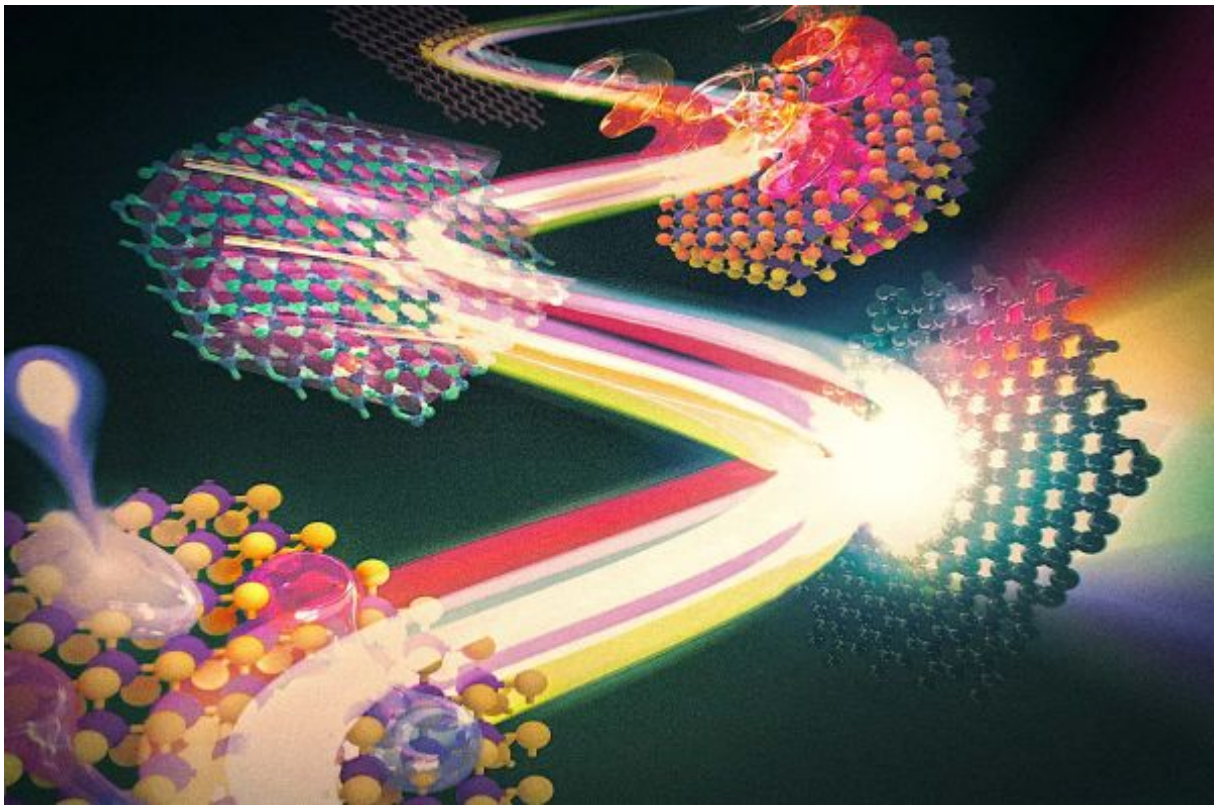


Roadmap for photonics with 2D materials and for quantum nanophotonics with free electrons

ICFO researchers have coordinated and published two roadmaps in ACS Photonics: one for photonics with 2D materials, featuring contributions from nearly 50 authors, and another for quantum nanophotonics with free electrons, involving almost 150 authors. These roadmaps lay the groundwork for future discoveries in these rapidly evolving fields.

October 13, 2025

ICFO researchers have played a leading role in developing two roadmaps, which have been published in ACS Photonics and coordinated by **ICREA Prof. at ICFO Javier Garcia de Abajo**. The first focuses on photonics with 2D materials, while the second addresses quantum nanophotonics with free electrons.

The first roadmap summarizes the breakthroughs achieved in photonics through the use of 2D materials. These one-atom-thick materials have enabled fundamental advances in 2D

polaritonics, nonlinear and ultrafast phenomena, topological and chiral effects, among others. They have also fueled the development of novel applications, including a new range of photonic platforms (based on layer-stacked and twisted architectures), integrated optical devices, sensors and quantum information processing technologies.

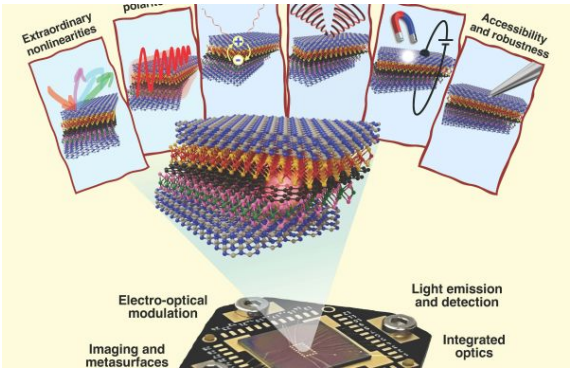
The second roadmap outlines recent advances in exploiting free electrons for quantum nanophotonics, exploring their ability to carry and transfer quantum information, create entanglement, and reveal previously inaccessible details of nanoscale quantum phenomena. It focuses in the fundamentals and current techniques in electron microscopy, as well as the ultrafast electron-light interactions that can occur in this context.

By identifying key challenges, opportunities, and future directions, these roadmaps lay the groundwork for guiding upcoming research and accelerating discoveries in these rapidly evolving fields.

References:

F. J. Garcia de Abajo, et. al., Roadmap for Photonics with 2D Materials, ACS Photonics 2025 12 (8), 3961-4095. DOI: 10.1021/acsphotonics.5c00353

F. J. Garcia de Abajo, et. al., Roadmap for Quantum Nanophotonics with Free Electrons, ACS Photonics 2025 12 (9), 4760-4817. DOI: 10.1021/acsphotonics.5c00585



Artistic illustration of the use of 2D materials for photonics applications. Source: ACS Photonics.

The image illustrates how synchronized light and electron pulses can interrogate the internal dynamics of a nanostructure. Cover in ACS Photonics.