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Exploring strangeness with HADES

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The standard model of particle physics contains three generations of quarks, whereas most of the matter is built out of quarks from the first generation, the up- and down-quarks. Nevertheless, strange quarks confined in hyperons can play an important role for example in compact astrophysical objects. Calculations show, that it is likely that hyperons appear at large nuclear densities which are realized in the interior of neutron stars. This appearance has interesting effects e.g. a softening of the equation of state, which leads to a reduction of the maximal mass of the star. For precise calculations it is necessary to know how particles with strangeness content interact with normal nuclear matter.

With the High Acceptance Di-Electron Spectrometer (HADES) located at GSI Helmholtzzentrum für Schwerionenforschung and working at the SIS18 accelerator (1-2 AGeV) various results dealing with strangeness physics were obtained. The whole setup was designed to measure the modification of hadrons (mainly vector mesons) when embedded in a nuclear medium but appeared to be also very succesful in studies of strangeness production.
Reactions of two colliding protons deliver a starting point for the interpretation of more complex systems like pA or AA collisions. With pp collisions at 3.5 GeV we have investigated the formation of resonances like the Λ(1405) which is predicted to be a molecular like state generated dynamically by the attractive interaction of an antikaon and a nucleon below its threshold. It turned out that the line shape of the resonance and the position of the pole mass reveal interesting facts about the underlying physics of this resonance. We have also searched for the existence of a hypothetical nuclear state, the kaonic cluster, which is formed out of two nucleons and an antikaon often abbreviated as ppK^− reported by other experiments. From theory side predictions for the binding energy and width of this state diverge. It is, therefore, necessary to set stronger constraints from experimental side.
With HADES also p+Nb reactions were measured where the kinetic energy of the proton was also 3.5 GeV. In this colliding system, one can already explore in-medium effects on particles at saturation density ρ0, in particular the modification of neutral kaons K^0 by a repulsive mean-field potential which is created by the nuclear environment. The data support a value of the repulsive potential for K^0 at rest of about 35 MeV at saturation density. The advantage in pA systems is the fixed density profile of the nucleus and we do not have to deal with a rapid evolution like in AA reactions. For this reason the meaured p+Nb serves as a link between elementary pp and the most complex AA reactions. HADES was recently upgraded and measurements of Au+Au collisions at 1.23 AGeV were performed with which it is now also possible to study effects of compressed matter at SIS18 energies.

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