The power of light-matter coupling

February 5 2015

A theoretical study shows that strong ties between light and organic matter at the nanoscale open the door to modifying these coupled systems' optical, electronic or chemical properties.

Light and matter can be so strongly linked that their characteristics become indistinguishable. These light-matter couplings are referred to as polaritons. Their energy oscillates continuously between both systems, giving rise to attractive new physical phenomena. Now, scientists in France have explained why such polaritons can remain for an unusual long time at the lowest energy levels, in such a way that alters the microscopic and macroscopic characteristics of their constituting matter. These findings thus pave the way for optical, electronic and chemical applications. The work has been published in EPJ D by Antoine Canaguier-Durand from the University of Strasbourg, France, and colleagues.

The authors elected to study polaritons made of organic molecules that are strongly coupled with a small number of photons. They examined polariton relaxation dynamics, which occur when polaritons transition from high energy to lower energy levels. To do so, the team employed a rigorous mathematical approach called "dressed atoms", which makes it possible to deduce characteristics such as transition rates from high to lower energy levels, for example.

In this study, the authors explain why the lifetime of the lowest lying polariton energy state is much longer than that of the higher lying state. These new results are in agreement with experimental results. But they are counter-intuitive compared to those provided by previous theoretical approximation methods, based on the behaviour of uncoupled light and matter, which hold that these states have the same duration.

This study thus confirms that it is possible to modify the pathways of vibrational transitions of molecules between higher and lower energy levels, the chemical photoreactions rates, or even to change conductivity in organic semiconductors as already observed.

More information: A. Canaguier-Durand, C. Genet, A. Lambrecht, T. W. Ebbesen, and S. Reynaud (2015), "Non-Markovian polariton dynamics in organic strong coupling," *European Physical Journal D* 69: 24, DOI: 10.1140/epjd/e2014-50539-x

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