Light induced topological phases in two-dimensional van der Waals heterostructures

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An appealing and challenging route towards engineering materials with specific properties is to find ways of designing or selectively manipulate materials, especially at the quantum level. We will discuss new states of matter that are optically induced and have no equilibrium counterparts, and we will identify the fingerprints of these novel states that will be probed with pump-probe spectroscopies. A particular appeal of light dressing is the possibility to engineer symmetry breaking which can lead to novel properties of materials, e.g coupling to circularly polarized photons leads to local breaking of time-reversal symmetry enabling the control over a large variety of materials properties (e.g.topology). We show that the new quantum electrodynamics density-functional formalism (QEDFT) can acocunt for those effects. For example, the concept of symmetry breaking with light to induce topological phases with linearly and circularly polarized light will be presented to show the transition to topologically non-trivial states in 2D materials. By controlling the Berry curvature in 2D layered materials (metal/insulator transition metal dichalcogenides, or TMD), a new class of quantum Hall states can be induced. In these states, the valley degree of freedom can be tuned with light. The theory for such states requires the treatment of strong electric fields; that is, low driving frequencies and the inclusion of dissipation and lattice degree of freedom.