Abstract for IAS International Conference on Energy Materials (January 19-23, 2026)

Multiscale Dynamics of Lithium-Ion Batteries: From Physical Insights to Data-Driven Prediction

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Lithium-ion batteries (LIBs) are at the forefront of energy storage innovation, playing a crucial role in electrification and climate change mitigation. The electrochemical performance of LIBs is governed by the intricate movement of lithium ions across multiple length scales—from atomic-scale lattice structures to microscale porous electrodes and full-cell architectures. Each electrode consists of densely packed particles with distinct crystallographic structures and surface properties, contributing to complex, heterogeneous lithium transport behavior.

In this talk, I will demonstrate how advanced analytical techniques provide unprecedented insights into these hierarchical, multiscale dynamics within operating batteries. By bridging nanoscale ion transport with macroscopic electrochemical responses, we reveal how these phenomena impact key performance metrics, including charge–discharge efficiency, capacity degradation, and thermal stability. Finally, I will discuss how the insights obtained from multiscale dynamics can be leveraged to enable data-driven prediction of battery cycle life.

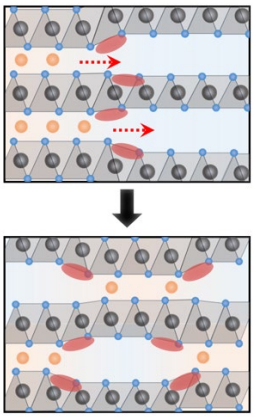

Fig 1. Strain-associated lithium transport

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