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Fermions, criticality and superconductivity

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Stellingen

accompanying the PhD thesis

Fermions, Criticality and Superconductivity

1. Below some finite critical temperature, infinitely long windings proliferate in both bosonic and fermionic systems. It is then the worldline supersymmetry that eliminates the Meissner effect for a gas of charged fermions.

Chapter 2

2. The NP hardness of the fermion sign problem tells us that there is no mathematically exact solution, but how many features of the physical world we understand well are actually based on exact mathematics?

Chapter 3

3. On approach to the quantum critical point, an interaction that was deemed irrelevant initially, takes over and dominates.

Chapter 4

4. The scaling behavior of the free fermion case is special and the pair operator in a general conformal fermionic state can be characterized by a scaling dimension that is any real number smaller than one.

Chapter 5

5. The pairing mechanism in quantum critical metals is still under intense debate. Since pairing happens in the Cooper channel, it is desirable to be able to measure the Cooper channel directly.

Chapter 6

6. Contrary to intuition, quantum mechanics actually renders a strongly interacting Bose or Fermi liquid to act like a system of free particles with renormalized mass.

*R. P. Feynman, Phys. Rev. **91**, 1291(1953)*

7. The fermionic quantum critical states discovered in cuprates and heavy fermions are the desired high dimensional generalizations of the Luttinger liquid.

8. The original purpose of renormalization group (RG) was to explain universality of the critical exponents and yet retain the connection to microscopic physics; but the quantum critical point sect ignores the starting point of RG and deals only with its end result. Microscopic variables are seen as 'irrelevant' and 'therefore' unimportant.

P. W. Anderson, Physica B **318**, 28(2002)

9. The existence of the string landscape suggests that our universe can be in a quantum glass state with large viscosity. The long distance dynamics slows down while the short distance dynamics stays the same. This explains the apparent smallness of the cosmological constant.

*J. She, JCAP*02(2007)021

10. A leader is best when people barely know that he exists, not so good when people obey and acclaim him, worst when they despise him.

Laozi, Tao Te Ching

Jian-Huang She
Leiden, Feb. 22, 2011