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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.:

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

- Interaction range
- Critical density \( 1/(q+1) \)
- Precision up to \( O(q^3) \)
- General results including all values of \( p \)
- Kinetic term becomes:

\[ \sum_i (e^{i\phi_i^\dagger} \phi_i + \text{h.c.}) \]

\[ K = \frac{\pi \csc ((\pi/p+1)/2L + 4\pi)}{4L(\pi/p+1)} + O(q) \]

2 THE OBJECTIVE
2.1 Spacing: \( p > 1 \)
Non-integrable
Solved only in the 1st order perturbation [1].
Try reaching higher orders and finite system sizes.
Describe critical behaviour.

2.2 Spacing: \( p = 1 \)
Integrable
Bethe ansatz approach [2].

Choose states

I Act with \( V \)

II Separate

III Orth-normalise

IV Repeat

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

The Hamiltonian matrix in new basis:

3 STRONG COUPLING EXPANSION

Example for \( p = 4, q = 1/3 \):

4 RESULTS AND CRITICALITY

Critical parameter \( K \) can be easily calculated

\[ K = \frac{\pi \csc ((\pi/p+1)/2L + 4\pi)}{4L(\pi/p+1)} + O(q) \]

5 OTHER PHASES

Other phases are present if

\[ U_{m} < (U_{m-1} + U_{m+1})/2 \]

is not satisfied and thus potential has an unusual behaviour.

6 CONCLUSIONS & OUTLOOK

High precision results for both integrable and non-integrable models
Critical parameter \( K \) easily obtained
Simple way of reaching higher order perturbations numerically & analytically

REFERENCES