T 51: Flavour Physics III

Time: Wednesday 16:15–18:45 Location: KH 01.011

T 51.1 Wed 16:15 KH 01.011

Angular analysis technique for systems of two identical vector mesons and its applications in the LHCb experiment — •Ilya Segal, Mikhail Mikhasenko, and Marian Stahl — Ruhr-University Bochum, Bochum, Germany

The angular analysis of systems composed of two identical vector mesons offers a powerful framework for probing a wide range of physical phenomena. Notable examples include searches for all-charm tetraquarks $T_{cc\bar{c}\bar{c}}$ in the $J/\psi\, J/\psi$ system, investigations of glueball candidate in the central exclusive production of $\phi\,\phi$, and studies of the internal structure of charmonia through their decays to $\phi\,\phi$. A dedicated technique for constructing reaction amplitudes for the production of resonances decaying into pairs of identical vector particles is presented. The method accounts for the full symmetry properties of the system and provides a consistent framework for amplitude modeling and angular analysis. Applications of this technique to LHCb data are presented.

T 51.2 Wed 16:30 KH 01.011

Dalitz analysis of B to D pi pi decays — •Melisa-Melek Akdag — University of Bonn, Bonn, Germany

Recent studies have provided strong evidence that the D_0^* meson is better described by an amplitude modeled using unitarized chiral perturbation theory rather than a traditional Breit-Wigner distribution. This finding underscores the importance of a more nuanced approach to modeling these states. The $D^+\pi^-\pi^-$ decay is dominated by a loop diagram that includes the ρ meson, resulting in significant theoretical uncertainties. To mitigate these uncertainties, we directly access the ρ meson in the analysis by incorporating the isospin conjugated modes which include the π^0 via the decay chain $\overline{B}^0 \to D^+\rho^-$ into our considerations.

To achieve these goals, it is crucial to analyze not only the $B^- \to D^+\pi^-\pi^-$ final state, which the LHCb experiment can measure with high precision, but also decays involving neutral pions, emerging from $\overline{B}^0 \to D^+\pi^-\pi^0$, where the Belle II experiment can uniquely contribute. This allows us to study the orbitally excited charmed mesons, the D_0^* and the D_2^* in the $D\pi\pi$ final state, and the D_1, D_1' and D_2^* in the $D^*\pi\pi$ final state. By studying both processes we can test heavy quark spin symmetry in these final states.

T 51.3 Wed 16:45 KH 01.011

Pole Search for $\Xi^*(1620)$ and $\Xi^*(1690)$ Resonances in the $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ Decay at LHCb — •Anna Lena Zimmer, Mikhail Mikhasenko, and Marian Stahl — Ruhr-Universität Bochum, Germany

Understanding the excitation spectrum of strange baryon resonances remains a challenge. In particular, many excited Ξ baryon states are poorly established and their properties vary widely between models. Pole positions characterize hadronic states in a reaction-independent manner, but are rarely determined with rigor. This project aims to extract the pole positions of $\Xi^*(1620)^0$ and $\Xi^*(1690)^0$ using parameters from an amplitude model of the decay $\Xi_c^+ \to \Xi^-\pi^+\pi^+$. The model is based on an analysis of the proton*proton collision data obtained by the LHCb detector at $\sqrt{s} = 13\,\text{TeV}$. The resonance poles are determined directly from the parameterized K-matrix model, coupling the $\Xi\pi$, $\Lambda\bar{K}$, $\Sigma\bar{K}$ and $\Xi\eta$ scattering channels. The extracted pole parameters aid in accurate reaction-independent quantification of the excitation spectrum and evaluation of coupled channel effects.

T 51.4 Wed 17:00 KH 01.011

Angular analysis of $\Omega_b^- \to \Xi_c^+ K^-\pi^-$ using LHCb Run3 data — •Dhruvanshu Parmar, Mikhail Mikhasenko, and Marian Stahl — Ruhr-Universität Bochum, Bochum, Germany

Using Run2 data, five excited states of Ω_c^0 were observed decaying into $\Xi_c^+ K^-$ in prompt inclusive production. From exclusive Ω_b^- decays, reconstructed with LHCb Run2 data, spin and parity of four out of the five previously observed states were studied. However, the results were inconclusive due to the limited statistics of Run2 dataset. To address this, the study of process $\Omega_b^- \to \Xi_c^+ K^-\pi^-$ is motivated using Run3 data of LHCb experiment, enabling precise measurement of these quantum numbers of excited Ω_c^0 states. Additional sensitivity in helicity amplitude of Ω_c^0 is achieved by accounting for the spin and parity dependencies arising from Ξ_c^+ decay. Selection techniques implemented to filter Ω_b^- events from Run3 data will be highlighted in the presentation, which are crucial to get necessary statistical precision for the angular analysis.

T 51.5 Wed 17:15 KH 01.011

Lineshape study of the $\chi_{c1}(3872)$ state with LHCb — •Robert Hentges[1], Mikhail Mikhasenko[1], Vanya Belyaev[2], and Matthew Needham[3] — [1]Ruhr-University Bochum — [2]Sapienza Universita e INFN, Roma — [3]University of Edinburgh

After its dicovery in 2003, the $\chi_{c1}(3872)$ state, also known as $X(3872)$, has been established as an exotic hadron. However, its exact nature as meson-anti-meson molecule, compact tetraquark, conventional charmonium or a mixture thereof is still being investigated. Using the full LHCb Run 1&2 data set of the inclusive $b \to (X(3872) \to J/\psi\,\pi^+\pi^-) + Any$ and exclusive $B^+ \to (X(3872) \to J/\psi\,\pi^+\pi^-)\,K^+$ decays, this analysis probes different lineshapes in their ability to describe the recorded data. The probed lineshapes arise from diverse theoretical models, taking into account the proximity of the $\chi_{c1}(3872)$ state to the $D^0\overline{D}^{*0}$ threshold. From these lineshapes, this analysis aims at precise determination of the physical parameters mass m and width Γ, as well as the scattering parameters. Especially knowledge of its position relative to the $D^0\overline{D}^{*0}$ threshold is required to advance our understanding of the state. Thus, a special focus is set on the systematic uncertainty stemming from background interference.

T 51.6 Wed 17:30 KH 01.011

Implementation of a generic three-body decay model in EvtGen for a Ξ_c^+ polarimetry analysis — •Henry van der Smagt, Ilya Segal, Mikhail Mikhasenko, and Marian Stahl — Ruhr-University Bochum, Bochum, Germany

The amplitude-serialization project of the LHCb Bochum group as part of the BMFTR-funded Democratizing-Models (DEMOS) consortium provides a generic and well-structured format that facilitates reproducibility and exchange within the high-energy physics community. This work presents a C++ implementation of the helicity formalism using the Dalitz-plot decomposition method. The framework is integrated into a new decay model EvtThreeBodyDecays for EvtGen, the main b-physics event generator, which constructs amplitude models from JSON descriptions. The model enables the inclusion of the recently published $\Xi_c^+ \to pK^-\pi^+$ decay variables in hadronic amplitude analyses involving the Ξ_c^+ baryon. Furthermore, it provides access to the polarimetry vector field of this decay, allowing studies of Ξ_c^+ polarization and improved handling of model-dependent uncertainties by describing all 31 alternative models.

T 51.7 Wed 17:45 KH 01.011

Event Selection for $\Upsilon(5S)$ Entanglement Studies — •Kilian Brückner, Hans-Günther Moser, Vanessa Geier, Louise Beriet, and Celia Álvarez — Max Planck Institut für Physik, Boltzmannstraße 8, 85748 Garching

The entanglement of $B^0\bar{B}^0$ meson pairs from $\Upsilon(4S)$ decays is an important resource for many analyses, especially for time dependent CP violation analyses. At the $\Upsilon(5S)$, however, more features of the entanglement itself can be studied.

Due to the higher energy of the $\Upsilon(5S)$, excited B^{0*} mesons can be produced from its decay. These spin 1 excited B^{0*} states decay via the emission of a photon, so that $C = +1$ and $C = -1$ entangled $B^0\bar{B}^0$ states are produced. In comparison, The $\Upsilon(4S)$ only provides a state entangled with a $C = -1$ wave function.

The challenge for an analysis at the $\Upsilon(5S)$ arises from the low amount of $121\,\text{fb}^{-1}$ of data, so far taken only by Belle. This requires an efficient event selection with many decay channels to keep statistics high enough.

In this talk, the full event selection for the analysis is described. This includes choosing the decay channels of the B mesons, as well as handling all occurring backgrounds. For the main background source of $q\bar{q}$ continuum, a gradient boosted decision tree is utilized.

T 51.8 Wed 18:00 KH 01.011

Entanglement studies with Belle $\Upsilon(5S)$ data — •Louise Beriet, Vanessa Geier, and Hans-Günther Moser — Max Planck Institute for Physics, Garching, Germany

Compared to the $\Upsilon(4S)$, the $\Upsilon(5S)$ can decay into excited B^{0*}, giving rise to $B^0/\bar{B}^0$ pairs in different quantum states. Directly after the $\Upsilon(5S)$ decay, the produced $B^{0(*)}\bar{B}^{0(*)}$ pairs are expected to be in a $J^{PC} = 1^{--}$ state. Following the radiative transition $B^{0*} \to B^0\gamma$, the system evolves into states with $J^{PC} = 1^{-+}$. Depending on the C-parity, the $B^0/\bar{B}^0$ can be in a symmetric (triplet) or antisymmetric (singlet) wave function, leading to different time evolutions of the entangled states. By mixing the two C-parity states $C = -1$ and $C = +1$, one can create a mixed state that is physically indistinguishable from a disentangled system.

We aim to study these effects using the $\Upsilon(5S)$ data available from Belle. The analysis includes the reconstruction of the signal $B^{0(*)}$ meson pairs through the decay chain $B^0 \to D^-(\to K^+\pi^-\pi^-)\pi^+$, as well as obtaining the vertex and flavor information of the other B-meson inclusively. In addition, the $B^0/\bar{B}^0$ quantum states are separated using the variables M_{bc} and ΔE.

We analyze the quantum coherence using the Partial Spontaneous Disentanglement model, which quantifies the entanglement via a number $\zeta \in [0, 1]$. This parameter can be extracted by performing a likelihood fit on time-dependent parameters, which themselves can be computed from the spatial separation of the B^0 pair. First results using Monte Carlo data are presented.

T 51.9 Wed 18:15 KH 01.011

Separation of different quantum states of B^0 $\bar{B}^0$ meson pairs at the Upsilon $5S$ — •Celia Álvarez Álvarez, Kilian Brückner, Vanessa Geier, and Hans-Günther Moser — Max Planck Institut für Physik, Boltzmannstr. 8 85748 Garching.

At the Upsilon $5S$ the energy is high enough that B^0 can be produced in excited states such as $\Upsilon(5S) \to B^0\bar{B}^0$, $\Upsilon(5S) \to B^{0*}\bar{B}^0 + c.c.$ and $\Upsilon(5S) \to B^{0*}\bar{B}^{0*}$. The B^{0*} decays via the emission of a photon and $B^0/\bar{B}^0$ pairs can be observed in different quantum states. Those pairs which stem from $B^0\bar{B}^0$ and $B^{0*}\bar{B}^{0*}$ have a $C = -1$ antisymmetric wave function, while the ones that decay from $B^{0*}\bar{B}^0 + c.c.$ have a $C = +1$ symmetric wave function. The different states show different forms of entanglement.

Using data of the Belle experiment, these three decay modes are reconstructed through the three hadronic decay chains: $B^0 \to D^-\pi^+$ with $D^- \to K^+\pi^-\pi^-$, $B^0 \to D^{*-}\pi^+$ with $D^{*-} \to \bar{D}^0\pi_s^-$ and $\bar{D}^0 \to K^+\pi^-$ or $\bar{D}^0 \to K^+\pi^-\pi^+\pi^-$. Using M_{bc}, the three decay modes are separated and signal and background is fitted using ΔE. Using the S-weight technique the Δt signal is extracted and a signal fit is performed with the weighted data.

T 51.10 Wed 18:30 KH 01.011

Study of Quantum Disentanglement in the $B^0\bar{B}^0$ System at Belle II — •Abhijith Rajagopalan, Maximilian Kei Hattenbach, Sagar Hazra, and Hans-Günther Moser — Max-Planck-Institute for Physics, Munich, Germany

Quantum entanglement has been extensively tested in systems of photons and atoms. Its investigation in the context of heavy, unstable particles such as B mesons remains an active and compelling area of research. Quantum entanglement is a crucial assumption for time dependent CP violation studies at Belle II. However, a fraction of these $B^0\bar{B}^0$ pairs that are disentangled would introduce systematic uncertainties in these studies, which are currently not accounted for. We present simulation-based studies of quantum entanglement in the $B^0\bar{B}^0$ system using the hadronic $B^0 \to D^{(*)-}\pi^+$ and $D^-\pi^+$ decay channels. We test the model of partial spontaneous disentanglement, in which a fraction of the $B^0\overline{B}^0$ pairs lose their entanglement and subsequently evolve independently.