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Luescher's finite volume test for two-baryon systems with attractive interactions

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Since the energy shift of two-baryon system due to the finite volume is negative for the attractive interaction, the Lueshcer's finite volume formula gives the phase shift at negative squared momentum, $k^2 < 0$, for the ground state. The phase shift at $k^2 < 0$ is not physical in the infinite volume where k^2 are all positive except for bound states, but it corresponds to the analytic continuation of the phase shift form $k^2 > 0$ to a real but negative k^2 in the infinite volume.

In this talk, using the Lueshcer's finite volume formula for the phase shift, we reexamine behaviors of the phase shifts at $k^2 < 0$ from previous lattice studies on various volumes. We have found that data, based on which existences of the bound states are claimed, give the phase shifts at $k^2 < 0$ which seems incompatible with the naive expectation predicted by the effective range expansion (ERE).
We therefore conclude that either of the following possibilities should hold.

(1). The naive ERE badly breaks down for these systems.

(2). Volumes are too small for the Luescher's formula to apply.

(3). Lattice data, most of which are obtained with the smeared source, are incorrect.

We have also applied the same analysis to our recent lattice data, which gave inconsistent conclusions between two sources on the existence of bound states for same two-baryon systems, an absence (wall source) or a presence (smeared source).
We have shown that behaviors of the phase shift at $k^2 < 0$ from the wall source seem consistent with the ERE, while those from the smeared source are incompatible with the ERE.
This result indicates that the smeared source result is less reliable, and therefore it favors the possibility (3) in the above.

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