Advanced Amplitude Analysis Techniques

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The amplitude analysis of hadronic three-body decays is an essential tool for the investigation both of heavy hadron weak decays and the associated CP violating effects, as well as the spectroscopy of short lived hadronic states, created in those processes. In particular, searches for exotic hadrons, i.e. such states which cannot be explained in the simple quark model, rely heavily on the amplitude analysis method. It is applied to measure the quantum numbers of new candidates and establish their resonant nature. Prominent examples are the two pentaquarks found as intermediate resonances in the decay $\Lambda_b \to J/\psi pK$. Even simple three-body systems display rather complex substructure such as resonances, threshold and rescattering effects. In the absence of a solvable theory of the strong interaction, we need models for the parameterization of the respective decay amplitudes. Traditionally, such amplitude models are based on the description of the three-body decay in terms of independent two-body resonances. While this method has been quite successful in describing experimental data, there are several long-standing theoretical problems with the approach.

The latest generation of experiments in hadron physics is collecting data samples with unprecedented statistics. Often, those samples are large enough for the potential inconsistencies in the traditional amplitude models to have significant observable effects. Therefore it is important to push the development of the amplitude models further and infuse them with so far often neglected theoretical constraints. The charm and charmonium sector is intriguing as the most discoveries of exotic hadronic phenomena over the last decade are being made there. Moreover, hadrons carrying charm or beauty are experimentally advantageous since they can be well isolated due to their long lifetime. This guarantees a very well defined initial state for the hadronic reaction which also simplifies theoretical consideration.

In this project we will look at three-body decays of the Λ_c into light hadrons such as $pK\pi$, pKK and $p\pi\pi$. Large data samples on these decays are being collected by the LHCb experiment at the Large Hadron Collider. The effect of different amplitude models as well as experimental uncertainties on the analysis will be studied. Participants of this group will learn how to put together a simple amplitude analysis, develop an understanding of the potential problems and possible solutions and familiarize themselves with advanced techniques.