Machine Learning from the Large Hadron Collider to van der Waals Materials

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Machine learning (ML) methods have recently achieved remarkable progress in automated signal identification, pattern recognition and classification, anomaly detection, uncertainty quantification, and unbiased background removal. In this talk, I will present applications of ML in processing multi-dimensional datasets acquired by Scanning Transmission Electron Microscopy (STEM) in van der Waals materials, using algorithms originally inspired by high-energy physics. These approaches are essential to fully exploit the capabilities of state-of-the-art detectors, where manual analysis is time-consuming and prone to bias.

First, we demonstrate how ML efficiently removes large background contributions in the low-loss region of Electron Energy-Loss Spectroscopy (EELS), enabling the identification of bandgap energy modulations [1,2]. Second, the combination of unsupervised learning with four-dimensional (4D) STEM enables the precise characterization of nanoscale strain fields across micron-sized specimens [3,4]. Third, we apply ML for core-loss background subtraction to identify signatures of Moiré modulation in twisted vdW materials [5]. Finally, I outline potential future applications of ML in TEM data analysis, including enhanced mapping of local polarization via simulation-based inference and automated feature identification in EELS spectra.

References

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Figures

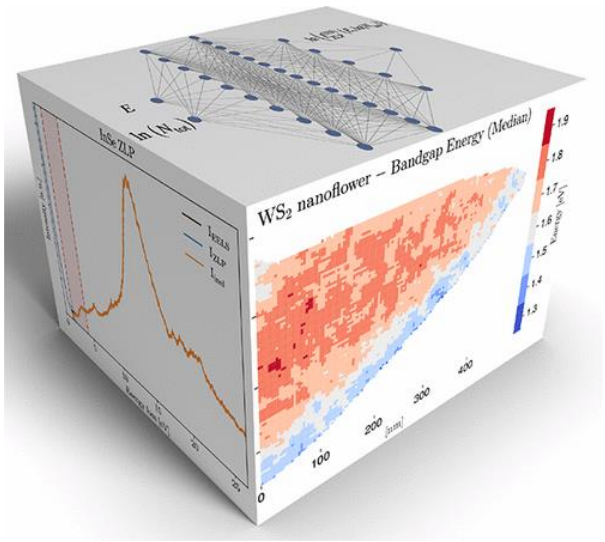

Figure 1: Schematic illustration showing how high-dimensional measurements from Scanning Transmission Electron Microscopy can be efficiently processed using machine learning techniques inspired from particle physics.