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Screening in crystalline liquids protects energetic carriers in hybrid perovskites[1] HAIMING ZHU, KIYOSHI MIYATA, Columbia University, YONGPING FU, University of Wisconsin-Madison, JUE WANG, PRAKRITI JOSHI, DANIEL NIESNER, KRISTOPHER WILLIAMS, Columbia University, SONG JIN, University of Wisconsin-Madison, XIAOYANG ZHU, Columbia University — Hybrid lead halide perovskites exhibit carrier properties that resemble those of pristine nonpolar semiconductors despite static and dynamic disorder, but how carriers are protected from efficient scattering with charged defects and optical phonons is unknown. Here, we reveal the carrier protection mechanism by comparing three single-crystal lead bromide perovskites: $CH_3NH_3PbBr_3$, $CH(NH_2)_2PbBr_3$, and $CsPbBr_3$. We observed hot fluorescence emission from energetic carriers with $\sim 10^2$ picosecond lifetimes in $CH_3NH_3PbBr_3$ or $CH(NH_2)_2PbBr_3$, but not in $CsPbBr_3$. The hot fluorescence is correlated with liquid-like molecular reorientational motions, suggesting that dynamic screening protects energetic carriers via solvation or large polaron formation on time scales competitive with that of ultrafast cooling. Similar protections likely exist for band-edge carriers. The long-lived energetic carriers may enable hot-carrier solar cells with efficiencies exceeding the Shockley-Queisser limit. (Science 2016, 353, 1409.)

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