

Multiscale modeling and neural operators

The behavior of polycrystalline materials involve physics at multiple length and time scales. The engineering properties that we observe and exploit in application are a sum total of all these interactions. Multiscale modeling seeks to understand this complexity with a divide and conquer approach. It introduces an ordered hierarchy of scales, and postulates that the interaction is pairwise within this hierarchy. The coarser-scale controls the finer-scale and filters the details of the finer scale. Still, the practical implementation of this approach is computationally challenging. This talk introduces the notion of neural operators as controlled approximations of operators mapping one function space to another and explains how they can be used for multiscale modeling. They lead to extremely high fidelity models that capture all the details of the small scale but can be directly implemented at the coarse scale in a computationally efficient manner. We demonstrate the ideas with examples drawn from first principles study of defects and crystal plasticity study of inelastic impact.