Cavity control of two-dimensional materials phenomena: “cavity twsitronics”

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We provide an overview of how well-established concepts in the fields of quantum chemistry and materials have to be adapted when the quantum nature of light becomes important. We will briefly introduce our newly developed quantum electrodynamics density-functional formalism (QEDFT) as a first principles framework to predict, characterize and control the spontaneous appearance of ordered phases of strongly interacting light-matter hybrids. We will pursue the question whether it is possible to create these new states of materials as ground-states of the system and show that light–matter coupling in cavities provides a pathway to break fundamental materials symmetries, like time-reversal symmetry in chiral cavities. We will discuss the potential to realize non-equilibrium states of matter that have so far been only accessible in laser-driven materials. We illustrate the realization of those ideas in some molecular complexes and in 2D materials. We will show that the combination of cavity-QED and 2D twisted van der Waals heterostructures provides a novel and unique platform for the seamless realization of a plethora of interacting quantum phenomena, including exotic and elusive correlated and topological phases of matter.