Strong coupling expansion of the t-V model

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1 INTRODUCTION

The generalised t-V model [1] of fermions distributed on a chain of L sites with p.b.c.:

\[ H = -t \sum_{i=1}^{L} (\phi_i^a \phi_{i+1}^a + \text{h.c.}) + \sum_{i=1}^{L} \sum_{m=1}^{p} U_m \phi_i^a \phi_{i+m}^a \]

\( p \) - interaction range

Away from critical density

- Luttinger liquid
- Highly degenerate ground state
- Interacting "hard rods"

Critical density \( q_c = \frac{\pi}{p+1} q = 1 - p \)

- Mott insulator
- Simple ground state
- "Rods" filling the lattice

2 THE OBJECTIVE

Spacing: \( p > 1 \)
Non-integrable

Solved only in the 1st order perturbation [1].

Try reaching higher orders and finite system sizes.

Describe critical behaviour.

Spacing: \( p = 1 \)
Integrable

Bethe ansatz approach [2].

Assume:

\[ H = H_0 + \lambda V \]

\( \lambda \ll 1, V \) can be treated as a perturbation [3].

\[ H_0 = -t \sum_{i=1}^{L} (\phi_i^a \phi_{i+1}^a + \text{h.c.}) \]

Choose states

Act with \( V \)

Ortho-normalise \( [1] \)

Repeat

The Hamiltonian matrix in new basis:

SCE step 0

With every SCE step we are increasing the accuracy by two orders in \( \lambda \).

3 STRONG COUPLING EXPANSION

4 RESULTS AND CRITICALITY

Ground state energy formulae for near critical densities

\[ \text{Small magnetic flux dependence} \]

Critical parameter \( K \) can be easily calculated

\[ K = \frac{\pi \text{sc}(\pi(p+1))}{2L + 4p} + O(t) \]

\( \pi \text{sc}(\pi(p+1)) \) is not satisfied and thus potential has an unusual behaviour.

E.g. ground state [0] \( \rightarrow [1] \)

Possible further work:

High precision results for both integrable and non-integrable models

Strong coupling expansion

Simple way of reaching higher order perturbations numerically & analytically

6 CONCLUSIONS & OUTLOOK

REFERENCES