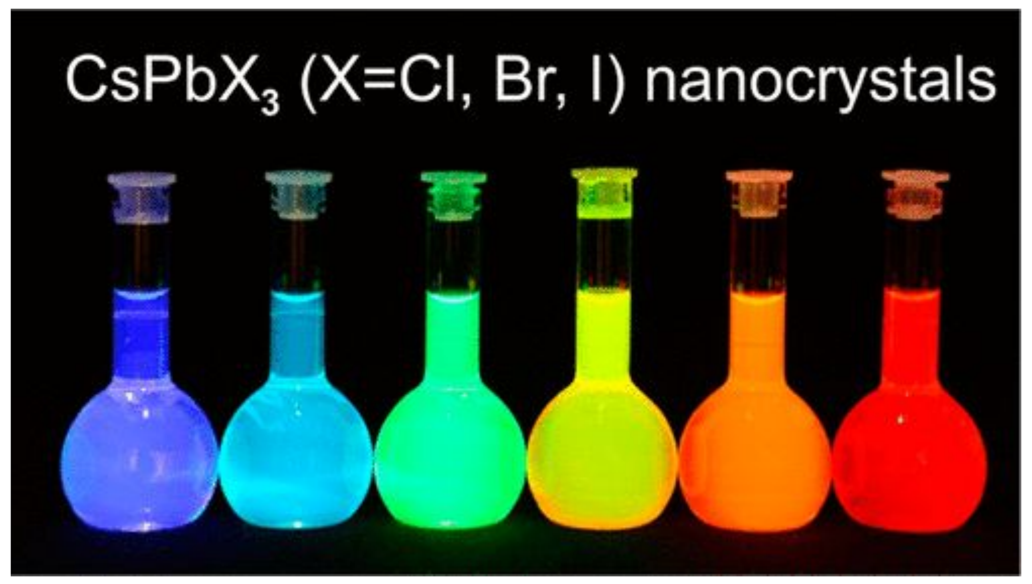
Quantum Innovations Promise Better, Brighter Optoelectronics

Taryn Morris† and Stephen Schrock†
†Bellaire High School

Nanocrystals of Cesium Lead Halide Perovskites ($CsPbX3$, X = Cl, Br, and I): Novel Optoelectronic Materials Showing Bright Emission with Wide Color Gamut Journal Cub

Research by Loredana Protesescu, Sergii Yakunin, Maryna I. Bodnarchuk, Franziska Krieg, Riccarda Caputo, Christopher H. Hendon, Ruo Xi Yang, Aron Walsh, and Maksym V. Kovalenko

What Are These Quantum Innovations?



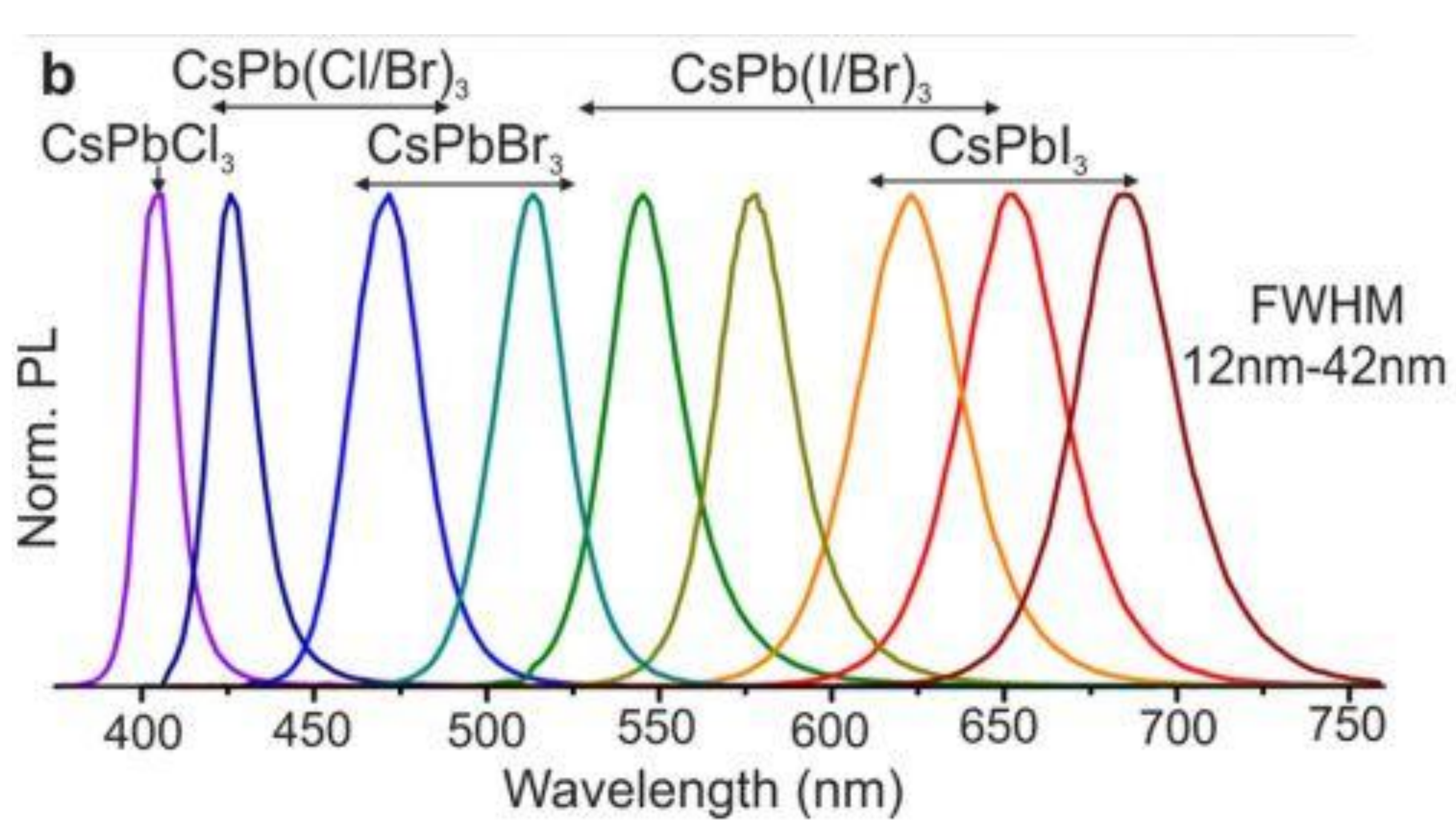
- Metal halides perovskites have shown success in the solar energy field
- They are being studied as materials that can emit light as tiny semiconductor materials nanometers in size called quantum dots

How Do These Quantum Dots Function?

- Narrow portions of the entire visible color spectrum able to be emitted through alteration of the size and composition of quantum dots
- Compositional variations include $CsPbCl_3$, $CsPbBr_3$, $CsPbI_3$, $CsPb(Cl/Br)_3$, and $CsPb(Br/I)_3$

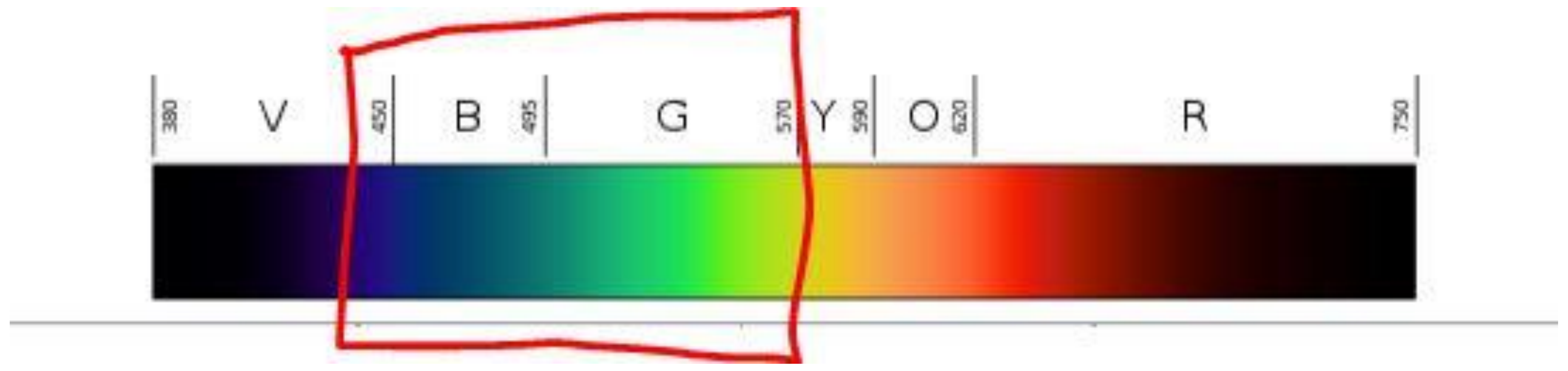
How Are These Quantum Dots Better?

- Light is able to be emitted from a specific portion of the visible light spectrum
- Highly efficient in emitting light (quantum yields of 50–90%)



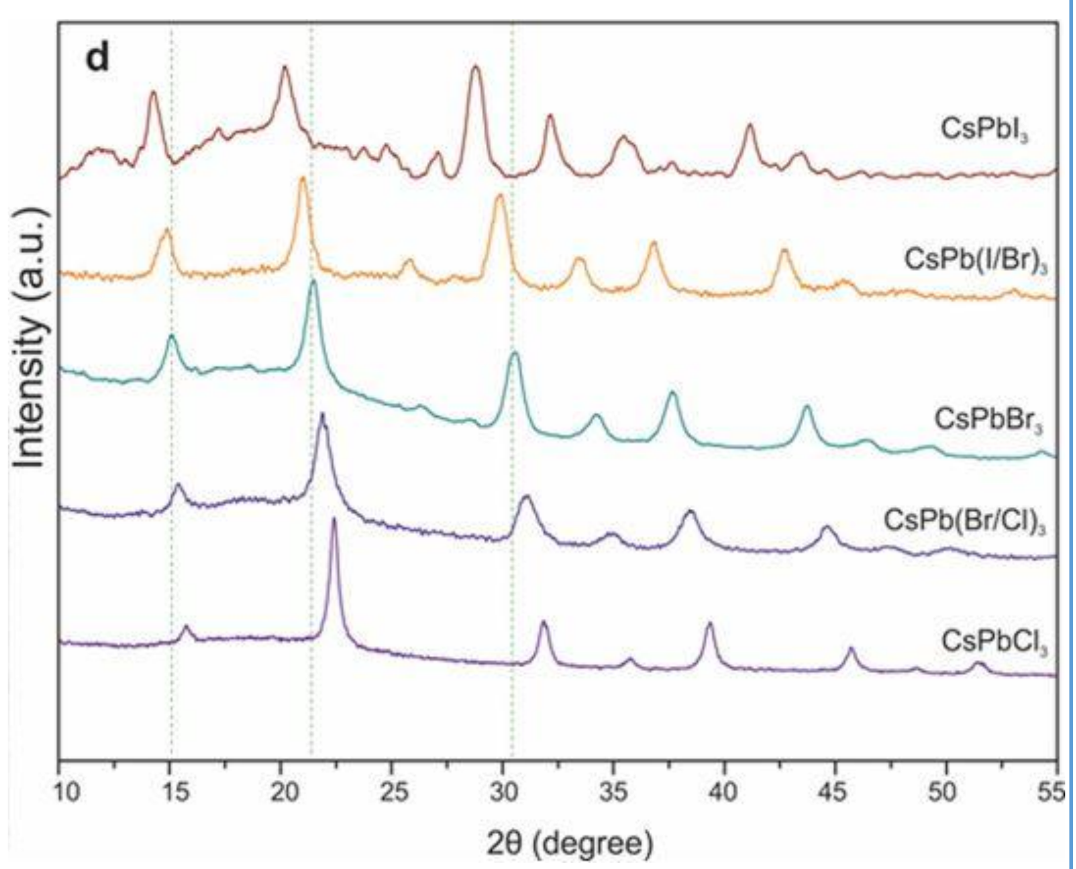
What Is the Current State of Optoelectronics?

- Metal chalcogenide-based quantum dots are typically used in optoelectronics
- These tend to degrade in blue and green spectral regions (410-530 nm)



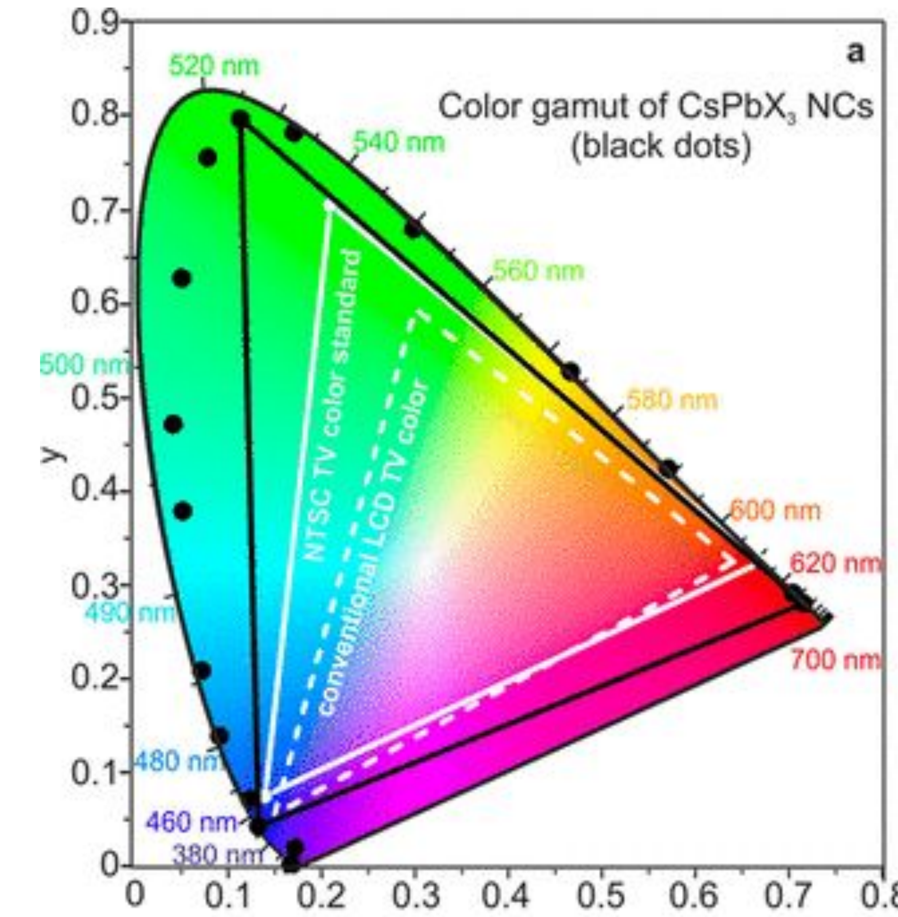
Methods of Manipulating the Quantum Dots

- Controlled arrested precipitation is used to synthesize Cs^{+}, $Pb2^{+}$, and X^{-} ions into $CsPbX_3$ nanocrystals
- Size of $CsPbX_3$ NCs can be changed within 4-15 nm by controlling the temperature of the boiling solvent from 140-200˚C used in this process
- Consistent X-ray diffraction patterns confirmed the 1:1:3 atomic ratio of each compositional variation



Future technological implications

- Digital screens
- Dyes for use in biological analysis
- Quantum dot lasers



We thank our mentors Hari Padmanabhan and Elise Koskelo, as well as Mr. Jimmy Newland, for their help and guidance. This work was completed as part of the Quantum Science & Technology Workshop @ Bellaire High School, supported by the MIT CQE-iQuISE (Center for Quantum Engineering, Interdisciplinary Quantum Information Science and Engineering) program.