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The impact of the local energy landscape on the diffusion of excitons in Ruddlesden-Popper hybrid perovskites flakes

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Halide perovskites are versatile semiconductors beneficial for many applications including photovoltaics and electroluminescent devices, having modular optoelectronic properties achievable by adjustment of composition and dimensionality. Ruddlesden - Popper layered perovskites are of particular interest due to their unique 2D character and excitons dynamics.

However, if long-range energy and charge carrier transport have been highlighted in such materials many aspects of such processes remain unexplained. In the following work, we use a non-invasive optical technique (derived from local time-resolved luminescence microscopy) to visualize exciton transport in exfoliated flakes of the BA2MAn - 1PbnI3n + 1 family of perovskites. Two distinct transport regimes are highlighted, depending on the temperature range. Above 100 K, diffusion occurs via a thermally activated hopping processes across localized states.

At lower temperatures, a non-uniform energy landscape emerges in which transport is dominated by downward energy transfer to low-energy states, leading to long-distance transport over hundreds of nanometers. The efficient, long-range and switchable downward transfer offers exciting possibilities for long-distance controlled directional transport in these 2D materials for new applications.

[1] Alan Baldwin et al. The Journal of Physical Chemistry Letters 2021 12 (16), 4003-4011