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HOW CAN ONE CALCULATE $\pi\pi$ SCATTERING LENGTHS IN LATTICE QCD ?

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Summary

Numerical simulations of lattice QCD can only be done on small lattices with linear extents L not much larger than (say) 10 fermi. In such small volumes, scattering amplitudes cannot be straightforwardly calculated, because the relevant cuts in the complex energy place of the appropriate 4-point function are absent. It is, however, possible to get a hold of the S-matrix at low energies by noting that two particles in a small box with periodic boundary conditions settle in discrete, well separated energy eigenstates, which can be considered stationary scattering states. The corresponding energy values can be expressed in a universal manner through the scattering amplitude so that their calculation in lattice QCD yields information about $\pi\pi$, πN, etc. scattering. In particular, a parameterfree determination of the $\pi\pi$ scattering lengths appears feasible along these lines as soon as the masses of the stable hadrons become calculable with a numerical accuracy $\lesssim 10\%$.

The fundamental relation between scattering amplitudes and energy values at finite L alluded to above will be derived and discussed in great detail in a forthcoming publication entitled "Volume Dependence of the Energy Spectrum in Massive Quantum Field Theories, Part I : Stable Particles States, and Part II : Scattering States".