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The Geometry of Interactions: Curved Field Space of Scalars at One Loop

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We present a systematic study of one-loop quantum corrections in scalar effective field theories from a geometric viewpoint, emphasizing the role of field-space curvature and its renormalisation. By treating the scalar fields as coordinates on a Riemannian manifold, we exploit field redefinition invariance to maintain manifest coordinate independence of physical observables. Focusing on the non-linear sigma model (NLSM) and \(\phi^4\) theory, we demonstrate how loop corrections induce momentum- and scale-dependent shifts in the curvature of the field-space manifold. These corrections can be elegantly captured through the recently proposed geometry-kinematics duality, which generalizes the colour-kinematics duality in gauge theories to curved field-space backgrounds. Our results highlight a universal structure emerging in the contractions of Riemann tensors that contribute to renormalisation of the field-space curvature. In particular, we find explicit expressions and a universal structure for the running curvature and Ricci scalar in simple models, illustrating how quantum effects reshape the underlying geometry. This geometric formulation unifies a broad class of scalar EFTs, providing insight into the interplay of curvature, scattering amplitudes, and renormalisation.

Primary authors: Prof. WEILER, Andreas (Technical University of Munich); Mr HASLEHNER, Dominik (Max Planck Institute for Physics & Technical University of Munich); Dr GENDY, Emanuele (Technical University of Munich); Dr BELLAFRONTE, Luigi (Florida State University); Mr AIGNER, Patrick (Technical University of Munich)

Presenter: Mr HASLEHNER, Dominik (Max Planck Institute for Physics & Technical University of Munich)

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