Seminar

Faddeev-Kulish states & Asymptotic Symmetries

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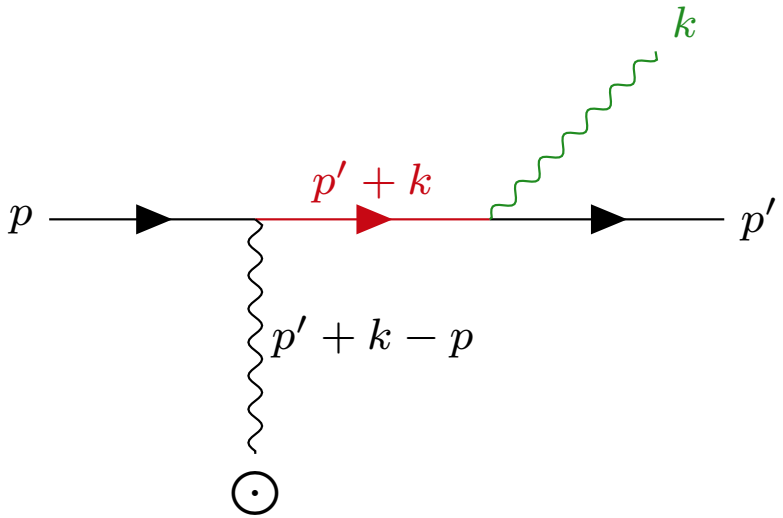
Introduction

The Infrared Problem

Consider the emission of a soft photon due to some scattering process



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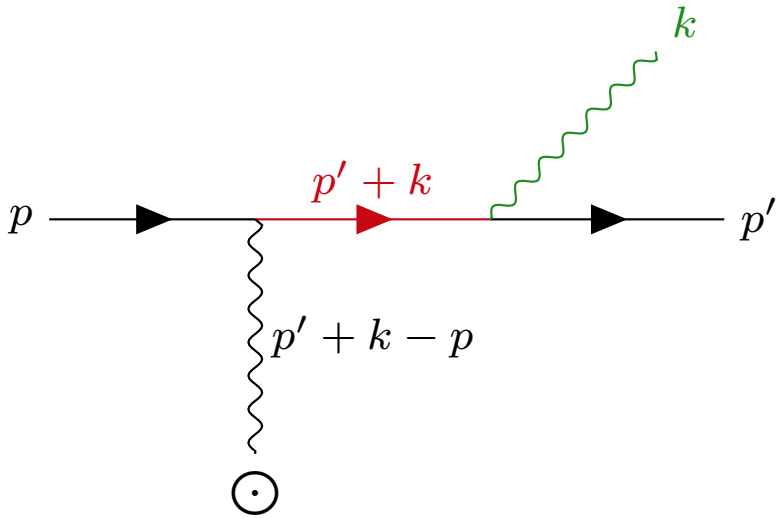

The amplitude will contain the factor

$$\frac{1}{2p'k}$$

This diverges when $k \to 0$

The Bloch-Nordsieck Theorem

Introduction. The Infrared Problem

Bloch-Nordsieck theorem

If you sum up all the graphs containing any number of loops and any number of emitted soft photons the divergences cancel to **all** orders of perturbation theory.

Cancels on cross-section level

It is not clear why this works, since each individual term is infinite. No obvious symmetry involved.

Faddeev-Kulish States

or Dressed Matter States

A Physical Starting Point
Faddeev-Kulish States

The Fock states are the problem!

We assume that our fields vanish at infinity, this is in contradiction to special relativity. In reality we have a non-vanishing interaction at infinity.

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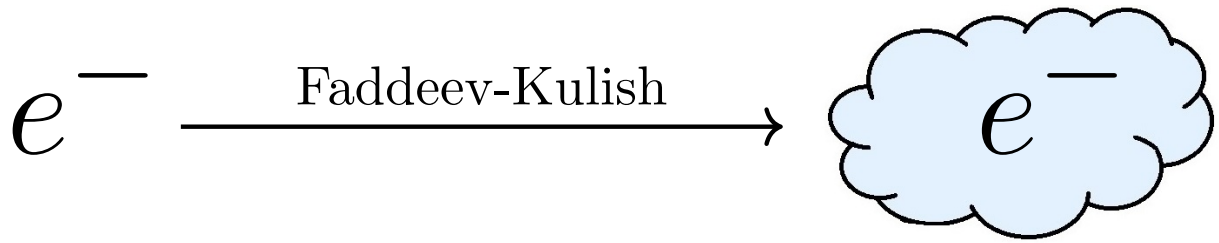


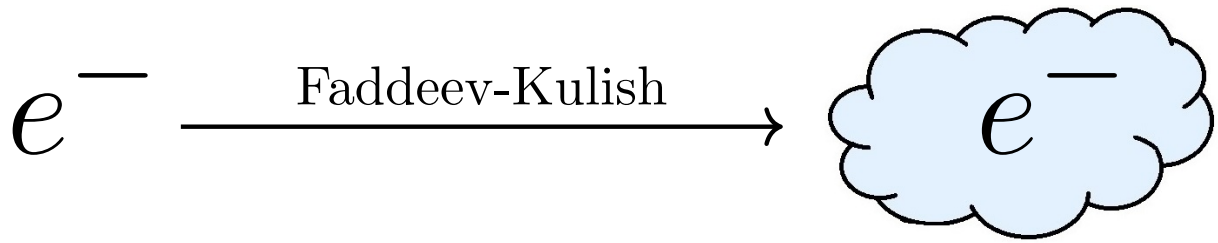
$$|\Psi\rangle_F \longrightarrow |\Psi\rangle_{FK} = U_{as}(t)\,|\Psi\rangle_F$$

A Physical Starting Point

Faddeev-Kulish States

Divergence cancels at a S-matrix level.

The divergence appeared due to us working in the wrong states and neglecting interactions. Still no symmetry arguments.



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Large Gauge Transformations

Asymptotic Symmetries

What is an LGT?
Large Gauge Transformations

Lorenz gauge $\partial^\mu A_\mu = 0$

$$A_\mu \to A'_\mu = A_\mu + \partial_\mu \lambda, \qquad \text{where} \qquad \partial_\mu \partial^\mu \lambda = 0$$

Fall-off

$$\lim_{r \to \infty} A_\mu(x) = 0$$

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Let us relax the fall-off condition

$$\lim_{r\to\infty} A_{\theta/\phi} = \mathcal{O}(1), \quad \Rightarrow \quad \lim_{r\to\infty} \lambda(x) = \varepsilon(\theta, \phi)$$

Angular components are non-vanishing at infinity.

Fock States

Fock states do not have a definite LGT charge, IR divergence occurred because we violated LGT charge conservation.

LGT Eigenstates
Large Gauge Transformations

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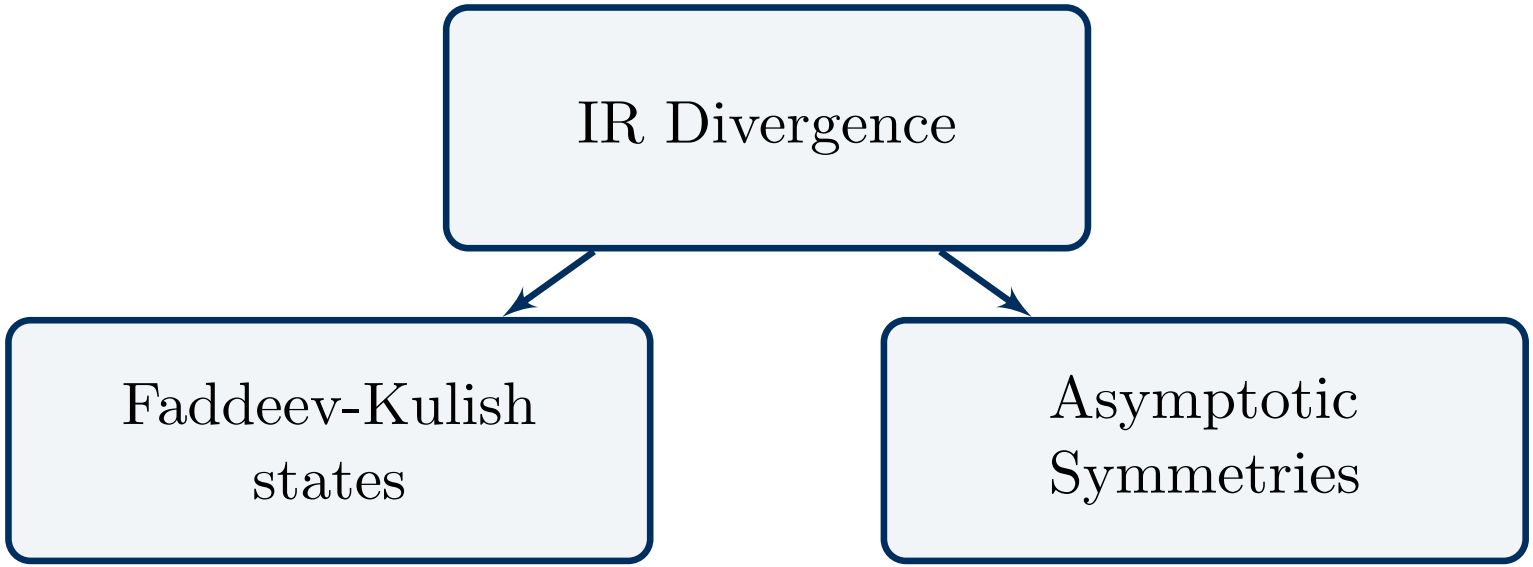
Faddeev-Kulish states

Are eigenstates of LGT and have definite charge, that's why the divergence cancels at S-matrix level. There **is** an underlying symmetry governing the process.

IR Divergence

Summary
Faddeev-Kulish states and Asymptotic Symmetries



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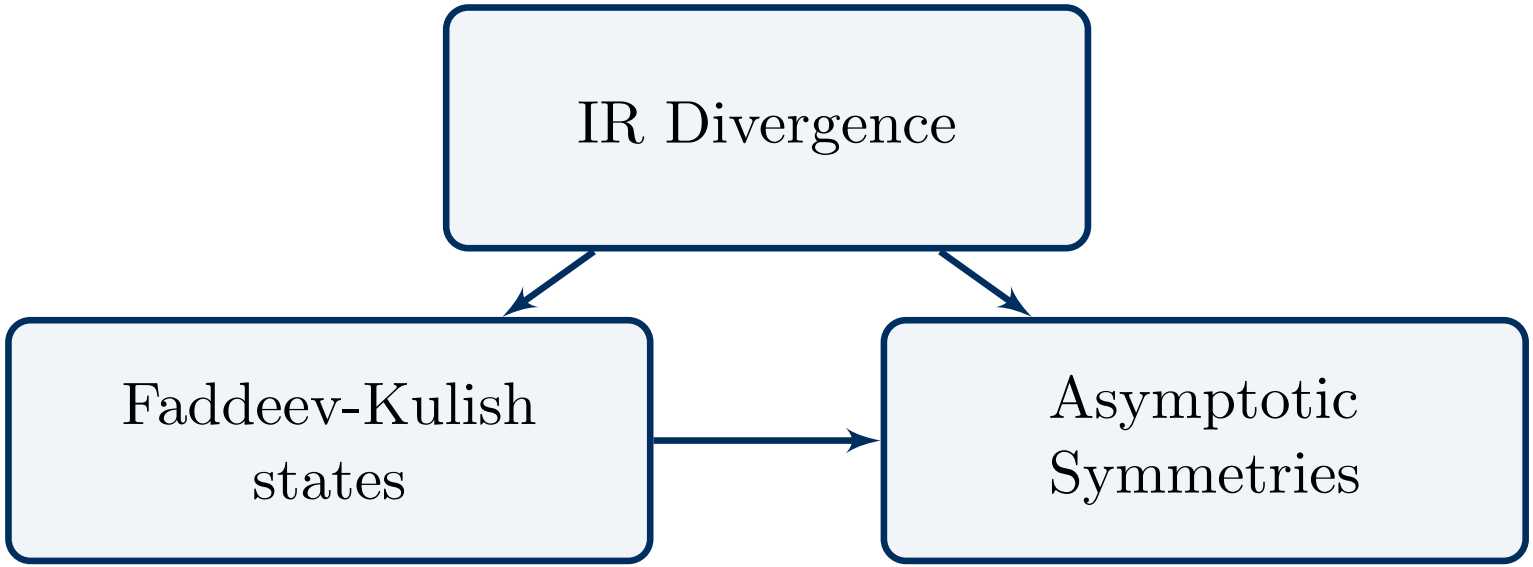

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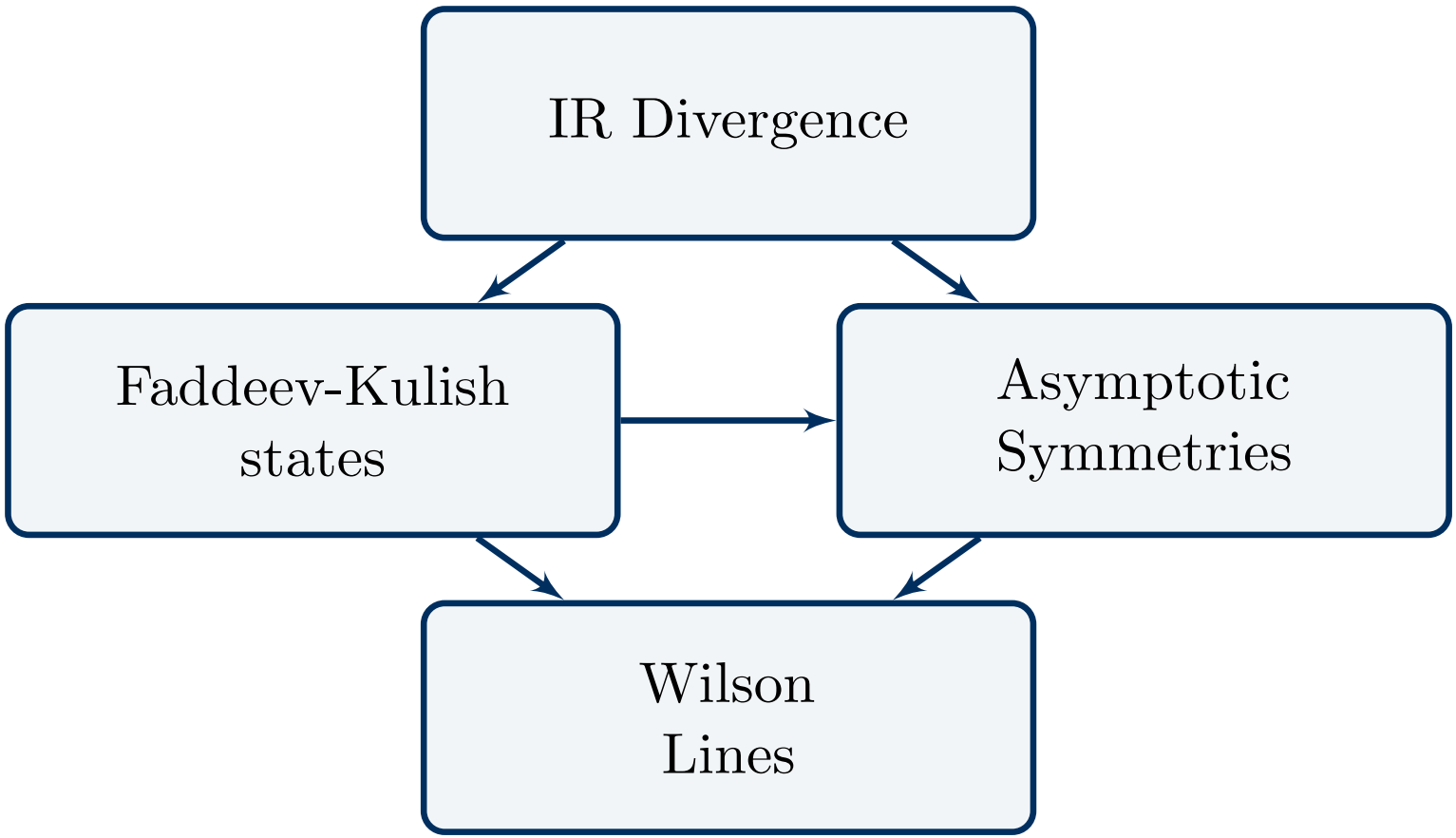

Thank you!