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Review of the PhD-Thesis of Diana Pawłowska, M.Sc.

„Femtoscopy of Strange Mesons produced in Relativistic Au+Au Collisions at the STAR Experiment"

The subject of this report is the evaluation of the PhD-Thesis of Diana Pawłowska, whose research work was performed at the Technical University of Warsaw (WUT) as a member of the STAR (Solenoidal Tracker At RHIC) Collaboration at the Brookhaven National Laboratory (BNL) in Upton, New York, USA. The PhD-Thesis of Ms Pawłowska discusses the measurement two-particle-correlations of strange mesons in ultra-relativistic heavy-ion collisions. Correlation measurements play a very important role in this field of research. On one side they allow to determine the spatial and temporal extent of the particle emitting source created in heavy-ion collisions and to extract information on its expansion dynamics. On the other side, these measurements provide a tool to learn about the properties of the strong interaction between pairs of hadrons, in particular those which cannot be directly studied in scattering experiments which applies to most of the strange particles, such as hyperons and kaons. On these hadronic interactions not much is known, however, they are decisive for the understanding of the equation-of-state of super-dense baryonic matter as found in the core of neutron stars. Therefore, correlations between strange particles are now being studied systematically in heavy-ion and proton-proton collisions at RHIC (Relativistic Heavy-Ion Collider), BNL, and at the LHC (Large Hadron Collider), CERN, where the now available event statistics allows for a systematic and statistically significant study of two-particle correlations of rare strange particles for the first time. In her PhD-work Ms. Diana Pawłowska investigated the correlations between neutral kaons ($K^0_s K^0_s$) and neutral and charged kaons ($K^0_s K^{\pm}$) using data on Au+Au collisions at a centre-of-mass energy of $\sqrt{s}$ = 200 GeV recorded with the STAR experiment.

The thesis of Ms. Pawłowska starts with a short review of the standard model of particle physics and Quantum Chromo-Dynamics (QCD). This is followed by a summary of the main concepts of heavy-ion physics and the most important observables for the formation of a Quark-Gluon Plasma (QGP), the high temperature phase of strongly interacting matter in which quarks and gluons can exist as quasi-free particles.
The third chapter of the thesis discusses several theoretical models used for the description of heavy-ion collisions. As an example for a transport model UrQMD is introduced and as an implementation of the statistical model approach the THERMINATOR 2 model is described. The latter is particularly suited for the comparison to femtoscopic measurements and includes a hydrodynamic description of the fireball evolution followed by a single freeze-out approach (i.e. chemical and kinetic freeze-out coincide).
In the next chapter a short description of the experimental setup of the STAR experiment is given. The Time Projection Chamber (TPC) and the Time-Of-Flight detector (TOF), as the components which are most important for the data analysis presented here, are presented in detail.
Chapter five contains a review of the basic theoretical concepts to describe and understand two-particle correlations. The theoretical basis of intensity-interferometry (Hanbury-Brown and Twiss) is summarised and the most common parameterisation of the correlation functions proposed by Bertsch and Pratt is introduced. The influence of the final state interaction between the particle pairs on the correlation function is discussed and theoretical descriptions of the two-kaon system depending on the scattering parameters are explained. This chapter closes with an overview on previous measurements and their interpretation. The system of two neutral kaons is connected to several additional theoretical complications due to the presence of different CP-eigenstates. Also the presence of the f_0 and a_0 resonances has a significant effect. These aspects are outlined in chapter six and different model calculations are discussed here.
In chapter seven Ms. Pawłowska presents the technical aspects of her analysis. She discusses the selection of good event, the different methods of particle identification (specific energy loss and time-of-flight) and the topological reconstruction of neutral strange particles. An important point for the measurement of two-particle correlation functions, that has to be taken investigated with great care, are the artifacts introduced by split or merged tracks, where the latter can be particularly relevant for particles identified via their V^0-topology, as is the case with K^0_s. Finally, corrections for the impurities in the selected particle samples and for the finite momentum resolution have to be determined and applied to the measured data.
The eighth chapter contains the final results of Ms. Pawłowska's analysis, the correlation functions of $K^0_sK^0_s$-pairs and $K^0_sK^\pm$-pairs as a function of the invariant relative momentum. These are determined for three different centrality selections and corrected for the purity of the particles samples. Ms. Pawłowska extracts source parameters (radius and λ-parameter) using theoretical calculations employing different strong final state interaction descriptions. Quite some work is invested in the determination of the systematic uncertainties of these source parameters by varying all relevant analysis criteria within reasonable ranges.
In the last chapter Ms. Pawłowska discusses her results and compares them with model predictions obtained with UrQMD and THERMINATOR which both provide a good

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description of the data. She outlines the possibility to determine the nature of the a_0-state from the correlation measurements (tetraquark vs. diquark-molecule). Unfortunately, the statistics available in the analysis presented here does not yet allow for a firm conclusion, which, however, should be possible with the new data now available.

In summary, the PhD-thesis of Ms. Pawłowska presents a challenging data analysis of high relevance. Even though a final conclusion on this measurement will only be possible once a re-analysis using the most recently available high statistics data set has been performed, the work of Ms. Pawłowska is essential for establishing the procedures and exploring the possibilities. She has investigated all the necessary corrections and performed a thorough investigation of all possible effects contributing to the systematic uncertainties. In her thesis Ms. Pawłowska also demonstrates a good understanding of the theoretical background of two-kaon correlations and that she is also able to discuss her analysis within a larger scope. The presentation of her work in the thesis is complete and detailed, however, it suffers a bit from imperfections in the use of the English language, which on several occasions result in slightly distorted and not easily understandable formulations. Nevertheless, it is obvious that the PhD-work of Ms. Pawłowska is sound and fulfils all scientific requirements. Therefore, I can clearly recommend the acceptance of this thesis and to proceed with the next steps in the promotion procedures.

Best Regards,

Prof. Dr. C. Blume