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Determination of the electromagnetic form factor of the Pion at large Q^2 using lattice QCD

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The electromagnetic form factor, $F_\pi(Q^2)$, of the pion describes how quarks are distributed inside the pion and is of considerable phenomenological interest. However, $F_\pi(Q^2)$ at large values of momentum transfer, Q^2 , has proven difficult to measure experimentally. This motivates numerical approaches to its calculations, such as lattice QCD. Though Lattice QCD calculations of $F_\pi(Q^2)$ exist for low Q^2 , it is also desirable to understand the behaviour of $F_\pi(Q^2)$ at large Q^2 in order to help guide future experimental measurements, for example at Jefferson Lab in the US. Accessing $F_\pi(Q^2)$ at high Q^2 , however, also presents challenges for Lattice QCD. This is due to the increased computational cost required to overcome gauge noise, as well as increased difficulty in extracting signals for boosted particles. We present a lattice QCD calculation of $F_\pi(Q^2)$ using the Feynman-Hellmann technique. We employ two noise reduction techniques, all-mode averaging (AMA) and momentum smearing (MS). Additionally, we also apply variational techniques between different operators which create the pion state to further improve correlator signal to noise ratios. By performing calculations on SU(3)-flavour symmetric ensembles, where light and strange quark masses are degenerate, as well as for ensembles where SU(3)-flavour symmetry is broken, i.e. where the light and strange masses are not degenerate, we find that these methods significantly improve the extraction of $F_\pi(Q^2)$, allowing access to $F_\pi(Q^2)$ at around $Q^2 = 10 \text{ GeV}^2$.

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