CFEL SCIENCE

SEMINAR

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Ultrafast optical frequency comb: classical and quantum noise studies

Ultrafast frequency combs have found tremendous utility as precision instruments in domains ranging from frequency metrology, optical clocks, broadband spectroscopy, and absolute distance measurement. This sensitivity originates from the fact that a comb carries a huge number of co-propagating, coherently-locked frequency modes. Accordingly, it is the aggregate noise arising from these individual teeth that limits the achievable sensitivity for a given measurement. While the distribution of noise across the comb has been examined, the role of correlations among various frequencies has gone largely unexplored. We have developed methods, inspired from quantum optics, to extract amplitude and phase correlations among a multitude of spectral bands. From these, we can deduce the spectral/temporal eigenmodes of a given optical frequency comb (OFC), and use it to either study the dynamics or the laser, or to optimize metrology experiments such as, for instance, ranging in turbulent medium [1,2].
But beyond characterizing the classical covariance matrix of an OFC, one can, using non-linear effects, manipulate this noise and eventually reduce it even below quantum vacuum noise, producing squeezed optical frequency combs. We have demonstrated that by proper control of non-linear crystals, optical cavities and pulse shaping it was possible to embed with an optical frequency comb up to 10 spectral/temporal modes with non-classical noise properties [3]. This tool is a versatile and scalable source for measurement based quantum computing.

[1] R. Schmeissner, V. Thiel, C. Jacquard, C. Fabre, and N. Treps, Opt Lett 39, 3603 (2014).
[2] P. Jian, O. Pinel, C. Fabre, B. Lamine, and N. Treps, Opt Express 20, 27133 (2012).
[3] J. Roslund, R. M. de Araújo, S. Jiang, C. Fabre, and N. Treps, Nature Photonics (2013).

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