Studies of low-energy kaons interactions in nuclear matter by SIDDHARTA-2 and AMADEUS

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Introduction

The low-energy QCD describing the strong interaction is still missing fundamental experimental results in strangenes sector in order to achieve a breakthrough in its understanding. The low-energy kaon-nucleon/nuclei interaction has been intensively studied by many experimental and theoretical groups [1, 2]. These studies are playing a key-role, with important consequences in various sectors of physics, like nuclear, particle physics as well as astrophysics (equation of state of neutron stars) [3, 4].

Combining the excellent quality kaon beam delivered by the DAΦNE electron-positron collider [5, 6] in Frascati (Italy) with new experimental techniques, as fast and very precise X ray detectors, like the Silicon Drift Detectors, and with the high acceptance charged and neutral particles KLOE detector [7], unprecedented measurements in the low-energy strangeness sector in the framework of SIDDHARTA and AMADEUS Collaborations have been performed.

Kaonic atom studies by SIDDHARTA/SIDDHARTA-2

The kaonic atoms, as kaonic hydrogen and kaonic deuterium, provide the isospin dependent kaon-nucleon scattering lengths from the measurement of X rays emitted in the deexcitation process to the fundamental 1s level of the initially excited formed atom [8, 9]. The measured strong interaction generated shifts and widths of kaonic hydrogen and deuterium are used as anchor points for the field theory calculations describing K$\bar{N}$ interaction.

The kaonic hydrogen measurement performed by the SIDDHARTA Collaboration results in the most precise values of the strong interaction observables like shift (ϵ_{1s}) and width (Γ_{1s}) of 1s state of the kaonic-hydrogen [10, 11]:

$$\epsilon_{1s} = -283 \pm 36(stat) \pm 6(syst)eV \qquad (1)$$

$$\Gamma_{1s} = 541 \pm 89(stat) \pm 22(syst)eV \qquad (2)$$

For the kaonic-deuterium measurement, SIDDHARTA performed only an exploratory measurement, which did not allow to extract the strong interaction parameters [12]. However, preparing a significantly improved setup, SIDDHARTA-2 is being realized to perform in 2019 a precise measurement of kaonic deuterium and of other exotic atoms.

AMADEUS studies

AMADEUS goal is to do the first complete investigation of the Λp, Σ^0p, Λd, Σ^0d and Λt channels, searching for signals coming from the possible bound states [13] and, in the same time, exploring intensively the rich physics of these channels [9, 14–16]. The absorption of low momentum K^- mesons (p_K=127 MeV/c), produced by the DAΦNE collider, on He and C nuclear targets is investigated, with the aim to get information on the resonant and non-resonant transition amplitudes few MeV below the K$\bar{N}$ threshold, which represent excellent tests for the theoretical predictions of the low energy QCD models in the strangeness sector. The measurement of K^- multiN BRs and low-momentum cross sections, is an essential tool for the investigation of the possible existence of K^- - multiN bound states and for the investigation of the

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K$^-$ properties in nuclear medium. The analysis of K^-"n" $\rightarrow \Lambda\pi^-$ process [15] allows to extract, for the first time, the modulus of the the non-resonant direct production amplitude below the KN threshold $|A_{K^-n\rightarrow\Lambda\pi^-}| = (0.334\pm0.018(\text{ stat})\pm0.058(\text{syst}))$fm as well as disentangle the K$^-$ nuclear absorption at-rest from the in-flight capture (Fig. 1).

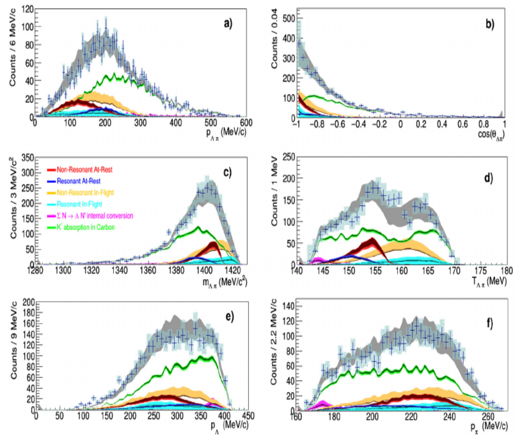

FIG. 1: Panels a)-f): $p_{\Lambda\pi^-}$, $\cos(\theta_{\Lambda\pi^-})$, $m_{\Lambda\pi^-}$, $T_{\Lambda\pi^-}$, p_Λ and p_{π^-} distributions. The experimental data and the corresponding statistical errors are represented by the blue crosses, the systematic errors are light blue boxes. The different contributions included in the fit are shown by the colored histograms: non-resonant at-rest (red), resonant at-rest (blue), non-resonant in-flight (brown), resonant in-flight (cyan), $\Sigma N \rightarrow \Lambda N'$ internal conversion (magenta), K$^-$ absorptions in Carbon (green). The light and dark bands correspond to systematic and statistical errors, respectively. The gray band shows the total fit with the corresponding statistical error. Figure is adopted from Ref. [15].

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