Subcycle quantum metrology of electric fields at multi-THz frequencies

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We demonstrate quantum metrology of the electric fields by direct measurement of the ground state via ultrabroadband electro-optic sampling. The valence electrons of a semiconductor detection crystal are used as a test charge and 5.8 fs-long optical pulses probe their non-resonant displacement. Rapid statistical readout allows us to detect minute fluctuations of the refractive index [1,2]. As an application of our new method, we recently characterized the statistics of squeezed mid-infrared transients with subcycle resolution [3]. Local acceleration of the reference frame in the nonlinear emitter leads to deviations from the vacuum noise level and generation of entangled photons. Panel (a) illustrates the principle of generating nonclassical mid-IR transients via redistribution of the vacuum fluctuations in space-time. Statistical electro-optic measurements yield information on the coherent field amplitudes and fluctuations that impinge on the detection crystal from free space. Panel (b) shows time-dependent relative differential noise (RDN), where RDN < 0 (shaded blue) corresponds to time segments with strong squeezing, while RDN > 0 (shaded red) reflects correlated photons which accompany squeezed vacuum due to Heisenberg's uncertainty principle.

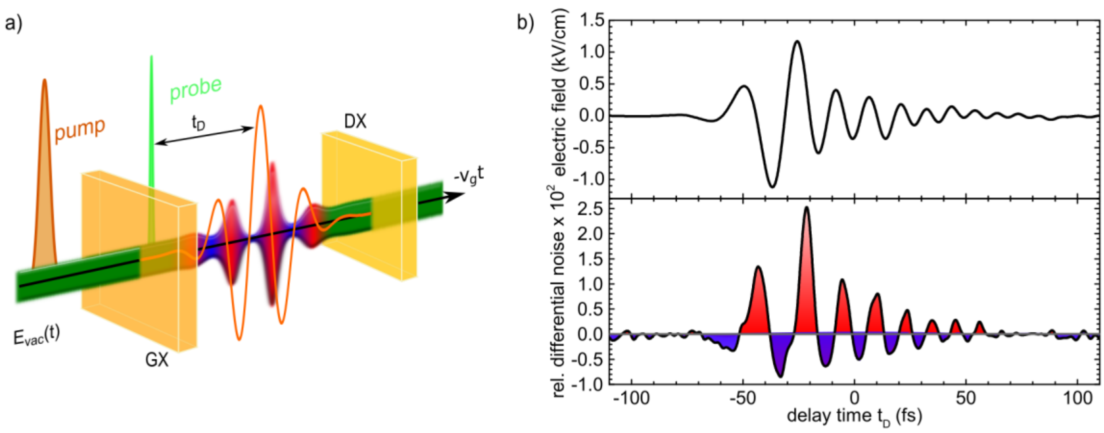

Figure (a) Schematic of the experiment; (b) Strong multi-THz transient generates refractive index anomaly, resulting in correlated relative differential noise signal.

Subcycle quantum metrology of multi-THz fields motivates an entirely new approach: non-classical spectroscopy [4] of low-energy phenomena in condensed matter.

References

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