Bosonic modes in Fermi liquid

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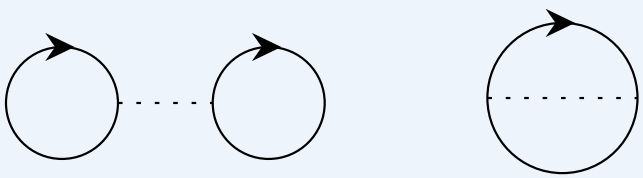
Background

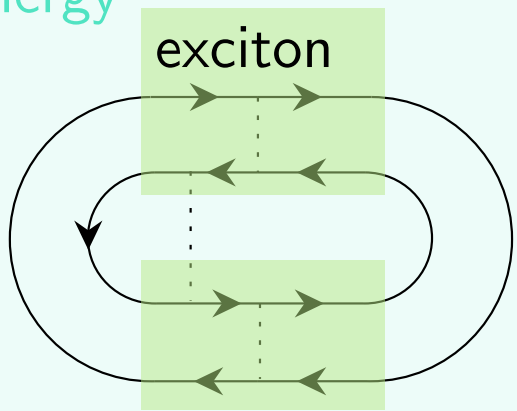
In a Fermi liquid we have . . .

- Quasiparticles (electron/hole) with Σ-correction
- Any anything else?

single electron energy



exciton energy



. . . and more

Question

What to do

Finding modes other than the corrected single electron/hole

Why it's important

Usually not for C_V but for optical response: ϵ, $\chi^{(3)}$, etc.

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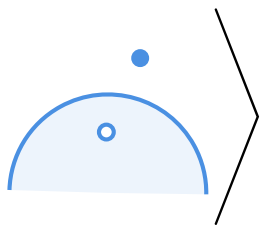
Today's topic

Electron-hole bosonic modes in Fermi liquid (with *some* scattering picked up back, i.e. beyond $\delta E \sim \varepsilon\, \delta n + f\, \delta n\, \delta n$), i.e.

$$|\text{single excitation}\rangle = \sum_{\boldsymbol{k}_1, \boldsymbol{k}_2} c_{\boldsymbol{k}_1 \boldsymbol{k}_2} \left| \right\rangle \tag{1}$$



No trion, higher order correlation, or even more exotic spinons, etc. beyond Fermi liquid

Overview

Three types of important bosonic modes:

- Zero sound in uncharged single-band Fermi liquid
- Plasmon in charged single-band Fermi liquid = zero sound + long range interaction
- Exciton in charged multi-band Fermi liquid

Methodology

Series calculation

Bethe–Salpeter equation (BSE) is used for quantitative calculations.
Problem: no picture about "how the electron moves"

Linking BSE with single-electron picture

Linear response of single-electron under external field = BSE

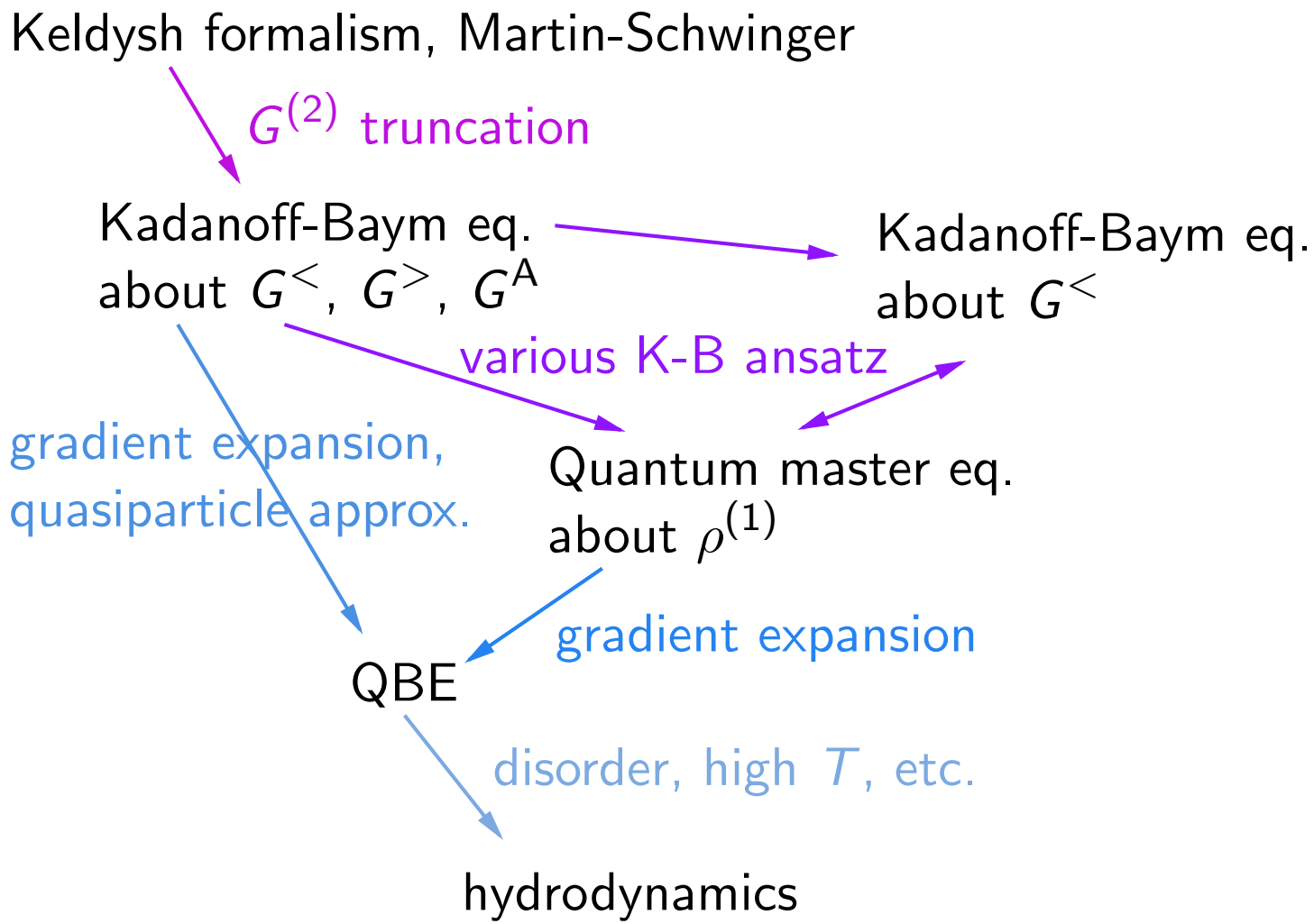
Simplified response theory

We use quantum Boltzmann equation (QBE)

Discussion

Is QBE reliable?

Yes! When we intuitively expect it to work –



Discussion