HK 27: Theorie

Zeit: Mittwoch 11:15–12:45 Raum: C

HK 27.1 Mi 11:15 C

Nucleon properties: from lattice QCD to the chiral limit — •Massimiliano Procura, Bernhard Musch, Thomas Hemmert, and Wolfram Weise — Physik-Department, Technische Universität München

The combination of lattice QCD and low-energy effective field theories for the strong interactions is developing as a quantitative tool to investigate non-perturbative aspects of nucleon structure. Chiral perturbation theory complements present lattice calculations by providing systematic analytical tools to extrapolate to small quark masses, small momenta and large volumes. We discuss state-of-the-art extrapolations for nucleon observables, including the axial-vector coupling constant g_A [1] and the axial $N \to \Delta$ transition form factors. The simultaneous analysis of selected nucleon observables at small quark masses promises to lead to an accurate determination of low-energy parameters in the effective theory.

Supported in part by BMBF and DFG.

[1] M. Procura, B. U. Musch, T. R. Hemmert and W. Weise, hep-lat/0610105, to appear in Phys. Rev. D.

HK 27.2 Mi 11:30 C

Dependence of the $^1S_0$ superfluid pairing gap on nuclear interactions — •Kai Hebeler[1], Achim Schwenk[2], and Bengt Friman[1] — [1]GSI, Darmstadt, Germany — [2]TRIUMF, Vancouver, Canada

We study in detail the dependence of the $^1S_0$ superfluid pairing gap on nuclear interactions and on charge-independence breaking at the BCS level. Starting from chiral effective-field theory and conventional nucleon-nucleon interactions, we use the renormalization group to generate low-momentum interactions $V_{\mathrm{low}\,k}$ with sharp and smooth regulators. The resulting BCS gaps are well constrained by the nucleon-nucleon scattering phase shifts, and the cutoff dependence is very weak for sharp or sufficiently narrow smooth regulators with cutoffs $\Lambda > 1.6\,\mathrm{fm}^{-1}$. It is therefore likely that the effect of three-nucleon interactions on $^1S_0$ superfluidity is small at the BCS level. The charge dependence of nuclear interactions has a 10% effect on the pairing gap.

HK 27.3 Mi 11:45 C

Semi-relativistic approach to NN scattering in baryon chiral perturbation theory — Dalibor Djukanovic, •Jambul Gegelia, Stefan Scherer, and Matthias Schindler — Institut für Kernphysik, Johannes Gutenberg-Universität, J.-J.-Becher-Weg 45, D-55099 Mainz

We consider a new approach to the nucleon-nucleon scattering problem in the framework of the higher-derivative formulation of baryon chiral perturbation theory. Starting with a Lorentz-invariant form of the effective Lagrangian we work out a new framework where the leading-order amplitude is calculated by solving renormalizable equations and corrections are taken into account perturbatively. Analogously to the KSW approach, all divergences to any finite order are absorbed in the redefinition of a finite number of parameters of the effective potential at given order. On the other hand, analogously to Weinberg's power counting, the one-pion-exchange potential is of leading order and is treated non-perturbatively. The suggested approach preserves all underlying symmetries (to a given order of accuracy) and makes the self-consistency of the power counting explicit.

HK 27.4 Mi 12:00 C

Brueckner-Hartree-Fock Calculations with Correlated Realistic NN-Interactions — •Patrick Hedfeld, Heiko Hergert, and Robert Roth — Institut fuer Kernphysik, TU Darmstadt, Schlossgartenstr.9, 64289 Germany

We present first Brueckner-Hartree-Fock calculations based on the correlated realistic interaction V_{UCOM} derived within the Unitary Correlation Operator Method (UCOM). Starting from the realistic Argonne V18 potential, the UCOM transformation is used to account for the dominant short-range central and tensor correlations explicitly. The resulting correlated interaction can be used directly in Hartree-Fock calculations. These results show that residual long-range correlations, which are covered neither by the unitary transformation nor by the Hartree-Fock many-body states, have to be included. Motivated by the success of simple second-order perturbation theory on top of the Hartree-Fock solution, we investigate a systematic summation of ladder diagrams in the framework of a fully self-consistent Brueckner-Hartree-Fock scheme. We discuss the implementation of the scheme and present first results for ground states throughout the nuclear chart and compare them to our previous HF and MBPT calculations.Work supported by the DFG (SFB 634).

HK 27.5 Mi 12:15 C

Pairing with Correlated Realistic NN Interactions — •Heiko Hergert, Robert Roth, Panagiota Papakonstantinou, Anneke Zapp, and Patrick Hedfeld — Institut f. Kernphysik, TU Darmstadt

We present results of Hartree-Fock-Bogoliubov (HFB) calculations based on a correlated realistic NN interaction V_{UCOM}. Contrary to other currently used schemes, the HFB formalism is entirely based on the many-body Hamiltonian — i.e., *the same interaction* V_{UCOM} is used in the particle-hole *and* the pairing channel. By this choice, we avoid conceptual and technical problems which have been uncovered in phenomenological approaches once particle-number projection (PNP) is considered. PNP results from approximate methods (Lipkin-Nogami) and exact variation after PNP are discussed.

Hartree-Fock calculations in the UCOM framework show that binding energies can be reproduced very well by treating long-range correlations not included in the UCOM transformation via perturbation theory or RPA [1,2]. Correspondingly, we explore the consistent treatment of these correlations in quasi-particle RPA.

We briefly touch on the the subject of $3N$ forces in these schemes.

Work supported by the DFG (SFB 634).

[1] R. Roth et al., Phys. Rev. **C73** (2006) 044312
[2] C. Barbieri et al., nucl-th/0608011, submitted to PRL

HK 27.6 Mi 12:30 C

Uncertainty bands for chiral extrapolations of lattice QCD results — •Bernhard Musch, Massimiliano Procura, Thomas Hemmert, and Wolfram Weise — Institut für theoretische Physik (T39), TU München, Germany

Lattice QCD calculations are so far performed with up- and down-quark masses typically more than 4 times as large as their physical values. Chiral perturbation theory provides a tool to extrapolate the calculated results and to extract universal low energy constants from them. Here we discuss the error analysis associated with the extrapolation. Statistical errors of the lattice calculations and systematic errors from fixed low energy constants are treated using least squares fits. As a first example, we fit lattice data of the nucleon mass [1] to chiral perturbation theory at order p^4 [2].

One way of estimating the theoretical uncertainty is to perform a matching of the theory to a framework with an additional degree of freedom. This is illustrated for the nucleon axial vector coupling constant g_A by effectively integrating out the leading contribution from the $\Delta(1232)$ isobar [3].

Supported by the DFG Emmy Noether-program.

[1] A. Ali Khan et al., Nucl. Phys. B689 (2004) 175-194
[2] M. Procura et al., Phys. Rev. D73 (2006), 114510
[3] M. Procura, B. Musch, T. Hemmert, W. Weise, hep-lat/0610105.