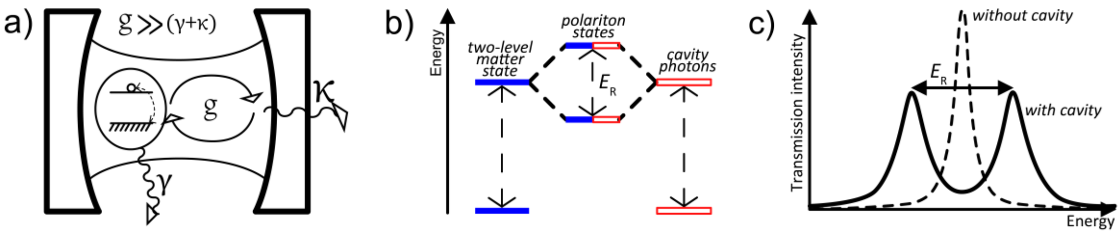
Polaritonic enhancement of metal halide perovskite photovoltaic performance

Clean, renewable solar energy is currently most widely harnessed by silicon solar cells. Competition has emerged over the last decade in the form of metal halide perovskites (MHPs), semiconductors whose excellent physical properties allow for highly efficient, easily fabricated solar cells. In recent years however, improvements in perovskite solar cells have slowed down, as changes to their composition and fabrication method now offer only diminishing returns.

This project will aim to improve the performance of MHP solar cells by incorporation of optical cavities to form hybrid light-matter states called 'polaritons'. Optical cavities can be thought of as a trap for light, which bounces between two precisely spaced mirrors many times before escaping. In the so-called 'strong coupling' regime, the rate (g) of reversible energy exchange between atoms of the material and the cavity modes is faster than the rate (κ and γ) of energy dissipation from the system (panel a). This can ultimately result in the formation of polaritons, separated in energy by the Rabi energy, E_R (panel b). Their formation can be detected through the appearance of a doublet structure in the transmission spectra (panel c) of the optical cavity.



Polaritons have been demonstrated in semiconductors, gases and molecules in solution,[1] and polaritonic effects have previously been exploited to achieve lasing in MHPs.[2] Recently, the formation of polaritonic states has also been found to alter chemical reactivity in solution-phase systems, opening up the tantalising possibility of achieving catalysis without the need for the addition of a physical catalyst.[3,4] This project will apply the same principles to the enhancement of solar cell efficiencies.

The PhD student on this project will use optical spectroscopic techniques to study the influence of polaritonic effects on MHP thin films in microcavities. They will also become acquainted with optical cavity fabrication, MHP thin-film deposition, and theoretical treatment of polaritonic and electronic processes in semiconductors but no particular prior experience of these techniques is required.

This project would suit budding scientists with a taste for both theory and experiment, from physics, physical chemistry or materials science backgrounds. This PhD studentship is available for start in October 2024. To discuss this project further, please contact Dr Adam Wright: a.d.wright@warwick.ac.uk

[1] A. D. Wright *et al.*, *J. Am. Chem. Soc.* **2023**, *145*, 5982.
[2] R. Su *et al.*, *Nat. Mater.* **2021**, *20*, 1315.
[3] R. F. Ribeiro *et al.*, *Chem. Sci.* **2018**, *9*, 6325.
[4] F. Gao *et al.*, *ChemPhotoChem* **2023**, *7*, e202200330.