IV. Properties of the SCET Lagrangian

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Residual gauge invariance:

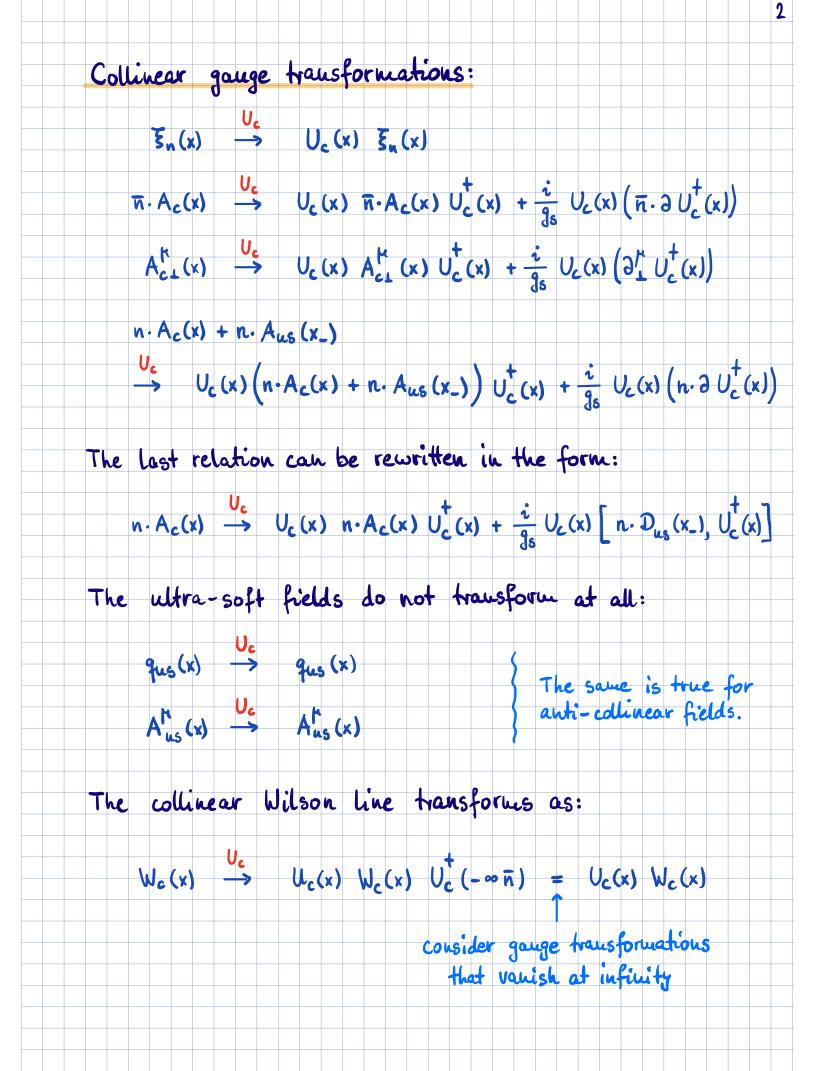
The SCET Lagrangian is <u>no longer</u> invariant under arbitrary local gauge transformations:

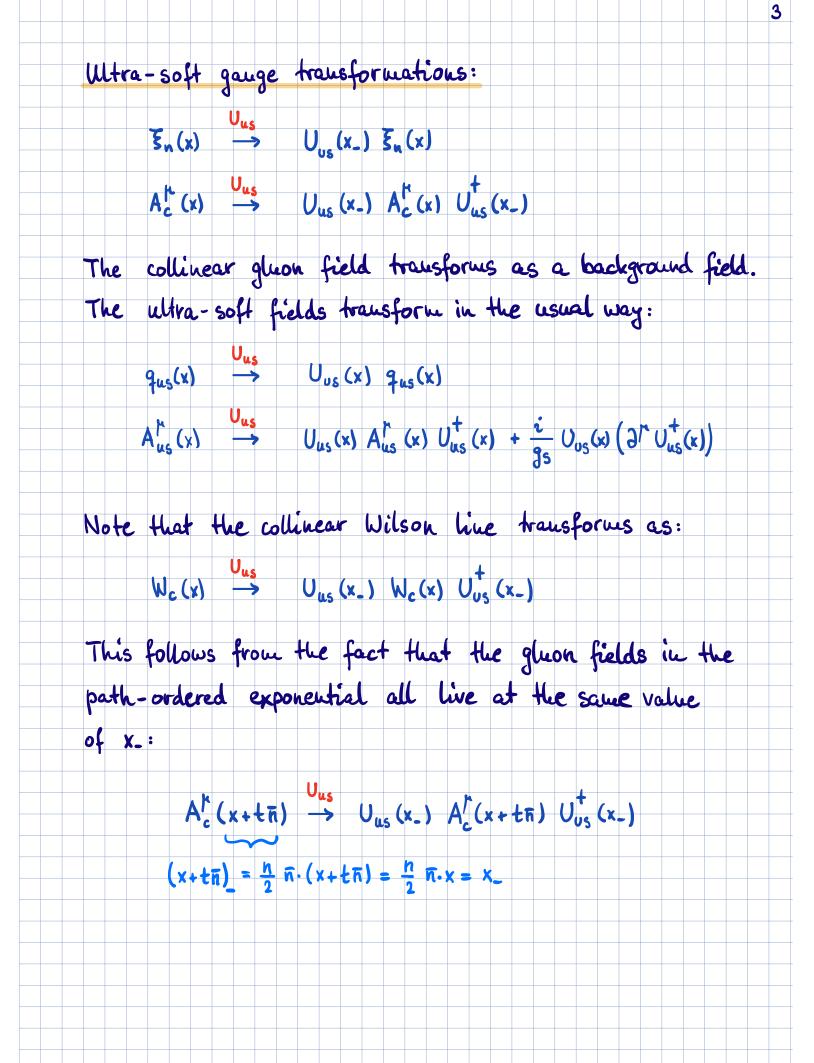
 $\Psi(x) \rightarrow U(x) \Psi(x)$

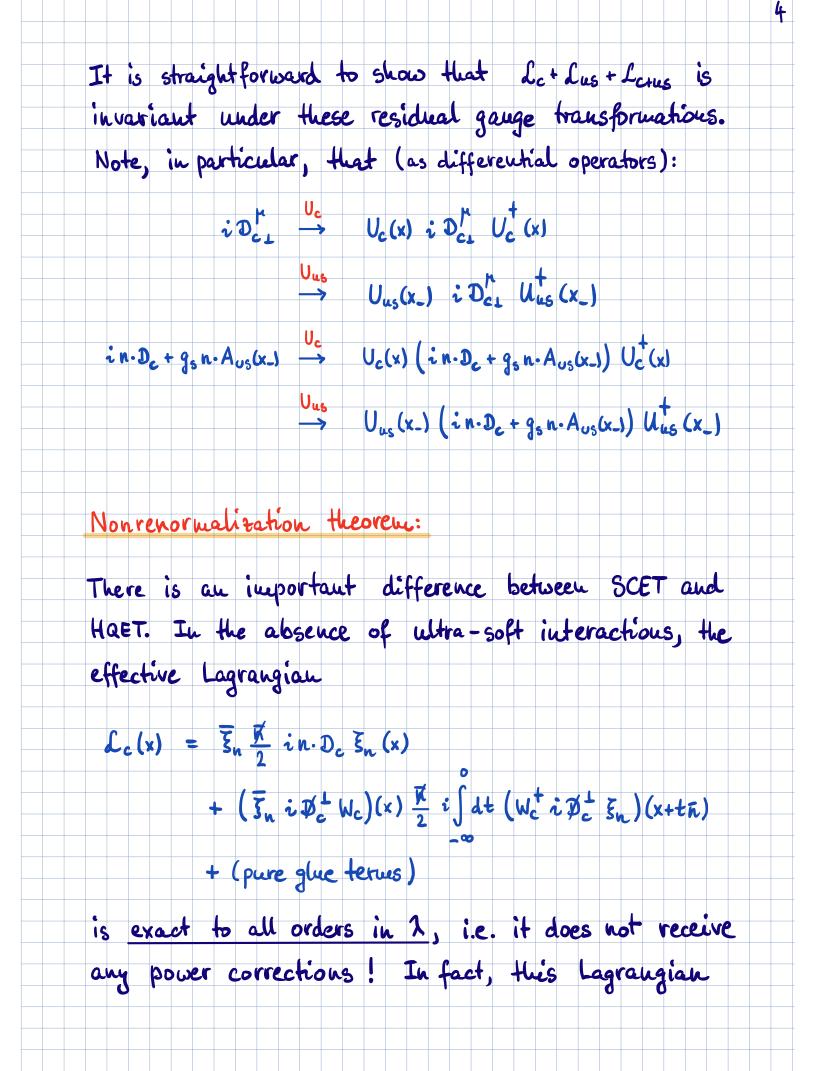
 $A^{\mu,a} t^{a} = \frac{i}{9s} U(x) \left(D^{\dagger}(x) U^{\dagger}(x) \right)$

The Fourier transform $\tilde{U}(p)$ could contain modes with arbitrary momenta (including hard ones), which would mix up the various modes in the EFT. However, the SCET Lagrangian is invariant (order by order in 2) under a set of collinear, anti-collinear and ultra-soft gauge transformations, which preserve the scaling properties of the various fields. (It is also invariant under global gauge transformations, of course.)

The appropriate form of the residual gauge transformations can be obtained by performing suitable expansions in the QCD relations shown above.







does not contain any small ratio of scales, unlike in HQET, where $iv \cdot D_s/m_a \ll 1$. By a Lorentz boost, a set of highly boosted collinear particles with womenta $p_c^* \sim (\lambda^2, 1, \lambda)$ can be transformed into a set of particles with momenta $\Lambda^{\mu}_{r} p_c^* \sim (\lambda, \lambda, \lambda)$. Thus, the Lagrangian \mathcal{L}_c is, in fact, completely equivalent to the QCD Lagrangian, and as a result its vertices do not receive any hard matching corrections.

Remarkably, this statement remains true when ultra-soft interactions are included.

(see: Beneke, Chapovsky, Diehl, Feldmann 2002)

Reparameterization invariance:

The choice of the light-like reference vectors n^{H} , \bar{n}^{H} ($n^{2}=0=\bar{n}^{2}$, $n\cdot\bar{n}=2$) in the construction of SCET is not unique. For instance, one can rescale:

 $n^{t} \rightarrow \xi n^{t}, \overline{n}^{t} \rightarrow \xi^{-1} \overline{n}^{t} \qquad (\underline{\pi})$

(with 3~2°)

One can also rotate n^{h} or \overline{n}^{μ} by small amounts away from the 2-axis. In infinitesimal form: $n^{h} \rightarrow n^{h} + \Delta_{1}^{\mu}$ (I) $n^{h} \rightarrow n^{h}$ (I) $\overline{n}^{h} \rightarrow \overline{n}^{h}$ (I) $n^{h} \rightarrow n^{h} + \overline{\Delta}_{1}^{\mu}$ (I) $(\Delta_{1} \sim \lambda)$ $(\overline{\Delta}_{1} \sim \lambda)$ The most general transformation is a combination of these three. The SCET Lagrangian is invariant under these reparameterization transformations as a consequence of Lorents invariance. The transformations (I) and (I)

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(see: Manohar, Meheu, Pirjol, Stewart 2002)

on the other hand, must be satisfied order by order

in λ .

relate the coefficients of operators arising at different

orders in A. Invariance under type-III transformations,