Extreme Terahertz brightness by focusing to a lambda-cubic volume

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Abstract: We demonstrate bright low-frequency terahertz (<5 THz) radiation confined to a diffraction-limited spot size by wavefront manipulation. Focusing to a lambda-cubic volume provides bright THz radiation at the PW/m^2 level.

Here we present a table-top laser-driven THz concept based on organic crystals which provides advanced THz focusing scheme. Using a conventional and collinear THz generation scheme based on organic crsytals DSTMS and OH1, we demonstrate a THz wavefront shaping concept based on manipulating the pump-pulse divergence. Using this approach the broadband THz radiation is focused to its physical limit and ultimately confined in the smallest possible lambda-cubic (λ^3) volume. This results in extremely bright THz radiation at the PW/m^2 and record-high Terahertz fields reaching up to 8 GV/m. The presented results are foreseen to have a great impact in nonlinear THz photonics.

The experimental scheme is shown in fig. 1. Our THz wavefront shaper employs the fact that, in first order, wavefront and divergence are related in paraxial approximation according to z(1+(ω/θz))^2 with ω and θ the spot size and divergence, respectively. By optimizing the pump divergence we observe a significant improvement of the THz spot size.

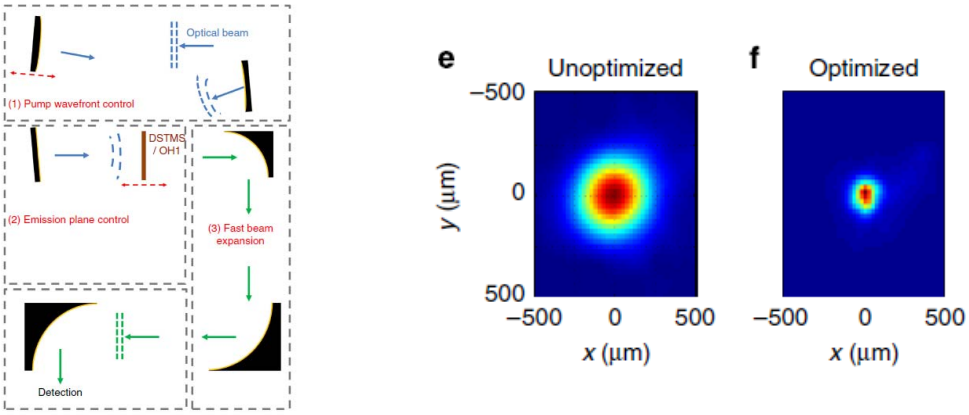

Fig. 1. (left) Experimental scheme for optimizing the THz wavefront by pump beam divergence modification. (right) Unoptimized and optimized THz focus.

In the lambda-cubic focusing scheme, the focus volume depends strongly on the THz frequency. Figure 2 illustrates this lambda-cubic dependence of the intensity in the focus. A set of low-pas filters is used to measure the evolution of spot size with the THz frequency.

In conclusion, we have experimentally presented Terahertz confinement to the lambda-cubic volume using low-frequency ultrabroadband THz pulses. This approach is used to demonstrate record-high electric field strengths of up to 8 GV/m in one single cycle. Our compact, ultra-intense THz source will open up new avenues for nonlinear THz applications.

References

[1] M. Shalaby and C.P. Hauri, Nat. Commun. 6, 5976 (2015).