Nonlinear Terahertz Photonics in Twisted Graphene and Topological Metamaterials

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Optical nonlinearity in the terahertz (THz) range represents a key technology to access high frequency spectral windows that are usually difficult to cover using conventional solid state laser technologies.

Over the past decade, the non-linear optical properties of graphene have been extensively investigated, and a wide range of related applications demonstrated, ranging from optical modulators [1] to saturable absorbers [2]. High harmonic generation (HHG) – the frequency up-conversion of an optical signal – in materials systems is governed by symmetries. This effect has been exploited in graphene [3], where HHG has been demonstrated, albeit only at odd multiples of the driving frequency owing to its inherent centro-symmetry. In topological insulators (TIs), unconventional HHG has been predicted [4], supported by the bulk and topological surface states, which are usually difficult to distinguish, relying on the ultrafast intraband dynamics, and the inversion symmetry-breaking even-order nonlinearity in the topological phase.

Here, we exploit innovative technological approaches in multilayer twisted graphene and large area topological insulator metamaterials and heterostructures to device highly efficient non-linear micro-devices, optically pumped by quantum cascade lasers (QCLs) delivering 2W optical power, and electrically-driven integrated plasmonic lasers comprising integrated QCL heterostructures, targeting HHG in the technologically relevant Reststrahlen gap (6-12 THz) at both odd or even orders, via symmetry breaking [5], [6], [7].

This talk will provide future perspectives in the fascinating field of topological photonics and non-linear THz photonics.

References

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