Parton Distributions and Lattice Calculations (PDFLattice 2024)



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## Mixture Models for uncertainty quanitification in PDFs

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Parton distribution functions (PDFs) form an essential part of particle physics calculations. Currently, the most precise predictions for these non-perturbative functions are generated through fits to global data. A problem that several PDF fitting groups encounter is the presence of tension in data sets that appear to pull the fits in different directions. In other words, the best fit depends on the choice of data set. Several methods to capture the uncertainty in PDFs in presence of seemingly inconsistent fits have been proposed and are currently in use. These methods are important to ensure that uncertainty in PDFs are not underestimated. Here we propose a novel method for estimating the uncertainty by introducing a generalized statistical model inspired by unsupervised machine learning techniques, namely the Gaussian Mixture Model (GMM). Using a toy model of PDFs, we demonstrate how the GMM can be used to faithfully reconstruct the likelihood associated with PDF fits, which can in turn be used to accurately determine the uncertainty on PDFs, especially in presence of tension in the fitted data sets. We further show how this statistical model reduces to the usual chi-squared likelihood function for a consistent data set and provide measures to optimize the number of Gaussians in the GMM.

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