Efficient Up-Conversion Photoluminescence in All-Inorganic Lead Halide Perovskite Nanocrystals

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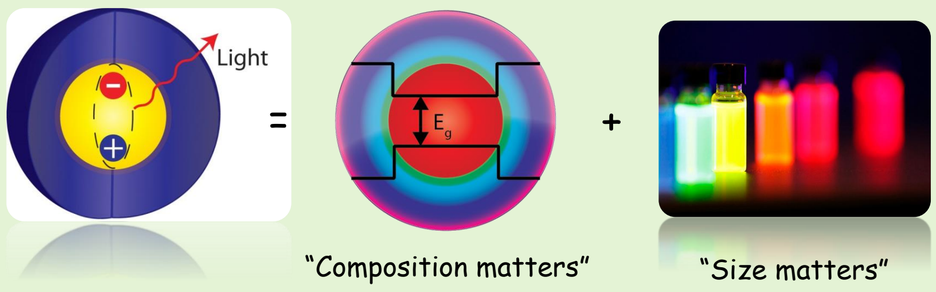
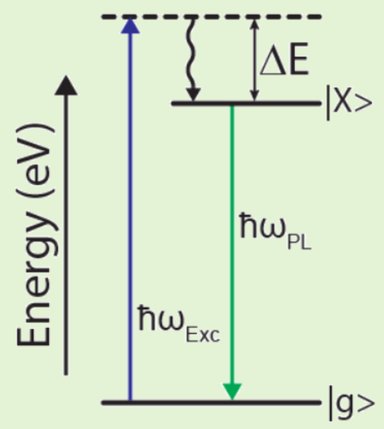
Introduction

Semiconductor colloidal nanocrystals (NCs) are nanometer-sized crystalline particles, whose remarkable optical properties can be tailored by controlling the NC size or composition.

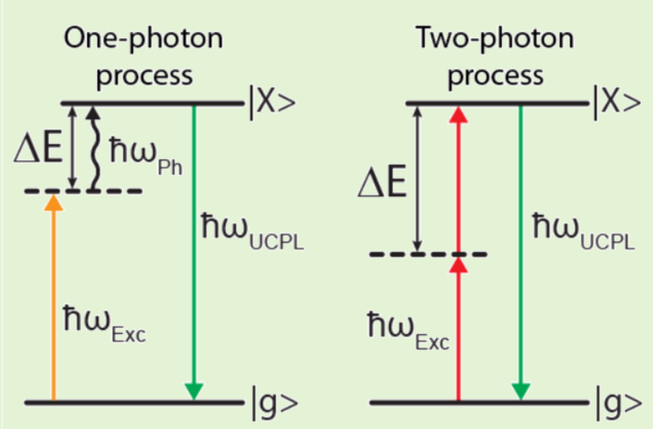


The underlying motivation is understanding linear and non-linear optical properties of emergent semiconductors materials in a NC form, with exotic crystal structures such as novel perovskites NCs for their use in optoelectronics applications.



$\hbar\omega_{Exc} > \hbar\omega_{PL}$

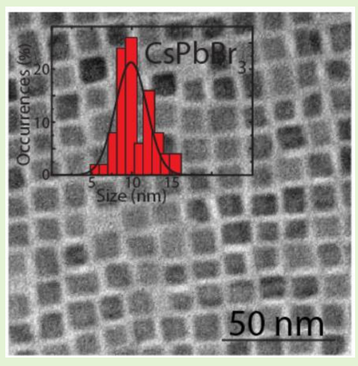
Excess energy is normally released in the form of phonons.



One-photon: $\hbar\omega_{Exc} + \hbar\omega_{ph} = \hbar\omega_{UCPL}$

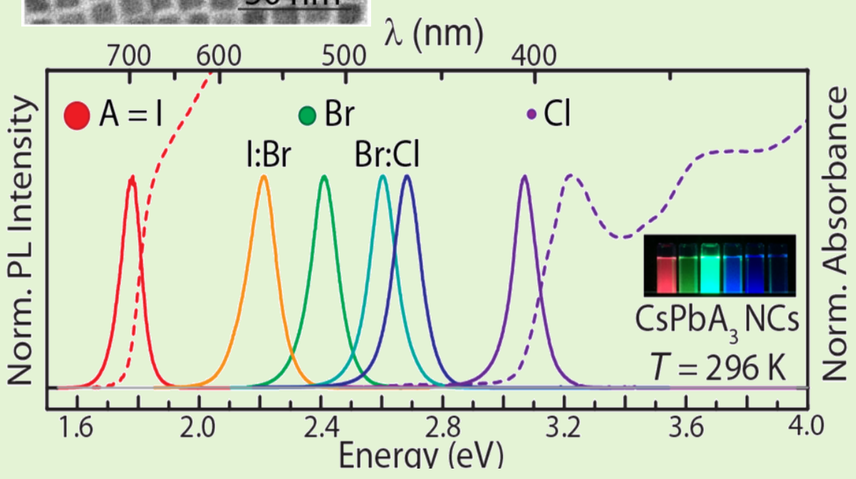
Two-photon: $\hbar\omega_{Exc} + \hbar\omega_{Exc} \geq \hbar\omega_{PL}$ occurs via an intermediate state.

Characterization



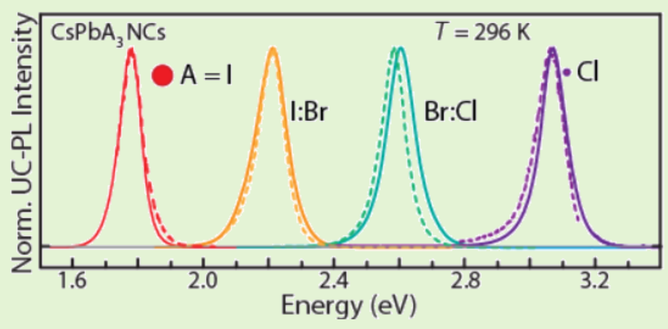
Representative TEM image of $CsPbBr_3$ NCs:

- cubic-like shape
- typical size of 10 nm

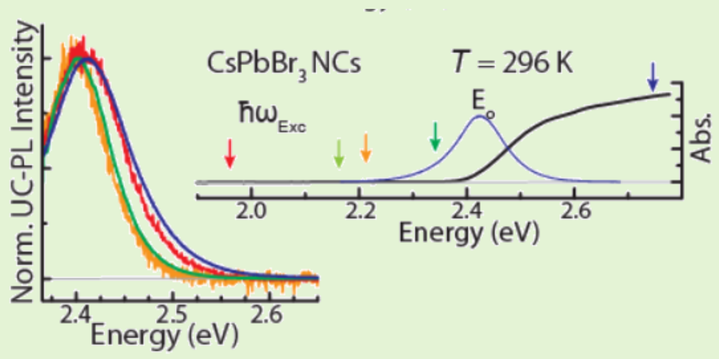


Room-temperature PL spectra for all investigated NCs and normalized absorption spectra for $CsPbI_3$ and $CsPbCl_3$.

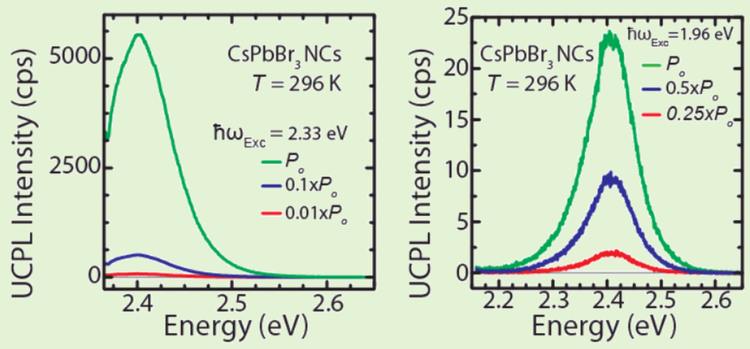
Results



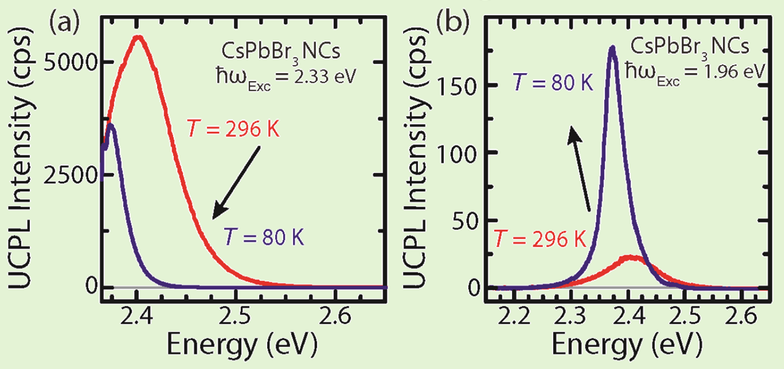
Normalized PL and UCPL spectra of different compositions.



Normalized UCPL spectra of $CsPbBr_3$ NCs under different excitation energies.

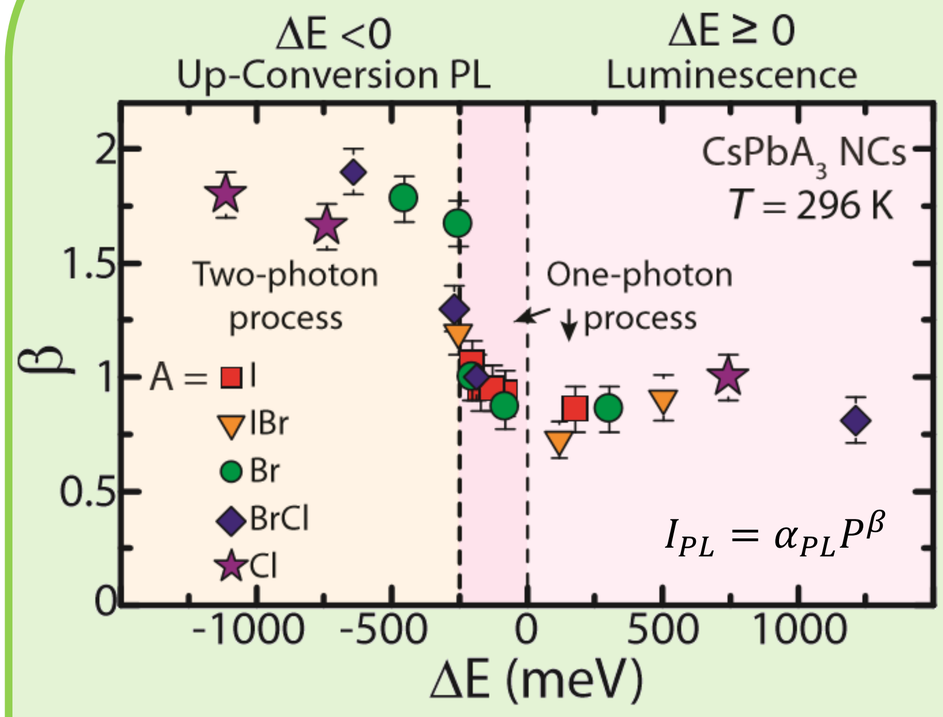


Power dependence of UCPL under different excitation energies.



Temperature dependence of UCPL under different excitation energies.

Discussion



One-photon process: $\Delta E \leq 200$ meV

Two-photon process: $\Delta E > 200$ meV

Largest gain: $\Delta E = 1100$ meV

Conclusion

Our results demonstrate that high-quality $CsPbX_3$ perovskite NCs are promising building-blocks for potential applications in up-conversion photoluminescence bio-imaging, photovoltaic light-energy harvesting. They are complementary to bulk perovskites solar-cells or for advanced applications such as non-linear optics and optical refrigeration. Besides the rich composition variety, further nanoparticle engineering of size, shape and core-shell hetero-nanocrystals may allow full control of the optical responses of these novel NCs.

References

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[5] To be submitted.

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