Interaction of kaons with some nucleic at the intermediate energies

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The interaction of the intermediate and high-energy particles with nuclei is considered a central subject in contemporary nuclear physics. After the experiments with 1 GeV proton beams (with a high resolution) [1], new trends in nuclear structure investigation have been developed. The traditional mechanisms of the nuclear reactions are based on the idea that the nucleus is a simple collection of protons and neutrons, which is predominantly used for interpreting the new data [2-4]. from the point of view of the conventional nuclear physics, the physical characteristics of the nucleons when they are in the nucleus are taken to be identical to that of the free nucleon, i.e. the properties of the nucleon (size, mass, magnetic moment, form factor and other internal properties) don't change either it is free or embedded in the nucleus. But, the measurements in deep inelastic scattering of different particles (leptons, mesons,..) with nuclei, at high momentum transfers, revealed some evidences for a deviation from of this traditional picture. One of the main famous successful investigations for nuclear reactions is the European Muon Collaboration (EMC) [5], in which the EMC effect indicated that the nucleons can significantly change their properties even in the ground states of nuclei.In recent years, the question of medium modification of nucleon properties has received a great deal of attention. Furthermore, a new epoch started in the theory of nuclear reactions based on the ideas of quantum chromodynamics (QCD), which is considered the fundamental theory of strong interactions. It is worth mentioning that, in these interactions, one takes into account the quark structure of nucleons and the fundamental degrees of freedom, which are quarks and gluons [6]. In addition, both QCD and measurements show that, in deep-inelastic scattering, the quark structure function of free nucleons differs from that of nucleons inside nuclei (EMC effect).Asymptotic freedom implies that, at high momentum transfer, the QCD description is appropriate, while the success of conventional nuclear physics implies that nucleons and mesons are the natural degrees of freedom at low and intermediate momentum transfers. In both descriptions, it is possible that the basic properties of the nucleon could be modified when the nucleon is in the nuclear medium.For more than two decades ago, the kaon physics has occupied and attracted the attention of both theoreticians and experimentalists in the domain of the nuclear physics. This is due to the fact that the kaon plays a growing role in the interactions with the different substructures of the hadrons [1], where both the strangeness and quantum numbers of this meson are conserved in strong interactions. Furthermore, kaons have two properties that make them unique tools. Firstly, that it can transfer a new degree of freedom to the nucleus and secondly that kaons come in two forms, (and) which differ substantially in their interactions with a nucleus. Defined inherent features favor the kaons as distinguished hadronic probes for studying the fine peculiarities of the intermediate energy nuclear interactions.Kaons were thus suggested as promising tools to probe the nuclear structure. This suggestion was first put forward by Aichilin and Ko almost 24 years ago [7]. It is known, from an experimental point of view, that the kaon nucleon interaction is shorter in range and relatively weak. The weakness of the interaction has generated much interest in -nucleus elastic scatterings, since it was anticipated that simple multiple scattering treatments of the process should be quite accurate. Therefore, the multiple scattering corrections to the first-order of the impulse approximation predictions should be relatively small [8]. So the can penetrate deeper into the nuclear interior and leave the nucleus undistorted by strong final state interaction.Already in the 1980s, the insufficiency of the impulse-approximation form of the - nucleus optical potential was somewhat surprising because of the findings of the experimental data of the elastic and inelastic differential cross-sections with both 12C and 40Ca [9]. Also in interactions, the total cross section is found to be higher than the theoretical calculations [10]. Other measurements have been obtained during the 1990s, including and elastic and inelastic differential cross sections at 715 MeV/c incident momentum [11-13], these experimental data and their analyses lent support to the substantial medium modifications demonstrated above based on studying integral cross sections. In addition, the total cross sections for mesons on several nuclei, in the range of beam energies less than 1 GeV, exceeded the expectations [14, 15]. Also including the work with the Glauber model [16] on meson scattering from complex nuclei have reviewed the relevance of modifications of the nucleon properties within the nuclei. Moreover, at the beam momentum used for recent experiments, the wavelength of the meson is small enough to match the length scale of individual nucleons within nuclei. These were interpreted as an indication that the nucleons within the nuclear medium do not behave as they do in free space [17]. The observed discrepancy, that the standard nuclear mechanisms do not agree with the experimental data, is widely discussed as an unconventional phenomenon in nuclear physics.In order to account for the increased reactivity in - nucleus interactions, several nonconventional medium effects have been proposed to remedy this phenomenon. Siegel et al. [18] and later Peterson [19] suggested that nucleons swell in the nuclear medium, primarily by increasing the dominant hard-core. Brown et al. [20] suggested that, the extra reactivity was due to the reduced in-medium masses of exchanged vector mesons (density dependent vector meson masses). Another source for increasing reactivity in - nucleus interactions is due to meson exchange current [21, 22]. These observations led to a great number of theoretical efforts invoking ‘nucleon swells’ or other means to enhance such cross sections, where none of these models provided a satisfactory solution for this discrepancy. On the other hand, the experimental data of the meson, as other hadrons, show that its interactions with nuclei are more peripheral and cannot be used to reflect their inner structure.The successful use of in the nuclear interaction requires the precise knowledge of the interaction mechanism of kaons with a nucleon. So we considered the inner quark structure of these kaons and the nucleon and their interactions, as shown in figures (1-1, 1-2). The meson carries an antistrange quark, which is unlikely to find a strange quark in the nucleon or nuclear targets. Hence, the projectile is protected from the most savage strong interactions, so it has a long mean free path (7-11 fm) in the nuclear medium.Fig. (1-1): Quark diagrams for ( )Fig. (1-2): Quark diagrams for ( )Fig. (1-3): Quark diagrams for ( )Fig. (1-4): Quark diagrams for ( )The scheme of unitary SU (3) quark model gives a qualitative explanation for the surprisingly different behavior of these two mesons (and). from the figures (1-1, 1-2), we see that, the -meson has strangeness number (S = +1) and its quark structure is one up quark “ ” and one antistrange quark “ ”. At the same time, it is clear, from these figures, that there are no (valence) strange quarks in the nucleon, which means that the quark- antiquark annihilation has not been suppressed, (i.e. the system cannot couple to a 3-quark object) [23]. We are thus in a non-perturbative region. For this reason, the interaction has important property; being weak energy dependent. This means that it has a long mean free path (7-11 fm), which corresponds to a smaller cross section. This provides a possible use of as a probe for the changes of the nucleon inside the nucleus and a good candidate for probing nuclear in-medium effects by studying scattering and reaction processes. On the other hand meson, as seem from figures (1-3, 1-4) has strangeness number S = -1 and its quark content is one anti-up quark “ ” and one strange quark “s”. Since the quark-antiquark annihilation is the dominant process in this case, then the interaction will have a shorter mean free path (~3 fm), which corresponds to a larger cross section (as shown in Fig. (2)).Fig.(2): Mean free path vs. and kaons momentum with protonand neutron in nuclear matter [24].The famous discrepancy of the very different behavior in the interactions of both kaons with nuclei is that the data are better reproduced than those of the even though the latter is expected to obey a simpler reaction mechanism [24]. (see Fig. (3))Fig. (3): Comparison between experimental cross sections ( )interaction (diamond points) [14, 15] and the correspondingcalculated one (square points), in the framework of the Glaubermodel, vs. meson momentum.The in-medium effect and the nucleon structure in the nucleus can be investigated by considering the ration (R),where is the total cross section for -nucleus (A) interaction and is the total cross section -deuterium (d) interaction. The theoretical ratio lies below the corresponding experimental data by about 2.5~3 standard deviations throughout the whole range of the laboratory momentum 450