The DEAR experiment at DAΦNE

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A new era in the field of low energy kaon physics will begin with the start of the new DAΦNE low-energy, high-luminosity e^+e^- collider. The objective of the **DEAR** (**D**AΦNE **E**xotic **A**tom **R**esearch) experiment is the determination of the isospin dependent $\bar{K}N$ scattering lengths via the measurement of the strong interaction shifts and widths of the kaonic hydrogen and kaonic deuterium K-series lines [1]. In practice, in the case of kaonic hydrogen, the K_α line at ~ 6.15 keV is the most important one for the determination of the shift and width of the *1s* level.

The challenging goal DEAR is aiming at is to measure the K_α line shift in hydrogen to a precision of 1 %, the width to a precision of a few percent, and kaonic deuterium for the first time.

The main challenge of DEAR is to detect a very weak x-ray signal out of the background of an e^+e^- collider with high statistics and high precision. Only recently these X rays have been observed for the first time (KpX at KEK [2]) with an overall statistics of only 114 counts in the K_α peak.

To overcome the background problem Charge-Coupled Devices (CCDs) are used as x-ray detectors. CCDs are characterized by a good energy resolution and by an unprecedented background rejection capability [3].

A kaonic atom is formed when a negative kaon enters a target, loses its kinetic energy through ionization and excitation of the molecules of the medium and eventually is captured, replacing the electron, in an excited orbit. Various cascade processes deexcite this kaonic atom to the ground state.

When a kaon reaches low-n states with small angular momentum, it is absorbed through a strong interaction with the nucleus. This strong interaction causes a shift in the energies of the low-lying levels from their purely electromagnetic values, whilst the finite lifetime of the state turns out in an increase in the observed level width.

The shift ϵ and the width Γ of the *1s* state of kaonic hydrogen are related in a fairly model-independent way to the real and imaginary part of the complex s-wave scattering length, a_{K^-p}: $\epsilon + \frac{i}{2}\Gamma = 2\alpha^3\mu^2 a_{K^-p} = (412\,\mathrm{eVfm}^{-1}) \cdot a_{K^-p}$ (Deser-Trueman formula [4]), where α is the fine structure constant and μ the reduced mass of the K^-p system. A similar relation applies to the case of kaonic deuterium and the corresponding scattering length, a_{K^-d}.

These observable scattering lengths are related to the isospin dependent scattering lengths a_0 and a_1 in the following way: $a_{K^-p} = \frac{1}{2}(a_0 + a_1)$, $a_{K^-d} = \frac{1}{2}\left(\frac{m_N+m_K}{m_N+m_K/2}\right)(a_0 + 3a_1) + C$. In the case of deuterium, the first term represents the lowest-order impulse approximation, in which the kaon scatters on each "free" nucleon. The second term, C, contains all high-order contributions, including three-body effects. This term can be larger than the first term, thus the extraction of the two isospin scattering lengths from an observation of the kaonic hydrogen and kaonic deuterium scattering lengths requires a dedicated analysis. An accurate determination of the K^-N isospin dependent scattering lengths will place strong constraints on low energy K^-N dynamics, which in turn constraints the SU(3) description of chiral symmetry breaking.

Crucial information about the nature of chiral symmetry breaking, and to what extent chiral symmetry is broken, is provided by the calculation of the meson-nucleon sigma terms. The meson-nucleon sigma terms are defined as the expectation value of a double commutator of the chiral symmetry breaking part of the strong-interaction Hamiltonian. The low energy theorem relates the sigma terms to the meson-nucleon scattering amplitude. A phenomenological procedure starting from the experimental amplitudes is then used to determine the sigma terms and therefore measure chiral symmetry breaking. According to an evaluation based on the uncertainties in the phenomenological procedure the sigma terms can be extracted at the level of 20 %, by combining the precision measurement to be performed by DEAR with the bulk of most recent analyses of low energy $K^\pm N$ scattering data. The sigma terms are also important inputs for the determination of the strangeness content of the proton.

Presently, the DEAR experiment is installed on DAΦNE and ready to start data taking.

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[2] T.M. Ito et al., Phys. Rev. A 58 (1998) 2366.
[3] J.-P. Egger et al., Part. World 3 (1993) 139.
[4] S. Deser *et al.*, Phys. Rev. **96** (1954) 774; T.L. Truemann, Nucl. Phys. **26** (1961) 57.