



Contribution ID: 260

Type: not specified

An extension to the Luescher's finite volume method above inelastic thresholds (formalism)

Friday, 18 June 2010 16:40 (20 minutes)

We propose a new method to calculate scattering amplitudes above inelastic thresholds as an extension to the Luescher's finite volume method for elastic scattering phase shifts.

In the infinite volume, the asymptotic form of hadronic Bethe-Salpeter (BS) wave functions at spatial infinity can be derived in exactly the same manner as given in Ref.[1,2,3]. It contains the information of the T-matrix of QCD in quite analogous way as the scattering theory of quantum mechanics. We introduce an energy-independent generally non-local coupled-channel interaction kernel so that it can simultaneously generate BS wave functions in wide range of energy region with an effective Schroedinger equation (coupled channel version). Note that this interaction kernel can generate T-matrix of QCD by construction.

In a finite volume, scattering spectrum is discretized. Each state obtained in a finite volume system corresponds to a particular linear combination of multiple incoming states in the infinite volume. To calculate T-matrix above inelastic thresholds, we need states with different linear combinations at the same energy. However, corresponding states are located at different energies due to the discretized spectrum, which is the reason why the standard Luescher's method is usually restricted to the elastic region.

Our plan is to avoid this difficulty by using the interaction kernel introduced above. We first construct the interaction kernel in a finite volume, and then use it to generate BS wave function in the infinite volume. Note that the energy independent interaction kernel is constructed by using BS wave functions from multiple energies, by which the states with different linear combinations of incoming states can be taken into account. For an interaction with finite range, the interaction kernel constructed in a finite volume is insensitive to the spatial size. (as long as the spatial size is sufficiently large) This implies that, once such interaction kernel is constructed, it can be used to generate BS wave functions at arbitrary spatial volume, which enables us to access the S-matrix of QCD in the infinite volume.

We will also discuss possible applications.

Reference:

- [1] C.-J.D.Lin, G.Martinelli, C.T.Sachrajda, M.Testa, Nucl.Phys.B619(2001)467.
- [2] S.Aoki et al., CP-PACS Coll., Phys.Rev.D71(2005)094504.
- [3] S.Aoki, T.Hatsuda, N.Ishii., Prog.Theor.Phys.123(2010)89.

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talk

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Session Classification: Parallel 50: Hadronic structure and interactions

Track Classification: Hadronic structure and interactions