Topological exciton-polaritons in transition metal dichalcogenide monolayers

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Topological photonics has seen a tremendous progress in the past years with numerous topological phases implemented in a variety of platforms, from microwave to optical frequencies. Enriching topological photonics by mixing light with condensed matter provides even more exciting avenues for controlling exotic states of light and matter. Indeed, integrating topological photonic systems with quantum wells and quantum dots has already led to major breakthroughs, such as topological lasers, topological polaritonic phases, active and nonlinear topological photonic devices. Consistent with their non-topological cousins, TPs represent “half-light and half-matter” excitations emerging as the result of strong coupling between electromagnetic and solid-state degrees of freedom. In addition, they are enriched by topological features. The combination of photonic topological properties (one-way pseudo-spin-polarized transport, topological protection against scattering) and strong interactions arising from light-matter hybridization, may support phenomena such as topological solitons, modulation instability and generation of squeezed topological light.

Here we present an approach to spin-Hall topological polaritronics based on the versatile platform of polaritonic metasurfaces containing monolayer transition metal dichalcogenides (TMDs). Our approach leverages the large exciton dipole moment in a monolayer semiconductor and the remarkable compatibility of 2D materials with various photonic structures to realize strong coupling between light and matter. We show that the strong coupling regime between a topological spin-Hall photonic metasurface and a TMD monolayer featuring a pair of degenerate TR partner excitons gives rise to a topological transition and the formation of a topological polaritonic phase characterized by nonvanishing spin-Chern numbers. Introduction of domain walls separating topological and trivial phases is then shown to produce spin-polarized polaritonic boundary modes. Spin-locking of these modes and their selective coupling to circularly polarized light of opposite handedness enables unique polaritonic spin-Hall phenomena that we demonstrate experimentally. In addition, by studying photoluminescence of WSe\textsubscript{2} topological metasurface, we confirm valley polarization of edge polaritons.