Research in Particle Physics (2)
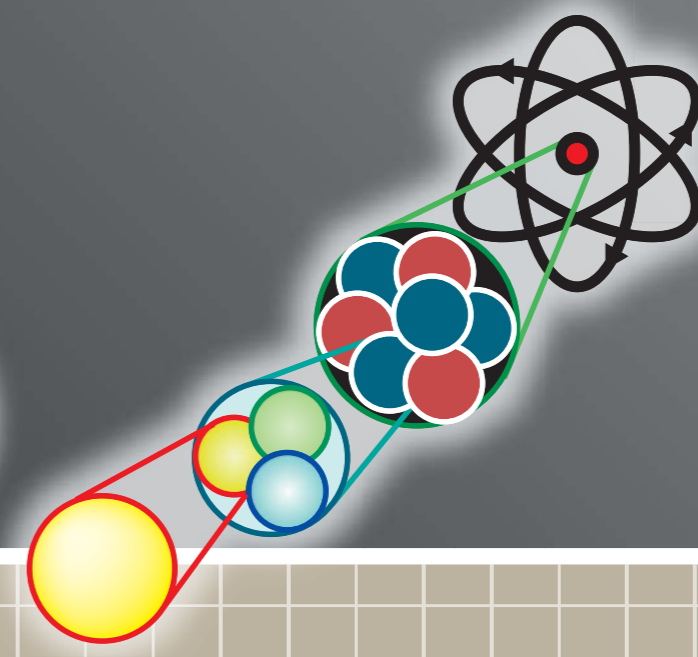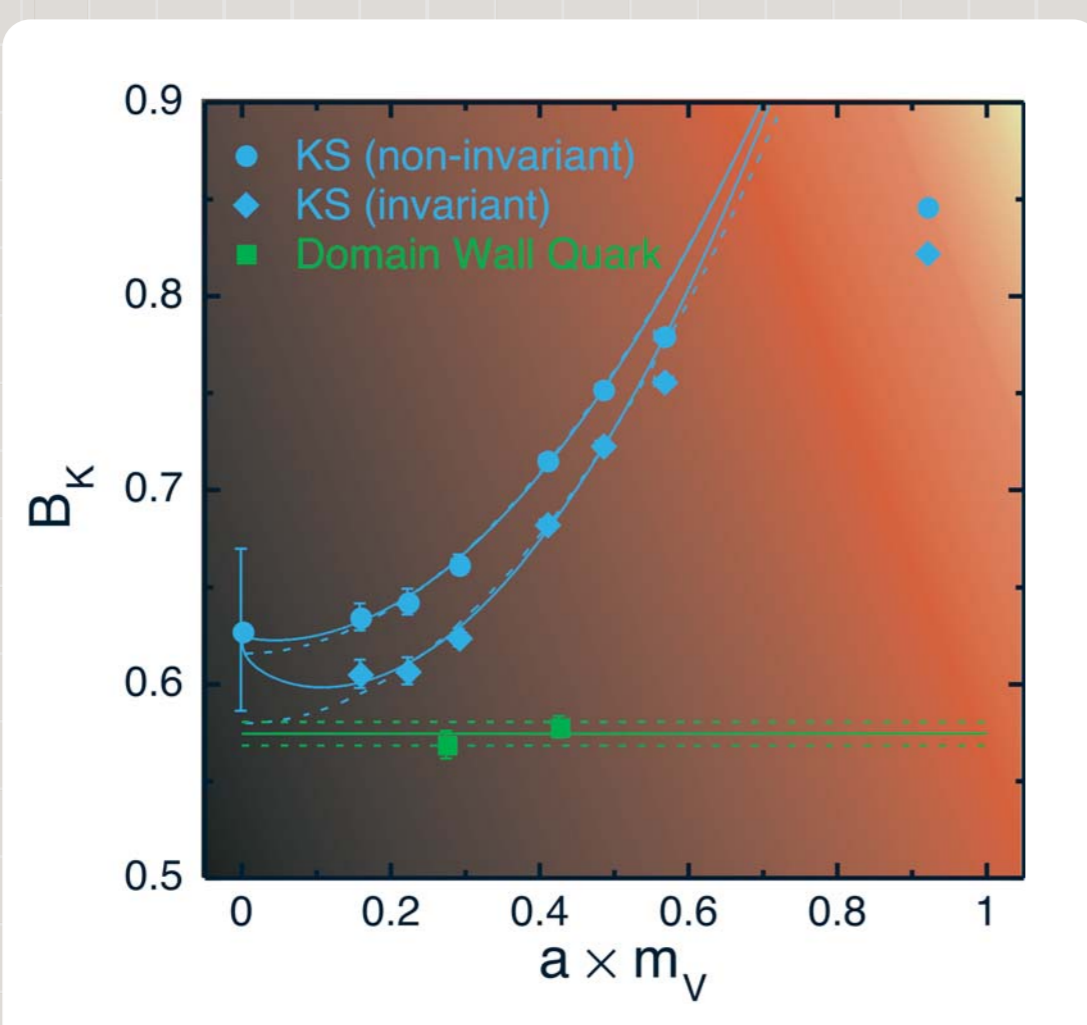
CP violation of weak interactions

The asymmetry between matter and anti-matter in the universe is believed to have its origin in the CP violation of weak interactions. On CP-PACS we have investigated several quantities relevant for CP violating weak interactions. This figure shows the B-parameter in the K meson mixing. The CP-PACS result obtained with domain-wall lattice quarks show a much weaker lattice-spacing dependence than the previous results using KS lattice quarks by JLQCD Collab., and hence are expected to give a more precise prediction in the continuum limit.

Towards a fully realistic simulation of QCD

Large scale simulations of QCD by the CP-PACS show the importance of dynamical quarks. In the two-flavor full QCD simulations, the third quark "s" is still treated in the quenched approximation. As the last step toward a fully realistic simulation of QCD, we have started a grand challenge project of 2+1 flavor full QCD simulations, concentrating all big computers accessible to us. Those include the CP-PACS and SR-8000/G1 at the Center for Computational Sciences, SR-8000/F1 at KEK, VPP-5000 at ACCC of Univ. Tsukuba, and the Earth-Simulator at the ES center. Total fraction of the peak performance for lattice QCD is about 2.5 TFLOPS. Adopting an exact simulation algorithm, the Polynomial Hybrid Monte Carlo algorithm, we have achieved the efficiency of 20-44% in the actual production runs.

From the first simulation at the lattice spacing $a \sim 1$ fm, we found that the discrepancy in meson masses from experiment is reduced by the introduction of dynamical "s" quark (lower right figure). Continuum extrapolation using this result and additional data on a coarser lattice suggests that the deviation of meson masses is absent in 2+1 flavor QCD in the continuum limit. We are currently performing simulations on a finer lattice to examine the continuum limit.

Machines	Peak GFLOPS	Fraction for LQCD	Performance of our code
CP-PACS (CCS)	614	614	20%
SR-8000/G1 (CCS)	173	173	44%
SR-8000/F1 (KEK)	1200	768	35%
VPP-5000 (ACCC)	768	230	44%
EarthSimulator (ES Center)	40960	640	31%
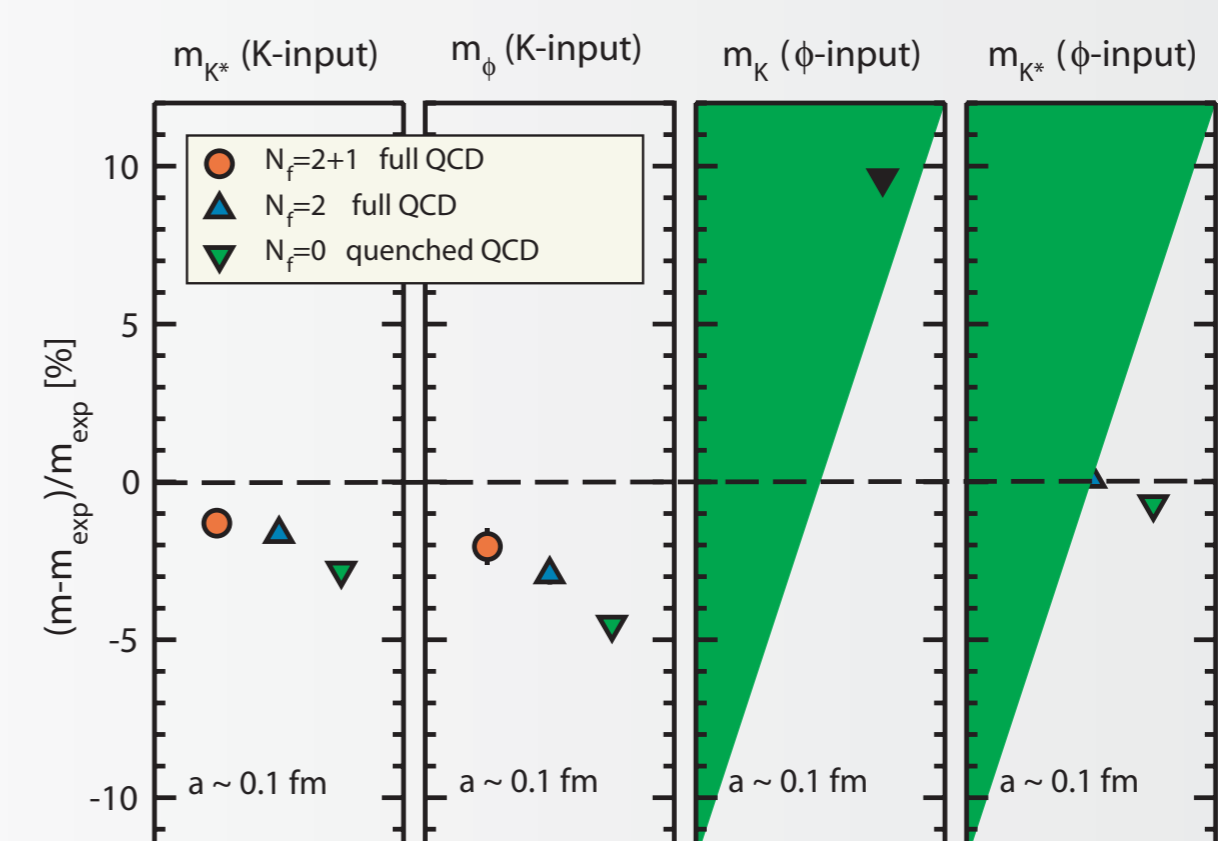
Relative deviation of meson masses from experiment at the lattice spacing $a \sim 1$ fm as a function of the number of dynamical quarks.

CP-PACS and JLQCD Collaborations (2004)