Colloidal perovskite quantum dots: from discovery to quantum light

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Lead halide perovskite nanocrystals (LHP NCs) - the latest generation of colloidal quantum dots (QDs) - possess dynamic, entropically stabilized soft lattices and electronically benign surfaces that, remarkably, do not compromise their textbook semiconductor optical quality. They are intrinsically bright emitters without the need for epitaxial wide-bandgap shells. In recent years, LHP NCs have emerged as the most intensively studied QD material, challenging the foundational paradigms of the field in nearly every respect. They are the first QDs to exhibit excitonic coherence on timescales comparable to their radiative lifetimes. Their giant oscillator strength effect enables extremely fast emission (lifetimes as short as 60 ps) even in relatively large NCs, while maintaining single-photon emission. Periodic ensembles of LHP NCs have further demonstrated collective, accelerated radiative decay - superfluorescence - a phenomenon previously unseen in colloidal systems. The excitonic fine structure of LHP NCs can be readily engineered through shape anisotropy. Furthemore, by simple near-field coupling to highly chiral plasmonic nanostructures, their otherwise linearly polarized emission becomes fully chiral, establishing LHP NCs as the first fully chiral colloidal single-photon emitters. Beyond photophysics, LHP QDs have recently proven to be efficient photocatalysts, mediating organic redox transformations that remain inaccessible to conventional photocatalysts. The presentation will summarize the contributions of my interdisciplinary team and our international collaborators, whose names will be acknowledged in the presentation and accompanying notes.