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The finite-volume spectrum in the presence of a long-range force

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Long-range forces are present in different systems which are studied on the lattice. For example, the role of the long-range force is very prominent in extracting the properties of the $T_{cc}^{+}\,(3875)$-meson from lattice data. Furthermore, the one-pion exchange provides a very significant contribution to the nucleon-nucleon scattering. In the presence of such a long-range interaction, the interpretation of the finite-volume spectrum becomes more difficult, due to a strong partial-wave mixing. In addition, the so-called left-hand cut moves very close to the physical threshold, and the finite-volume energy levels that lie below the upper rim of the left-hand cut cannot be analyzed with the use of the standard Lüscher formula which contains real scattering phases.

We suggest a solution of the problem, based on the finite-volume generalization of the well-known Modified Effective Range Expansion (MERE) approach. Within this approach, the long- and short-range parts of the interaction potential are split. An exact solution is found for the long-range part, whose explicit form is known. It is then only the short-range part of the infinite-volume amplitude that is extracted on the lattice, and it is analytic in a much larger domain of the complex plane in the vicinity of the physical threshold than the full amplitude. The problems related to the left-hand cut and the partial-wave mixing do not emerge in this approach anymore. Last but not least, the implementation of the present method is not very different from the original Lüscher framework and can be carried out with a comparable effort.

In conclusion, I briefly review alternative approaches to the problem at hand which are available in the literature, and carry out a detailed comparison to the framework suggested in the present work.

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