Understanding the long-range carrier mobility within metal halide perovskite thin films

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Many different characterisation methods have been employed for assessing the optoelectronic properties of metal halide perovskites. For metal halide perovskites, a broad range of charge carrier mobilities have been estimated via different techniques. Using transient methods, mobilities are often estimated assuming an initial charge carrier population following an optical excitation pulse, and simultaneously measuring the photo-conductivity via either non-contact or contact methods. However, for nanosecond to millisecond transient methods, an accurate determination of the carrier mobility is hindered by both early-time recombination, often during the photo-excitation pulse, and the branching ratio of excitons to free-carriers. Here we demonstrate how these effects can be accounted for in order to reliably estimate charge carrier mobilities over a broad range of photo-excitation densities. We determine that the long-range mobilities for FACs- and FAMACs- mixed cation mixed halide perovskite and $CH_3NH_3PbI_{3-x}Cl_x$ polycrystalline perovskite films are in the range from 7 down to 0.1 $cm^2\ V^{-1}\ s^{-1}$ and are invariant of carrier density.