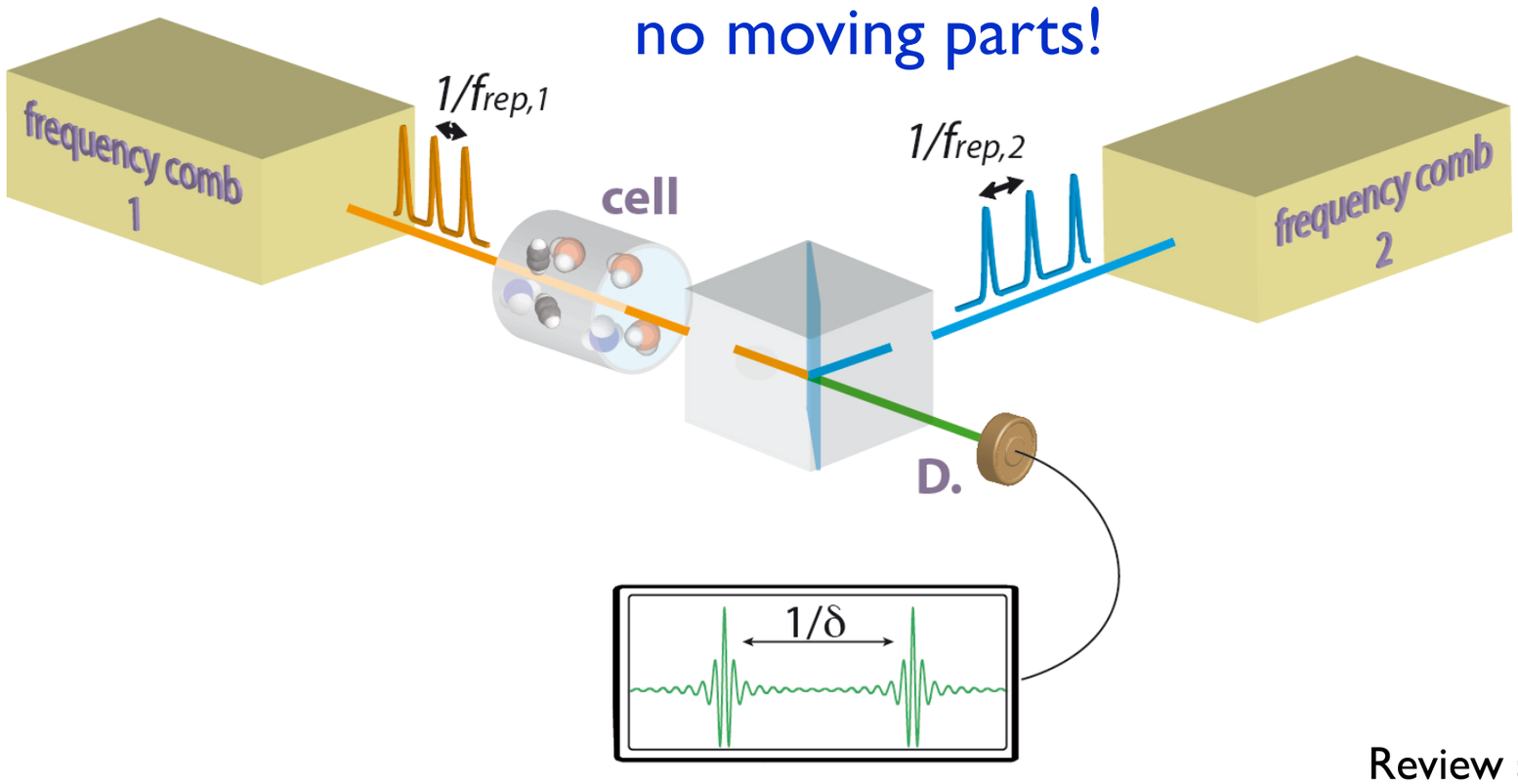


Frequency comb:

- A million of phase-coherent evenly-spaced narrow laser lines
- A simple tool for measuring optical frequencies of 100's of THz.
- A phase coherent link between the optical and the radio-frequency region.

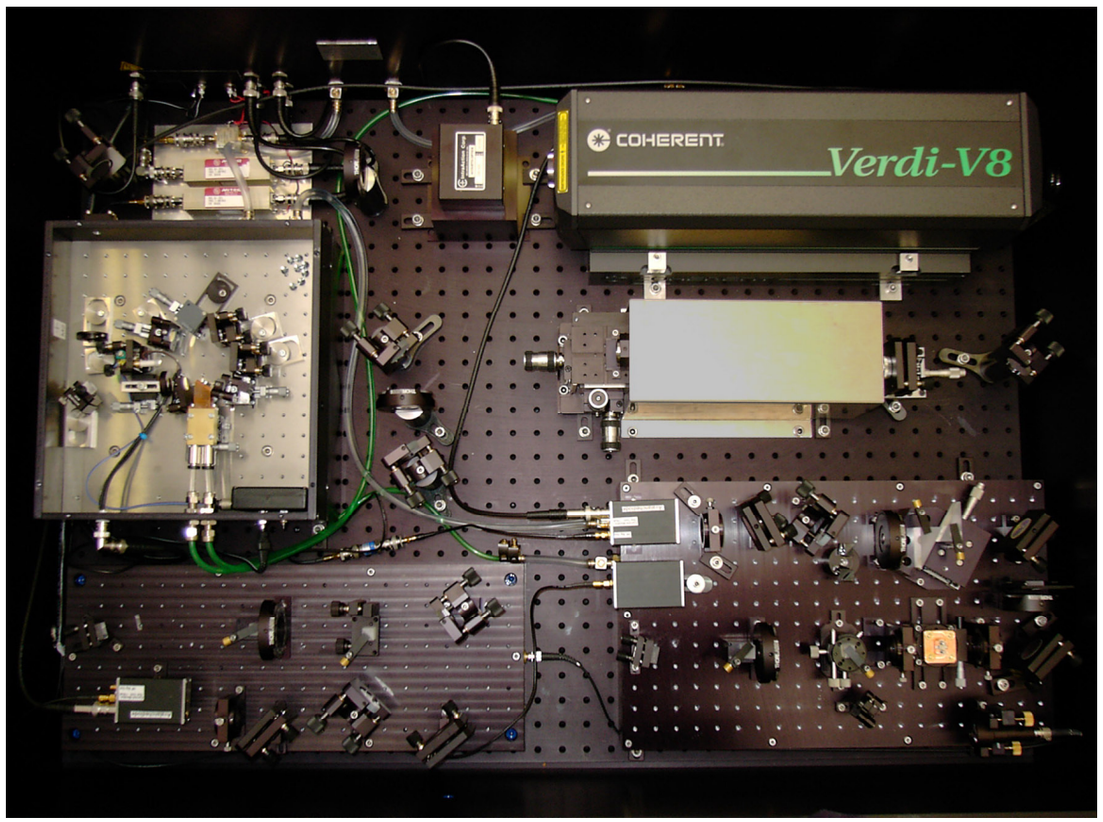


Dual-comb interferometer:

- Two mutually-coherent frequency comb generators of slightly different repetition frequencies.
- Mimics a scanning Michelson-interferometer
- No moving parts. Absence of geometric limitations. Frequency-comb calibration. Broad span with a single photodetector.

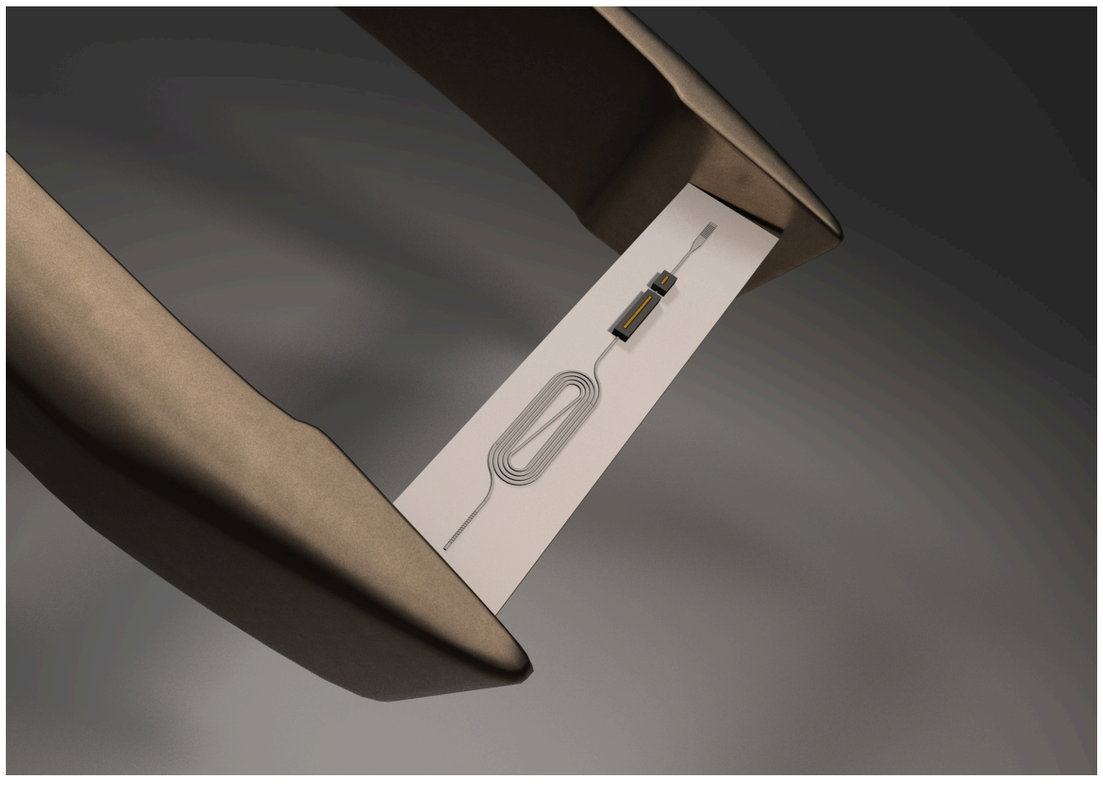
Review article: *Nature Photonics* **13**, 146-157 (2019).

Frequency comb technology for interferometry and spectroscopy



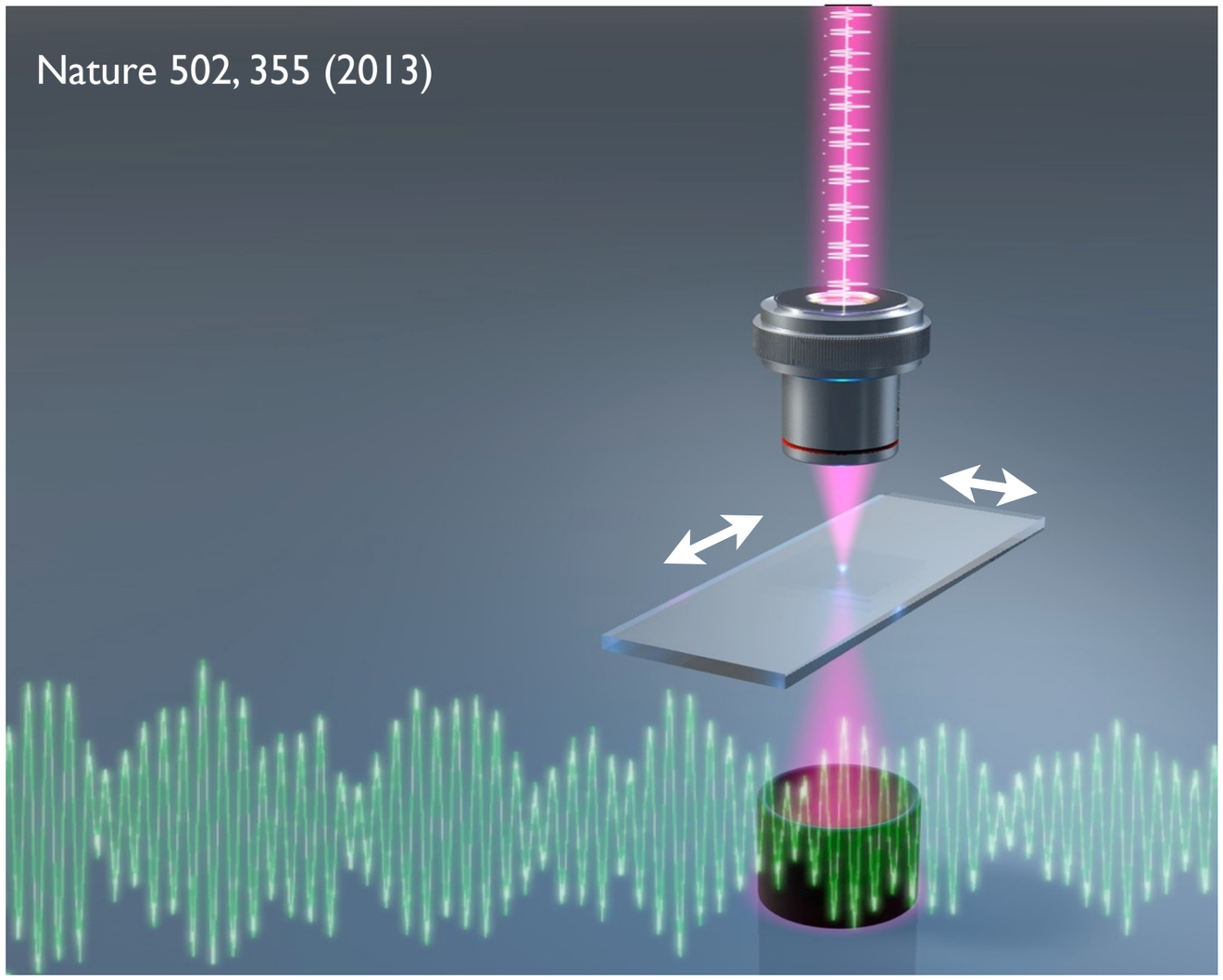
We develop the technology for laser frequency combs suited to our applications.
(sometimes by assembling commercially available parts, sometimes in collaboration with other research groups).

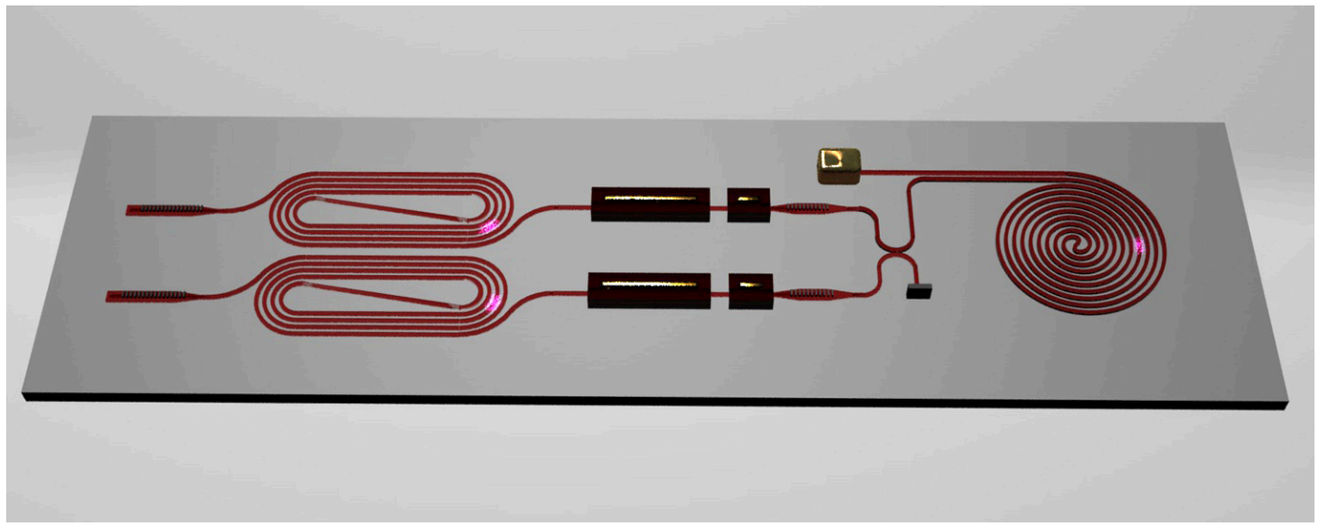
Main goals:
- Spectral range of emission (mid-infrared, visible, ultraviolet)
- Frequency stability of the comb lines
- Comb line spacing (from 1 MHz to 100 GHz, fixed or adjustable)
- Pulse duration / Spectral span
- Flat-top spectrum
- Compactness: from the laboratory set-up to the chip-scale device



Explored solutions involve:
- fiber-based femtosecond lasers,
- nonlinear frequency conversion,
- solid-state fs lasers
- semiconductor fs lasers
- electro-optic modulators,
- devices on a nano-fabricated photonics chip

Applications in interferometry and spectroscopy





Development of instrumentation:

- coherent interferometers.

- measurement techniques:
  - spectroscopy (broad span, short measurement time)
  - ranging
  - photon-level detection
  - spectroscopy-laboratory on a chip…

- sampling spectrometric techniques:
  - absorption and dispersion linear spectroscopy
  - nonlinear spectroscopy (coherent Raman effects, Doppler-free two-photon excitation)
  - hyperspectral imaging
  - spectro-imaging microscopy…

- multimodal instruments combining several diagnostics

Applications:

Spectroscopy:

- fundamental spectroscopy: precision spectroscopy of atoms and molecules at high resolution, tests of fundamental laws of physics
- applied spectroscopy for trace gas detection, analytical chemistry, biology

Distance metrology, 3D profiling