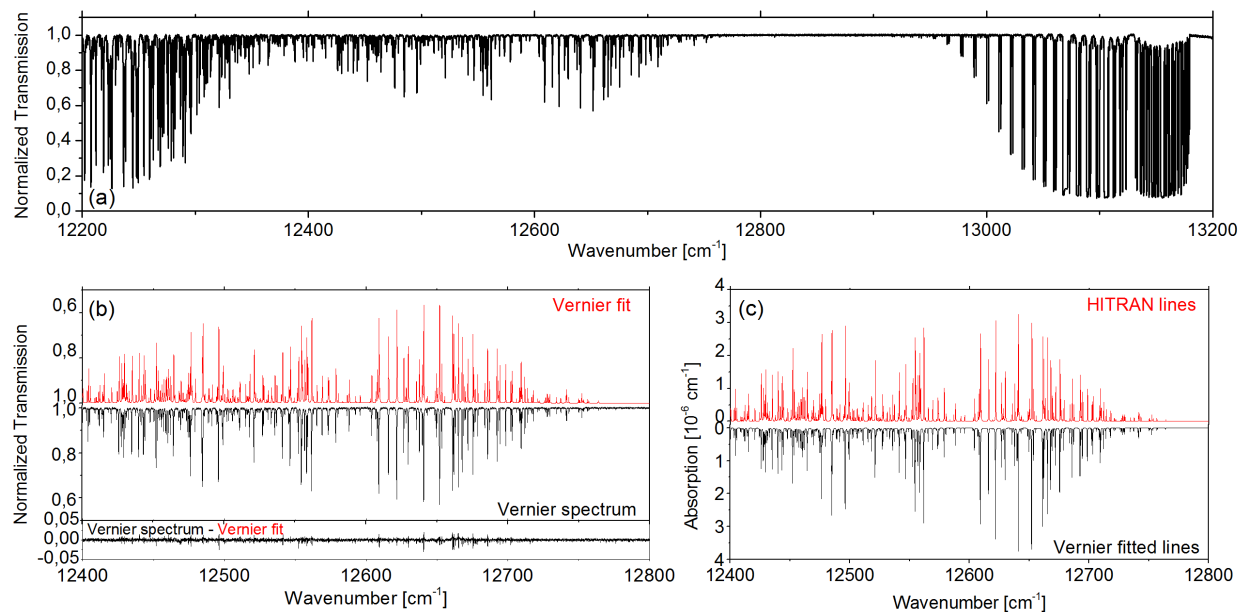


## A Very Broadband Direct Frequency Comb - Cavity Enhanced Vernier Spectrometer

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In Vernier spectroscopy an optical frequency comb (OFC) is coupled to a cavity with a free spectral range (FSR) slightly mismatched from the OFC repetition rate ( $f_{\text{rep}}$ )<sup>[1]</sup>, creating a beating pattern between the cavity transmission and the OFC, with a periodicity proportional to the inverse of the FSR/ $f_{\text{rep}}$  mismatch, in the THz range, easily resolved with a standard grating. In the case of small mismatch, this comb-like pattern (the Vernier comb) offers a continuous transmission when it is spectrally swept, as one order of the Vernier comb contains several OFC modes partially transmitted by the cavity. We use a Titanium:Sapphire femtosecond laser ( $f_{\text{rep}}$  of 90 MHz), coupled to an open air cavity with a finesse of 3000. A rotating grating is placed right after the cavity, translating any frequency fluctuation of the Vernier orders in spatial displacement. The cavity length is stabilized in regards of the OFC by detecting the position of one of the Vernier orders with a split-photodiode, enabling also a precise spectral sweeping of this order across the entire OFC (tens of THz) when the grating is rotated<sup>[2]</sup>. We show in Fig.(a) Vernier spectra from the  $3\nu+\delta$  band of H<sub>2</sub>O and the A-band of O<sub>2</sub> around 800 nm. Taking care of the absorption and dispersion effects induced by a molecular transition on the Vernier signal, we are able to fit the parameters of the 300 water lines in the 12400-12800 cm<sup>-1</sup> range, the result being presented in Fig.(b) together with the Vernier spectrum and the residuum. The retrieved absorption spectrum showed in Fig.(c) is in good agreement with the calculated spectrum under the same conditions using the HITRAN database<sup>[3]</sup>. We will further discuss the Vernier lineshapes and other significant properties of the Vernier spectrometer.



### References

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