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Leigh Ann Green

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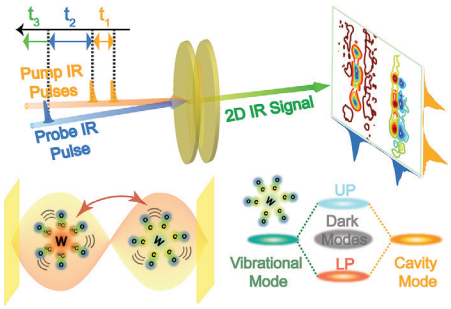
Molecular vibrational polaritons and ultrafast vibrational spectroscopy combine to further studies into synthetic chemistry and quantum technology.



Light-matter strong coupling, while studied extensively as a phenomenon of physics, is in its infancy stage in relation to chemistry. Authors Bo Xiang and Wei Xiong discuss the revolutionary potentials of light-matter strong coupling in chemical physics, specifically the subset of vibrational strong coupling.

Molecular vibrational polaritons, formed from the strong coupling of molecular vibrational modes and cavity photon modes, exert peculiar influences on chemical reactions. Some reactions are accelerated, and others are decelerated while under the influence of vibrational strong coupling. This opens the door to the exciting potential of using a photonic cavity (with or without light) to control chemical reactions.

Understanding the dynamics of molecular vibrational polaritons has proven challenging. Ultrafast time scales involved in the interactions between polaritons and dark modes present one of the biggest hurdles in these studies.

Ultrafast vibrational spectroscopy is an ideal tool to use in the investigation of molecular vibrational polariton dynamics. The authors provide an overview of recent ultrafast spectroscopic works from various researchers in this field. These works show molecular vibrational polaritons can have distinct dynamics from their individual molecular components outside of a cavity.

Areas impacted by this emerging field of study include chemical reactivity and selectivity, and a potential new quantum simulation platform.

“This is a very new field with a lot of challenges and opportunities,” said Xiong.

The authors said that a joint force between theorists, ultrafast spectroscopists, and vibrational strong coupling experts is needed to fully understand how polaritons influence chemical reactions. They stress new physical-chemical tools and techniques will be required to further advance applications into fields such as synthetic chemistry, photonics, and quantum technology.

Source: “Molecular vibrational polariton: Its dynamics and potentials in novel chemistry and quantum technology,” by Bo Xiang and Wei Xiong, *Journal of Chemical Physics* (2021). The article can be accessed at https://doi.org/10.1063/5.0054896.