| Cambridge: | TIMOTHY LAMBDEN | Cryogenic scanning transmission electron microscopy

| Berkley: | ALEX ODDO | synthesis and characterization of cesium lead bromide perovskites

# Investigating the Nanoscale Structure and Photophysical Properties of Perovskite Materials Using Cryogenic Scanning Transmission Electron Microscopy

## Introduction:

Advances in electron microscopy have revolutionized the study of beam-sensitive 'soft' materials at the nanoscale, enabling the investigation of materials that were previously difficult to explore. The development of detector technology, computational power, and improved microscope interfaces has paved the way for optimizing acquisition strategies to obtain high-quality data without sample damage. This research proposal aims to combine the expertise of two students, Timothy Lambden and Alex Oddo, to investigate perovskite materials using cryogenic scanning transmission electron microscopy (CryoSTEM) while synthesizing and characterizing cesium lead bromide perovskite nanocrystals. The ultimate goal is to understand how the nanoscale structure, morphology, and size influence the photophysical properties of perovskite materials.

## Objectives:

1. Develop optimized acquisition strategies for CryoSTEM to maximize data quality without significant sample damage, including the development of ice-free cryo holders and optimization of smart scanning and in-painting techniques.

2. Investigate the nanoscale structure of perovskite materials, specifically cesium lead bromide, using CryoSTEM to understand their morphology and crystallographic features.

3. Characterize the photophysical properties of cesium lead bromide perovskite materials, including bandgap, photoluminescence quantum yield, charge carrier lifetime, and the interplay of the phonon coupling.

4. Compare the photophysical properties of confined perovskite nanowires with traditional nanocrystals to understand the influence of size confinement on the performance of perovskite materials.

## Methodology:

1. Synthesize cesium lead bromide perovskite materials with well-defined nanocrystal and nanowire structures using established techniques.

2. Prepare samples for CryoSTEM analysis, such as by flash-freezing the perovskite samples using the developed ice-free cryo holders for preserving the native structure.

3. Utilize CryoSTEM to characterize the nanoscale structure of the perovskite materials, including imaging crystallographic features and morphology at high-resolution.

4. Employ spectroscopic techniques, such as photoluminescence spectroscopy and nuclear magnetic resonance (NMR), to measure the photophysical properties of the perovskite materials.

5. Compare the photophysical properties of confined perovskite nanowires with traditional nanocrystals through systematic analysis and characterization.

## Expected Outcomes:

1. Optimization of CryoSTEM acquisition strategies will enable high-quality imaging of perovskite materials, providing valuable insights into their structure and morphology.

2. Characterization of the photophysical properties of cesium lead bromide perovskite materials will expand our fundamental understanding of how the nanoscale structure influences their performance.

3. Comparative analysis of confined perovskite nanowires and traditional nanocrystals will shed light on the effects of size confinement, offering potential insights for the design and optimization of optoelectronic devices.

## Conclusion:

This research proposal combines the expertise of Timothy Lambden, who specializes in CryoSTEM and electron microscopy techniques, and Alex Oddo, who focuses on the synthesis and characterization of cesium lead bromide perovskite materials. By leveraging advanced microscopy techniques and spectroscopic analysis, this study aims to elucidate the nanoscale structure and photophysical properties of perovskite materials. The findings have broad implications for the development of next-generation photovoltaics and other optoelectronic devices.