Soft-Collinear Effective Field Theory
Introduction and References

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Pre-Workshop School for SCET 2026
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Tools for QFT computations

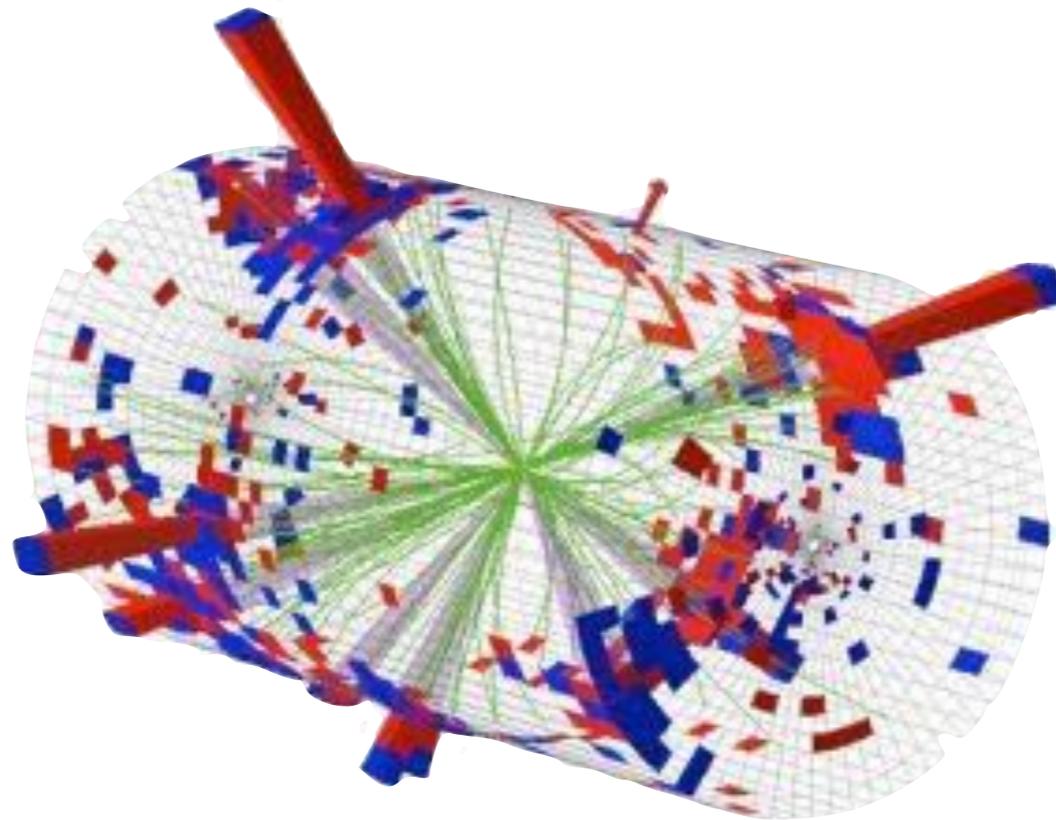Expansion in the interaction strength: perturbation theory

Expansion in scale ratios: Effective Field Theories

Numerical methods: lattice simulations

Toy models: solvable models SUSY theories AdS/CFT

EFTs are an important, basic tool in QFT, relevant whenever there are scale hierarchies!

Jet physics at the LHC

Many large scale hierarchies!

$$\sqrt{s} \gg p_{\mathrm{Jet}}^{T} \gg M_{\mathrm{Jet}} \gg E_{\mathrm{out}} \gg m_{\mathrm{proton}} \sim \Lambda_{\mathrm{QCD}}$$

Many applications of Soft-Collinear Effective Theory!

Goals

- Basics of SCET for newcomers, foundation for the advanced SCET lectures

  - Xiangdong Ji Non-perturbative SCET with large-momentum lattice QCD

  - Chris Lee Event shapes and jet algorithms

  - Matthias Neubert SCET at next-to-leading power

- Discuss recent progress on a few subtleties for the experts

Outline

- Momentum regions in loop and phase-space integrals

  - Method of regions

  - Sudakov form factor

  - Exceptional regions: Glauber, Landshoff

  - All-order proofs, cascades of regions

- Introduction to SCET

  - Effective Lagrangian (at leading power)

  - E.m. current operator at large momentum transfer

  - Decoupling and $i\varepsilon$'s

  - Label-formalism vs. position space

Outline […]

- *N*-jet processes

  - Gauge invariant building blocks

  - Leading-power operators

  - Factorization constraints on infrared divergences in *n*-point scattering amplitudes

Original Literature

Original SCET papers (label formalism):

- C.W. Bauer, S. Fleming, D. Pirjol and I.W. Stewart, *An effective field theory for collinear and soft gluons: Heavy to light decays,* PRD 63, 114020 (2001) [hep-ph/0011336]

- C.W. Bauer, S. Fleming, D. Pirjol and I.W. Stewart, *Soft-Collinear Factorization in Effective Field Theory,* PRD 65, 054022 (2002) [hep-ph/0109045]

- C.W. Bauer, S. Fleming, D. Pirjol, I.Z. Rothstein and I.W. Stewart, *Hard scattering factorization from effective field theory*, PRD 66, 014017 (2002) [hep-ph/0202088]

SCET in position space:

- M. Beneke, A.P. Chapovsky, M. Diehl and T. Feldmann,``Soft-collinear effective theory and heavy-to-light currents beyond leading power,'' Nucl. Phys. B643, 431 (2002) [arXiv:hep-ph/0206152]
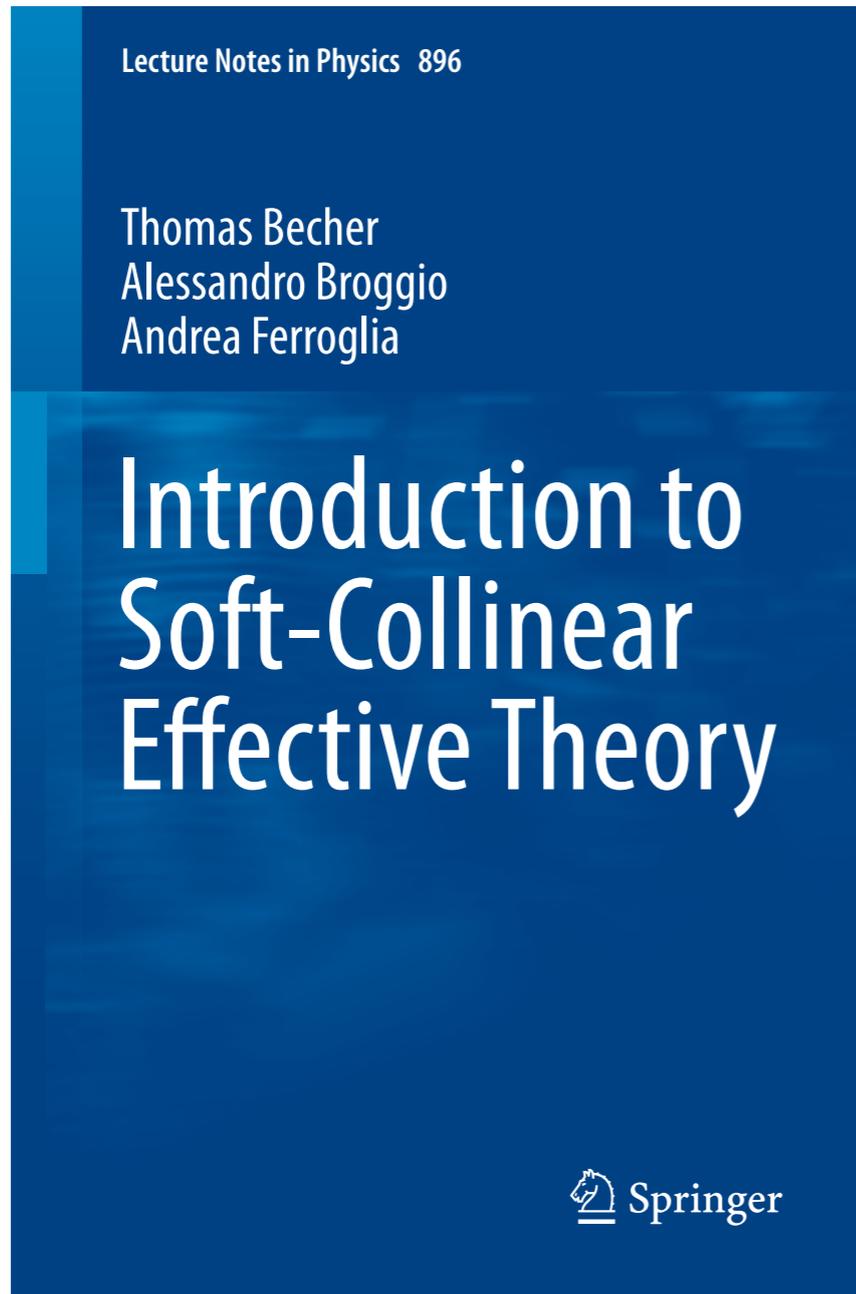
SCET in Korea

Since the very early days Junegone Chay and Chul Kim were contributing to SCET, starting with
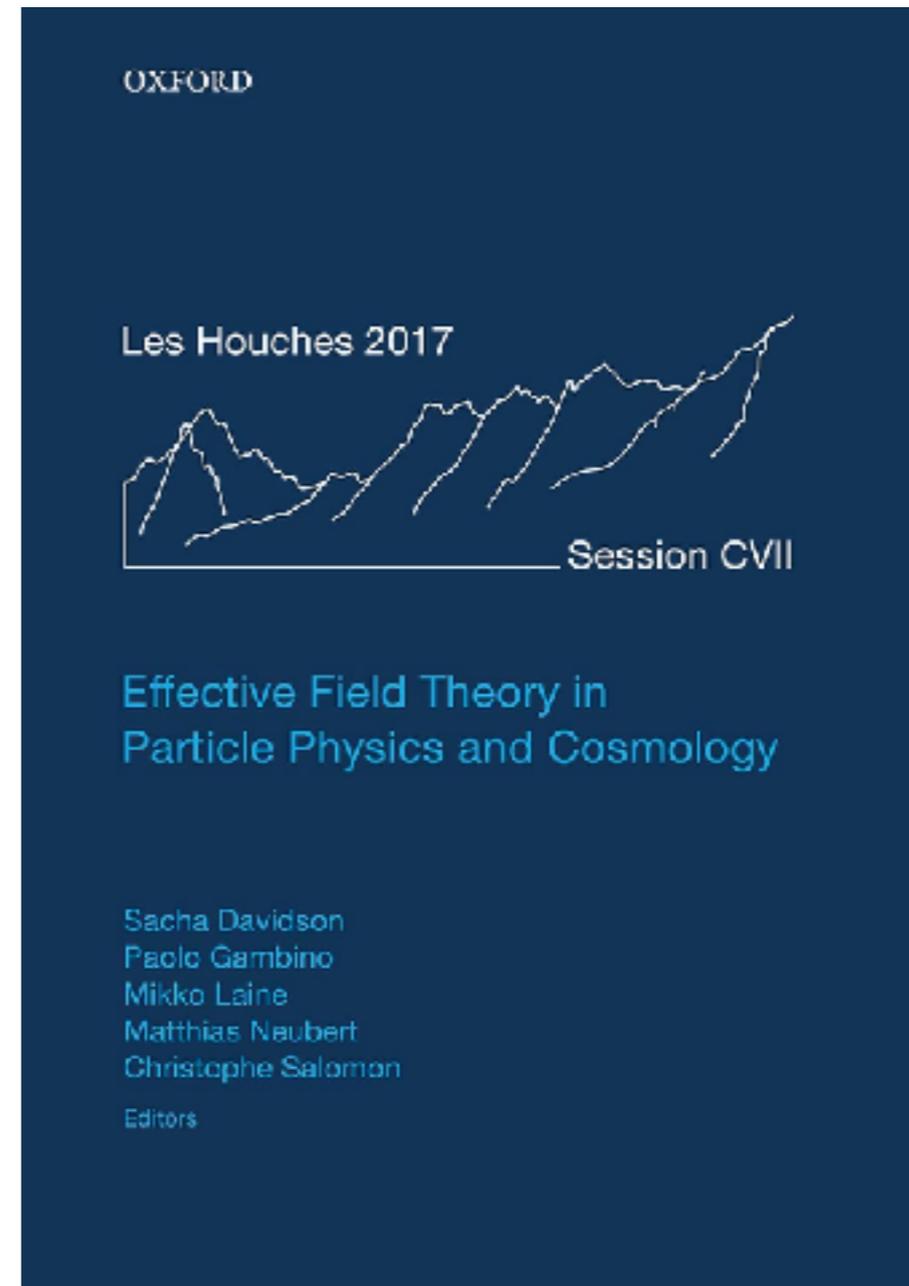
- Collinear effective theory at subleading order and its application to heavy - light currents, Phys. Rev. D **65** (2002), 114016 [arXiv:hep-ph/0201197 [hep-ph]].

Fitting to have the SCET in conference in Seoul!

Lecture notes

Lecture Notes in Physics 896

Thomas Becher
Alessandro Broggio
Andrea Ferroglia

Introduction to Soft-Collinear Effective Theory

Springer

arXiv:1410.1892, 172 pages

OXFORD

Les Houches 2017

Session CVII

Effective Field Theory in Particle Physics and Cosmology

Sacha Davidson
Paolo Gambino
Mikko Laine
Matthias Neubert
Christophe Salomon

Editors

arXiv:1803.04310, 57p

More SCET and EFT resources

- **edX online course on EFT** by Iain Stewart, see Video lectures on SCET and other EFTs

  - includes a set of **TASI lecture notes on SCET** by Christian Bauer and Iain Stewart

  - Uses and introduces the label formalism

- **As scales become separated**, EFT lectures by Tim Cohen, 1903.03622

- Chapter 36 in Quantum Field Theory and the Standard Model by Matt Schwartz