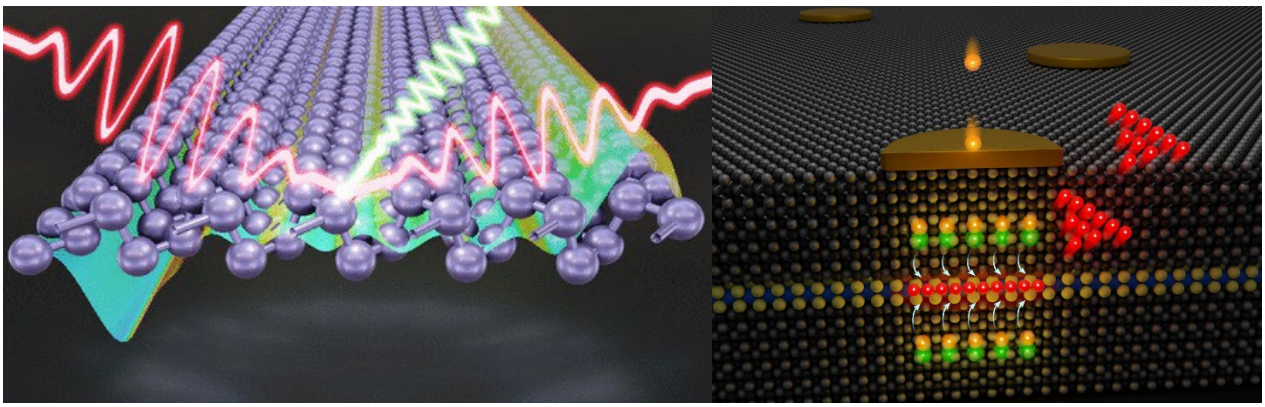
2023 annual highlights

The research highlights of 2023 show exciting progress in understanding polaritonic phenomena, which involve the interaction between light and matter. To put it simply, polaritons are fascinating hybrid entities that are part light and part matter. They play a crucial role in the development of future technologies that involve the interaction between solid-state quantum systems and advanced photonics.

We have been exploring the behavior of light-induced free-electron oscillations, called plasmon polaritons, in thin materials such as phosphorene, a two-dimensional (2D) semiconductor. Although phosphorene is a semiconductor, meaning that its electrons are bound rather than free to move, we found that highly doped 2D monolayers support unique plasmon polaritons due to the interaction of light with added conduction electrons (left-hand graphics). We predict that phosphorene nanoribbons can support adjustable localized plasmons that concentrate light within the atomically thin material to drive an intense nonlinear optical response enabling the control of light by light. This discovery positions phosphorene as a versatile material for nonlinear plasmonics, with potential applications in the challenging-to-achieve high-harmonic generation.

Beyond plasmon polaritons, we also investigated exciton polaritons in semiconducting 2D materials. Exciton polaritons arise when light interacts with excitons, which are hydrogen-like pairs of electrically bound negatively charged electrons and the positively charged holes left behind when electrons are excited. By studying the decay dynamics of excitons in 2D transition metal dichalcogenide (TMDC) monolayers, we observed an intriguing phenomenon: excitons acting as ensembles of photon emitters (right-hand graphics). This curious observation could signify a crucial step toward advancing light information and computing technologies, where information is encoded in photons.



Artist's impressions of light emission from plasmon polaritons in a phosphorene nanoribbon (left panel) and photon bunching from exciton polaritons in a tungsten disulfide monolayer (right panel). Results from ACS Nano **17**, 20043 (2023) and 2D Materials **10**, 021002 (2023).