

2021.12 Week 2

1.1 Preface

This is the first paper that I write as a document to introduce some new concept. To be honest, I feel of no confidence about my writing skill. Nevertheless, I have to do this, not only as a summarization of my research, but also as a practice, since I will write my own article sooner or later.

I should feel fortunate to realize before my PhD career, that summarization is as important as learning. Everytime you learn something, you enter a beautiful house, appreciate every delicate part, and get superized about the wisdom of the architect. But only looking does not help you build such a house yourself. To do this, you need to start from groundwork, and then build the framework, and then add decorations. To learn physics, you need to go through such a process in your mind, following the paths of pioneers. This is so called summarization.

1.2 The Peierl Instability

You can see all derivation from the [reference](#). But you still have some problems. Collect them all and answer them next week.

1.3 The Derivation of Messiner's Effect

Next week.

1.4 The Origin of Bragg Scattering

Next week.

1.5 How to undersatand detailed balance?

There are at least two ways to understand this.

1.5.1 Assemble perspective

This perspective tells you detailed balance exists in equilibrium, but does not ensure the convergence. (you should further think about this and write it down next week.)

1.5.2 Probability perspective

All macrostates have their probability. We list (ignore the fact of denumerability) all the states and write down their probabilities as a vector x . x determines the macrostate. Everytime you do an update, you get a new macrostate x' .

$$x' = Ax, \quad (1.5.1)$$

where A is an operator satisfy some properties. When the system arrive at equilibrium, the macrostate x^* satisfies

$$x^* = Ax^*. \quad (1.5.2)$$

reference.

1.6 The Idea of CDW in Bosonic System

The rough idea about the formation of CDW in bosonic system is given by Prof. Wei during a discussion with us group members. When there are proper interaction U between electrons, compared with the hopping parameter t , the electron will be localized in supercells and thus form a charge order in space. The electron can freely hop within the supercell, but are hard to hop to the neighboring supercell because of the renormalized \tilde{U} .

While Xinyi and Xinyao have done the analysis on 2×2 supercell respectively in cubic and triangular lattice, seeing some very complex result without clear physical meaning, I come up some basic problem.

- The CDW is explained by the instability near Fermi surface for Fermi liquid, but there is no such concept in bosonic system. The question is, can we give a experimental definition of CDW.
- Under what condition does there exist CDW? What kind of material, and what kind of temperature?
- What is the competition between CDW and superfluid? Why such competition?
- I don not understand why $1/4$ filling can have CDW. Why do not electrons flow freely? (This question itself shows question.)

2021.12 Week 3

2.1 Plan

What is most important this week? Tuesday afternoon, you still have to serve as a teaching assistant. Wednesday afternoon, you will have the group meeting. The only thing you can report is the Meissner's effect. But you absolutely need to discuss first with Tony or someone else.

*** There still remains some questions you need to answer. Why London's paper is of enough importance to be published? What is London Moment? Why is it the same case in rotating frame?

** Talk about the results of QMC with Wei, do more calculation. Convince him that the question is hard to deal using other method. (How?¹)

- Find the answers of all unsolved questions in Week2.
- Finish reading two materials, Annett and CDW note.

2.2 Summary

This is a week of gaming. I have only done few things, though I got a lot of fun.

2.2.1 QMC result

The **result** is ...

2.2.2 The retardation effect

2.2.3 The CDW in bosonic system

¹It is not hard to realize that, if we know the proportion of each winding number, why we need to do QMC anymore?

2021.12 Week 4

3.1 Plan

You still need to finish the plan made in Week 2. Meanwhile, there are another things to think about.

*** QMC calculation is done under certain temeperature. To extrapolate the zero-temperature behavior, we need to calculate under several different temperature. On the other hand, we can detect whether CDW occurs in the jamming region by measuring the density-density correlation function.