High-Order Harmonic Generation in Solids

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High-order harmonic generation (HHG) is a strong-field-driven process that has enabled the generation of attosecond pulses, as marked by the 2023 Nobel Prize in physics [1]. Originally HHG studies were focused on gaseous media, but with its experimental realization in solid materials in 2010 [2], there has been interest in exploiting its underlying microscopic mechanism to solve important material science problems [3].

In this talk, I will discuss our recent discovery, where we have identified a unique HHG response from the topologically protected surface states, especially when the driving laser field is circularly polarized [4]. Our results in one of the prototypical three-dimensional topological insulators Bi2Se3 show that HHG can probe topological phase transitions [5]. We compare our HHG results with angle-resolved photoelectron spectroscopy (ARPES) results and confirm that HHG can be a novel all-optical probe of topologically protected surface states, possibly in a wide range of materials. The advantage of HHG over conventional approaches such as ARPES is that HHG does not require samples to be in ultra-high vacuum conditions. Most importantly, at the microscopic level, high-harmonic spectroscopy offers sub-cycle temporal resolution, providing for the first time, unprecedented access to the dynamics of electrons in solid-state materials. Our results show that Attosecond Science is no longer limited to gaseous media.

References

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