Lattice meets Continuum

Monday 30 September 2024 - Thursday 3 October 2024
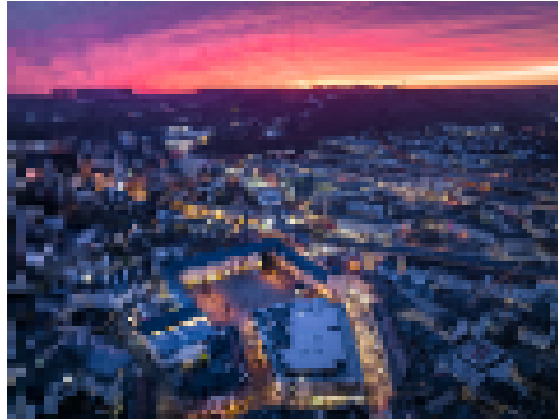
Book of Abstracts

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Short Flow-Time Expansion of the LEFT basis: Background Field Method and Chiral Symmetry

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In this talk, I will present the Short Flow-Time expansion (SFTE) of operators present in the Low Energy Effective Field Theory (LEFT) up to dimension six, in the HV scheme. To be able to perform an off-shell calculation and avoid mixing with gauge-variant operators, we make use of the Background Field Method applied to the Gradient Flow. Moreover, we restore chiral symmetry by introducing appropriate counterterms. This work paves the way toward systematic higher-order SFTEs of LEFT operators, a key aspect to connect lattice simulations to continuum studies, which is a necessary ingredient e.g. for a robust determination of new-physics contributions to the neutron electric dipole moment.

Afternoon 2 / 2

Continuum approaches to semileptonic $s \to d$ and $b \to s(d)$ transitions

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In this talk I will discuss a continuum approach to the nonlocal contribution to rare kaon decays such as $K^+ \to \pi^+ \nu\nu$, with an emphasis on whether and how to decouple the charm. I will also motivate determinations of isospin breaking effects in $\Delta B = 0$ four-quark operators as input for theoretical predictions of inclusive semileptonic $b \to s(d)$ decays.

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Gradient Flow Renormalisation for Meson Mixing and Lifetimes

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The gradient flow offers a unique renormalization scheme applicable in both perturbation theory and lattice calculations. Especially, it suppresses operator mixing on the lattice, shifting it to the perturbative matching calculation. In this talk, we discuss using the gradient flow scheme for the four-quark operators describing neutral meson mixing and lifetimes. While meson mixing calculations are well-established on the lattice and validate our procedure, a lattice calculation of matrix elements for heavy meson lifetimes remains outstanding. We provide an overview of the full calculation process and present some preliminary results.

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Semileptonic B decays into final states with heavy sterile neutrinos

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$B \to D^* \ell \nu$ decays are sensitive to contributions in which the missing energy and momentum stem from a hypothetical heavy sterile neutrino N. Belle II data on angular distributions in this decay are a used to search for hints $B \to D^* \ell N$ in a model-independent way. To this end dimension-6 operators with different Dirac structures are considered and competitive upper bounds on some of their couplings are derived. I will show the allowed regions in the coupling-versus-mass plane and discuss the implications.

Afternoon 1 / 5

Radiative corrections to $B \to \ell \nu$

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In this talk I will focus on the study of the leptonic $B \to \ell \nu$ decay at next-to-leading order in QED. The future improvements of experimental measurements of this channel require a reliable theory prediction, hence a careful theoretical estimate of QED corrections. The multi-scale character of this process requires an appropriate effective theory (EFT) construction to factorize the different contributions. In the first part of this talk, I will discuss the EFT description of the process at the partonic level, which is based on Heavy Quark Effective Theory and Soft Collinear Effective Theory. I will show how the inclusion of QED corrections demands a generalisation of the hadronic decay constant defining a new non-perturbative input. In the second part of the talk, I will discuss the EFT description below the confinement scale based on the Chiral Lagrangian including Heavy Mesons (B and B*). I will show that depending on the cut on final state radiation and on the lepton flavor the contribution from excited states of the B meson can become important.

Afternoon 1 / 6

Sum Rules for Lifetimes

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Precise determination of hadronic matrix elements plays a crucial role for interpreting potential deviations from the Standard Model observed in experiments testing flavor physics. While lattice QCD provides first principles calculations, current results are still limited to a subset of the operators that may appear in theories of new physics. The sum rule approach allows for a complementary determination of matrix elements directly from QCD, with theoretical uncertainties that can be systematically improved. Previous research successfully ascertained Standard Model hadronic matrix elements for dimension-six F=0,2 operators, demonstrating competitiveness with lattice findings. Our aim is to expand upon these findings by including the entire set of four-quark QCD operators for lifetimes, crucial in scenarios Beyond the Standard Model, where lattice results are currently absent. This extension includes operators with Dirac structures not previously examined in sum rules analyses documented in existing literature. This will provide for the first time bag parameter results which can increase the precision of a wide variety of new physics theories. The bag parameter results will be determined using HQET sum rules for three-point correlators, which requires a three-loop computation. In addition there is a one-loop computation of the QCD-HQET matching required.

Afternoon 1 / 7

Extracting excited-state contributions of the B_s to D_s semi-leptonic decays from inclusive lattice simulations

Authors: Adreas Juettner[1]; Ahmed Elgaziari[1]; Alessandro Barone[2]; Ryan Kellermann[3]; Shoji Hashimoto[3]; Takashi Kaneko[3]; Zhi HU[3]

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We present a pilot study on extracting the P-wave form factors of the B_s to D_s semi-leptonic decays from the B_s four-point correlators. With their inclusive nature, four-point correlators include all the exclusive states from B_s with valence content of c and s quarks. We access the excited-state contributions by carefully fitting the correlators using multiple exponentials. In this pilot study, 2+1-flavour domain-wall fermion actions with approximately physical masses are utilized for light quarks. Heavy quarks, c and b, are simulated using relativistic-heavy quark actions. A single lattice ensemble with a lattice spacing of 0.11 fm is used for the analysis.

I am very eager to participate in this event, but currently, I am still seeking funding for the trip if my abstract gets accepted.

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Factorial growth of perturbation theory and inclusive semileptonic B decays

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TBA

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Form factors for semi-leptonic $B_{(s)} \to D^*_{(s)} \ell \nu_\ell$ decays

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Semileptonic $B_{(s)}$ decays are of great phenomenological interest because they allow to extract CKM matrix elements or test lepton flavor universality. Taking advantage of existing data, we explore extracting form factors for vector final states using the narrow width approximation. Based on RBC-UKQCD's set of 2+1 flavor gauge field ensembles with Shamir domain-wall fermion and Iwasaki gauge field action, we study semileptonic $B_{(s)}$ decays using unitary light and strange quarks, Möbius domain wall fermions for charm quarks, and bottom quarks simulated with the relativistic heavy quark (RHQ) action. Exploratory results for $B_s \to D^*_s \ell \nu_\ell$ are presented.

Morning 2 / 10

Inclusive charm and tau decays

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The computation of observables from inclusive hadronic processes is widely regarded as a challenging task from the lattice QCD perspective. However, the access to such observables at the non-perturbative level is crucial, especially in Flavour Physics, where high-precision comparisons of first-principles theoretical predictions and experimental measurements could reveal discrepancies, potentially pointing to New Physics Scenarios beyond the Standard Model. A viable practical solution is provided by the Hansen-Lupo-Tantalo reconstruction method from Euclidean lattice correlation functions. Two recent applications of this method include the hadronic decays of the τ lepton, allowing for the extraction of the $V_{\rm us}$ and $V_{\rm ud}$ CKM matrix elements, and the semi-leptonic decay of the charmed D_s meson. Alongside a discussion of the methodology, we illustrate results for both the applications.

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Semileptonic Inclusive Decay of the D_s Meson from Lattice QCD

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We analyse the decay of the D_s meson, focusing on the $D_s \to X\ell\nu$ channel based on Extended Twisted mass ensembles at the physical pion mass value.
On the basis of four-point correlation functions, we use the HLT reconstruction method to calculate the differential decay rate and differential first lepton energy moment.
The analysis is performed at four different lattice spacings, and three different volumes to address the associated systematic uncertainties.
We focus on the systematic errors arising from the procedure and include data for the first lepton energy moment.

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Semileptonic B->D* decays

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Semileptonic B->D* decays

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Semileptonic decays in the continuum

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Vcb using inclusive q^2 moments

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Inclusive decays on the lattice

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Neutral meson mixing from lattice QCD

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Meson mixing and lifetimes

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Hadron spectroscopy and exotic states from lattice QCD

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Hadron spectroscopy and exotic states in the continuum

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Decays with 2 or more hadronic final states

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Afternoon 1 / 23

Gradient flow and the short flow time expansion

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Matching perturbation theory and lattice

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Light cone sum rules and lattice QCD

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Experimental overview: |Vcb| & |Vub| at Belle and Belle II

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Excited B*pi states in B->pi decays

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Spectroscopy of tetra-quarks and other exotic states

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Semileptonic decays lattice QCD

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HQET on the lattice

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TBA

CKM unitarity and a truly global EFT analysis

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A look into the $f_0(980)$ through the lens of rare B meson decays

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The nature of many experimentally observed hadronic resonances has been a topic of debate ever since the 1960's. In this work, we focus on studying the $f_0(980)$, the second lightest unflavoured scalar resonance. We comment on the different descriptions for it in the quark model, and focus specifically on the pure $s\bar{s}$ picture. We mainly explore the $B_s^0 \to f_0(980)\mu^+\mu^-$ decay. We analyse the impact of the form factors, which are difficult to determine theoretically. They come from the hadronic matrix element and contain the hadronic information of the decay. Using the framework of the Weak Effective Theory, we utilize Wilson coefficients derived from observables of rare decays with the same quark-level transition, like $B \to K^{(*)}\mu^+\mu^-$, to probe the hadronic nature of the $f_0(980)$, even in the presence of possible New Physics. The effect of different theoretical form factor calculations on several observables is explored in detail. A range for the experimental untagged

branching ratio integrated in the $[1, 6]$ q^2 bin (where q^2 is the square of the 4-momenta of the muon pair) is found to be $\mathcal{BR}_{\text{exp}} \in [0.04, 2.11] \times 10^{-7}$, according to the current form factor calculations, which all assume a pure $s\bar{s}$ state. The viability of extracting the form factors from experimental data is also studied, finding that determining one of them from the branching ratio would be possible with good precision.