Chiral Dynamics of $\bar{K}N$ Interactions ◇

B. Borasoy [a,b], R. Nißler [a,b], and W. Weise
[a] Physik Department, TU München [b] HISKP, Universität Bonn

The low-energy $\bar{K}N$ system is of special interest as a testing ground for chiral SU(3) symmetry in QCD and, in particular, for the role of explicit symmetry breaking induced by the relatively large mass of the strange quark. Most significantly, the existence of the $\Lambda(1405)$ resonance just 25 MeV below the K^-p threshold makes chiral perturbation theory inapplicable in this channel. Non-perturbative coupled-channel techniques based on driving terms of the chiral SU(3) effective Lagrangian have proved useful and successful in dealing with this problem, by generating the $\Lambda(1405)$ dynamically as an I = 0 $\bar{K}N$ quasibound state and as a resonance in the $\pi\Sigma$ channel. High-precision K^-p threshold data set important constraints for such theoretical approaches.

Now that new accurate results for the strong interaction shift and width of kaonic hydrogen from the DEAR experiment [1] are available, there is renewed interest in an improved analysis of these data along with existing information on K^-p scattering, the $\pi\Sigma$ mass spectrum and K^-p threshold decay ratios. It is therefore worth investigating whether both the DEAR data and the K^-p scattering data can be accommodated by coupled-channels analyses.

In [2] we have employed four variants of coupled-channels approaches which all show the feature that the agreement with $\bar{K}N$ scattering data is partly spoilt once the new tight constraints imposed by the DEAR experiment are accounted for, see Fig. 1. (We mention though that the results of these models fall within the larger error ranges of the KEK experiment [3].) The largest discrepancies are observed in the elastic K^-p channel, Fig. 2, where the calculated cross section is substantially lowered by inclusion of the DEAR data. Electromagnetic corrections to the strong interaction shift and width in kaonic hydrogen as calculated in [4] reduce the discrepancy, but are not able to compensate the difference between the coupled-channels approaches and the experimental data. Further tight phenomenological constraints in the $\bar{K}N$ system are provided by the threshold branching ratios which have been measured very precisely. Inclusion of the DEAR data produces results for the branching ratio R_c which disagree with the quoted experimental error ranges.

Another consistency check could be provided by studying the $K^-p \to \pi\Sigma$ amplitude below the K^-p threshold where the inclusion of the DEAR data amounts to a substantial change. Experiments towards this direction are currently analyzed at SPring-8/LEPS and at ELSA, where photoproduction of $\Lambda(1405)$ has been measured.

The comparison between the different variants of the coupled-channels approaches employed in [2] can be summarized as follows. The quality of the fits to data is improved substantially by including next-to-leading order contact interactions with new parameters of the effective Lagrangian. The inclusion of the Born terms, on the other hand, leads only to minor changes.

In conclusion, the present updated analysis of low-energy K^-p interactions emphasizes the importance of the constraints set by the new accurate kaonic hydrogen data from the DEAR experiment. At the same time this analysis points to questions of consistency with previously measured sets of K^-p scattering data. Developments aiming for a precision at the level of a few eV in the shift and width of kaonic hydrogen, foreseen at DAΦNE in the near future, will further clarify the situation.

The new constrained analysis of the $\bar{K}N$ amplitude presented here is also of considerable interest in view of the continuing quest for kaon condensation in dense baryonic matter, and for the possible existence of deeply bound kaon-nuclear states, an issue which is presently under lively discussion.

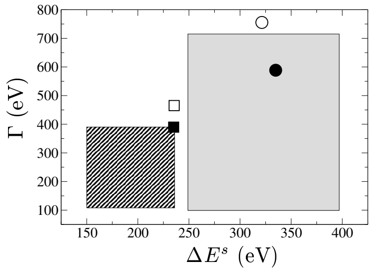

Fig. 1: Results for the strong interaction shift ΔE^s and width Γ of kaonic hydrogen from a fit to low-energy $\bar{K}N$ scattering data excluding the new DEAR results (circles) and from a fit which is forced to satisfy the DEAR constraints (squares). Filled (empty) symbols correspond to the inclusion (omission) of electromagnetic corrections as calculated in [4], The preliminary DEAR data are represented by the shaded box [1], the KEK data by the light gray box [3].

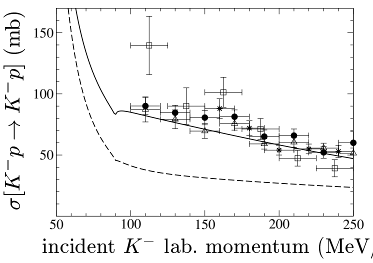

Fig. 2: Total elastic cross section of K^-p scattering resulting from the fit where the DEAR constraints are omitted (solid line) and the fit which satisfies these constraints (dashed line), compared to various experimental data sets (references can be found in [2]). Coulomb effects are included in the calculation.

References

[1] M. Cargnelli *et al.*(DEAR collaboration), Proceedings of "8th International Workshop on Meson Production, Properties and Interaction (MESON 2004)", Kraków, Poland, June 2004, to appear in Int. J. Mod. Phys. A.
[2] B. Borasoy, R. Nißler and W. Weise, hep-ph/0410305 and preprint 2005.
[3] M. Iwasaki *et al.*, Phys. Rev. Lett. **78** (1997) 3067
T. M. Ito *et al.*, Phys. Rev. **C58** (1998) 2366
[4] U.-G. Meißner, U. Raha, and A. Rusetsky, Eur.Phys.J **C35** (2004) 349

◇ Work supported in part by DFG, BMBF, and the EU Integrated Infrastructure Initiative Hadronphysics RII3-CT-2004-506078