THE ROLE OF BOUNDARY CONDITIONS IN QUANTUM COMPUTATIONS OF SCATTERING OBSERVABLES

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RECENTLY PROPOSED THAT REAL TIME CALCULATIONS MAY BE POSSIBLE THROUGH:

- IMPROVED MONTE CARLO SAMPLING
- QUANTUM COMPUTATIONS

IN PRINCIPLE, COULD GIVE ACCESS TO SCATTERING OBSERVABLES FOR HIGH ENERGIES

VOLUME TRUNCATION LEADS TO NO ASYMPTOTIC STATES

2 DIFFERENT POSSIBILITIES TO RESOLVE THIS:

- LÜSCHER’S SCATTERING FORMALISM
- DIRECTLY EXTRACT OBSERVABLES FROM $\infty$-VOL. LIMIT
INFINITE VOLUME SCATTERING AMPLITUDE

2 → 2 HADRONIC AMPLITUDES

\[ iM = \frac{\mathcal{K}}{iB} \]

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FOCUSBING ON THIS

\[ \mathcal{T} \equiv i \int d^2 x e^{i\omega t - i\mathbf{q} \cdot \mathbf{x}} \]

\[ \times \langle \mathbf{p}_f | T\{\mathcal{J}(x)\mathcal{J}'(0)\} | \mathbf{p}_i \rangle_c \]

IN 1+1D

WITHOUT COUPLED CHANNELS

1+J → 1+J COMPTON-LIKE AMPLITUDES
\[ i\mathcal{T}_L = \mathcal{T} + \mathcal{H} + \mathcal{F} + \cdots \]
\[ = \mathcal{T} + \mathcal{H} + \mathcal{F} + \cdots \]
\[ \mathcal{T}_L = \mathcal{T} - \mathcal{H} \frac{1}{F^{-1} + \mathcal{M}} \mathcal{H}' \]

\[ F(E^*, P, L) = \frac{1}{2} \left[ \frac{1}{L} \sum_n - \int \frac{dk}{2\pi} \right] \frac{1}{2\omega_k} \frac{1}{(P - k)^2 - m^2 + i\epsilon} \]

GIVES A METHOD TO
EXTRACT \( \mathcal{T} \) FROM FINITE-VOLUME INFORMATION
AN UNEXPECTED APPLICATION

USE $\tau_L$ TO PREDICT VOLUME EFFECTS IN MINKOWSKI OBSERVABLES

IDENTIFY VALUES OF $\epsilon$ AND $L$ THAT GIVE AN ESTIMATE OF THE LIMIT

$$\lim_{\epsilon \to 0} \lim_{n \to \infty} \tau_L(p_f, q, p_i) = \tau(E^*, Q^2, Q_{i,f}^2)$$

$$E \to E + i\epsilon$$

NON-PERTURBATIVE, MODEL INDEPENDENT APPROACH!
INFINITE VOLUME SCATTERING AMPLITUDE

NUMERICAL RESULTS

\[ T_L = T - \mathcal{H} \frac{1}{F^{-1} + \mathcal{M}} \mathcal{H}' \]

\[ \sigma_L = \% \text{ DIFFERENCE} \]

\\[ mL = 20, \ cL = 4 \]
\[ L = \infty \]

\\[ mL = 100, \ cL = 1 \]

OUCH!

ENHANCED VOLUME EFFECTS

F IS TOO LARGE
FINITE-VOLUME DISTORTIONS

\[ F(E^*, P, L) = \frac{1}{2} \left[ \frac{1}{L} \sum_n - \int \frac{dk}{2\pi} \right] \frac{1}{2\omega_k} \frac{1}{(P - k)^2 - m^2 + i\epsilon} \]

\[ P = \frac{2\pi d}{L} \]
Infinite Volume Scattering Amplitude

Averaging Technique

Varying $P$ changes $\tilde{T}_L$ but not $\tilde{T}$

Averaged over $mL = 20, 25, 30$

Binned over redundant kinematics

$\bar{Q}^2 = 2m^2$

$\bar{Q}^2 = 10m^2$
WE HAVE EXPLORED THE POSSIBILITY OF EXTRACTING SCATTERING AMPLITUDES FROM FINITE-VOLUME MINKOWSKI CORRELATION FUNCTIONS

FOCUS: COMPTON-LIKE AMPLITUDES

NAÏVE ANALYSIS SHOW THAT ONE NEEDS VOLUMES OF $mL \approx O(100)$ TO RECOVER INFINITE VOLUME AMPLITUDE

BINNING: VOLUMES OF $mL \approx 20 - 30$ ALLOW TO RECOVER AMPLITUDE