Enhanced interactions through strong light-matter coupling

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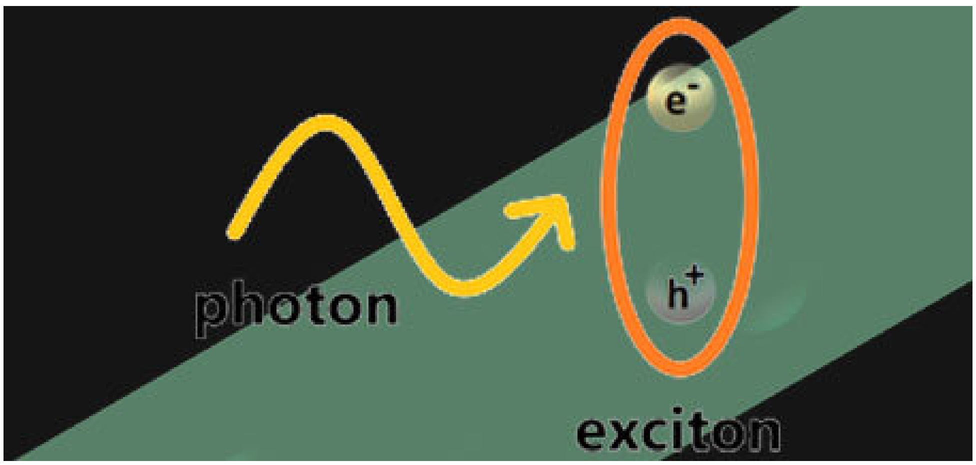

Credit: FLEET

Why do two-dimensional exciton-polaritons interact? The exciton-polariton quasiparticle is part light (photon), and part matter (exciton). Their excitonic (matter) part confers them the ability to interact with other particles, a property lacking to bare photons.

In theory, when confined to only two dimensions, slow, cooled excitons should cease any interaction with one another. However in practice, this behavior is not observed with exciton-polaritons. In a new study, FLEET researchers at Monash University discovered that the answer is found to lie in the "light-like" characteristics of these quasiparticles. This has potential applications in using polaritons in atomically-thin semiconductors, such as ultra-low energy electronics.

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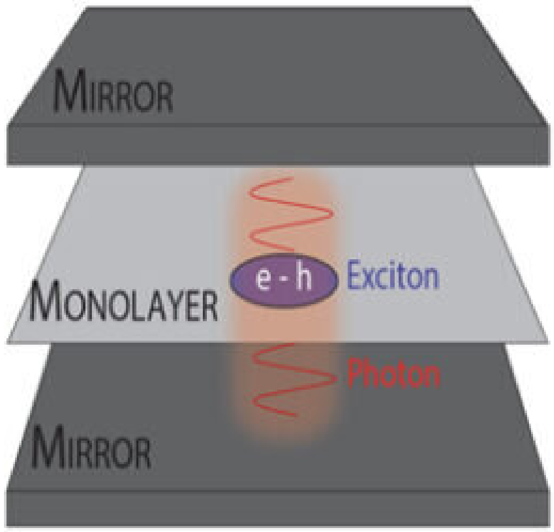
"We sought answers to a fundamental question about exciton-polaritons not asked previously," explains lead author Dr. Olivier Bleu. "If polaritons live in two dimensions, why is the disappearance of their interactions at slow velocities not happening in experiments, as predicted by quantum scattering theory?"

The team demonstrated that the strong coupling between excitons and photons, together with the huge exciton-photon mass ratio, modifies the scattering behavior expected for "bare" two-dimensional excitons and implies that polariton interactions remain finite.

"More precisely, we showed that the regime where the interactions should vanish is not observable since it would require a sample much larger than the known universe," explains co-author Dr. Jesper Levinsen.

The results show that polaritons interact more than excitons, which contrasts with the common assumption about these key quasiparticles. "This work sheds new light on the interactions between hybrid light-matter quasiparticles, and will allow us to deepen our understanding of these systems," says corresponding author A/Prof Meera Parish.



Exciton-polariton: hybrid quasiparticle between a photon (light) and an exciton (bound electron-hole pair). Credit: FLEET

Quasiparticles that are both light and matter

Exciton-polaritons form when excitons (electron-hole pairs) are strongly-coupled with light (photons) trapped in an optical cavity. This "split personality" gives the exciton-polariton unique properties, taking some of the characteristics of light and some of the characteristics of matter.

Their capacity to interact is at the heart of a variety of fascinating phenomena observable in experiments and still not completely understood, including polariton Bose-Einstein condensation, superfluidity and quantum optical effects.

"Polariton interactions in microcavities with atomically thin semiconductor layers" was published in *Physical Review Research* in November 2020.

The study was conducted in Dr. Jesper Levinsen and A/Prof Meera

Parish's group at Monash University, which investigates the behavior of large groups of interacting quantum particles that exhibit exotic behavior, such as superfluidity, in which they flow without encountering resistance.

This work expands the fundamental knowledge of quantum physics in systems ranging from cold atomic gases to solid-state semiconductors, and has the potential to underpin a new generation of near-zero-resistance, ultra-low-energy electronic devices.

More information: Olivier Bleu et al. Polariton interactions in microcavities with atomically thin semiconductor layers, *Physical Review Research* (2020). DOI: 10.1103/physrevresearch.2.043185

Provided by FLEET

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