Description of doctoral project
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Short-distance constraints on the hadronic light-by-light contribution to the muon $g-2$

The anomalous magnetic moment $(g-2)$ of the muon, a 200 times heavier sibling of the electron, currently receives a lot of attention. The reason is that it can be measured and calculated with sub-ppm accuracy making it one of the most precisely known quantities in physics and a stringent test for the theory it is calculated in, the Standard Model of particle physics (SM). Indeed, there is a long-standing discrepancy between theory and experiment, which recently increased to $4.2\,\sigma$ due to a new measurement at Fermilab and could be a sign for new physics.

While being an electromagnetic property of the muon, the high precision makes it necessary to account for all known particles and forces in the SM prediction and the uncertainty is in fact dominated by effects of the strong interaction. An important effect of this type is hadronic light-by-light scattering, which I am dealing with in my doctoral thesis. Its contribution to the muon $g-2$ is given by integrals over all energies of a tensor describing the interaction of four virtual photons via the strong interaction. At low energies, a description in terms of hadrons is appropriate and this is achieved via so-called dispersion relations and experimental data on sub-processes. At high energies, however, the calculation proceeds with quarks and gluons as degrees of freedom using the operator product expansion and perturbative QCD. It is my aim to better understand the interplay between the two descriptions, especially how the high-energy results can be understood in the hadronic language. This also helps improve the description of the intermediate and mixed regimes, which are important for a precise estimate of the hadronic light-by-light contribution to the muon $g-2$.