Quantum Materials for Nonlinear Terahertz Photonics

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Nonlinear optical phenomena play a key role in many fundamental processes and are highly relevant for a wide range of applications, including quantum technologies, optical computing, and advanced spectroscopies. Many excellent materials are available for nonlinear optics in the visible and infrared part of the electromagnetic spectrum. Until a few years ago, this was not the case for the terahertz regime, where only moderate nonlinearities were obtained with quantum well systems. This situation changed dramatically with the observation of highly efficient harmonic generation in quantum materials with massless Dirac fermions – charge carriers with a linear energy-momentum dispersion relation – such as graphene [1] and topological insulators [2]. In this talk, I will discuss the most recent results, obtained with a large group of collaborators, including researchers at TELBE (Germany), Bielefeld University (Germany), ICFO (Spain), ICN2 (Spain), and several more. In particular, I will present ways of obtaining enhanced THz nonlinearities using quantum materials. These approaches include i) enhancing the THz nonlinearity of quantum materials through electrical control of the Fermi energy [3], ii) using metal grating structures with micrometer-sized gaps that lead to local field enhancement [4]; and iii) circumventing the saturation of harmonic generation that occurs in graphene due to heat accumulation by exploiting "Coulomb cooling" that provides enhanced electronic dissipation [5,6].

References

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