Notes of Connecting Few-body and Many-body Pictures of Fractional Quantum Hall Physics

Taper

September 29, 2016

Abstract

YouTube link [1]. Note that, although I have the video on hand, the lecturers are speaking somehow too fast and it would be too time-consuming to replay these lectures. So the content is..... quite unorgnised and bare. Therefore, this note could be viewed just as a collection of key words.

Contents

1 Using Optical Emission to Study Competing Phase in the Second Landau Level

By:

Antonio Levy, Aron Pinczuk, Yuliya Kuznetsova (Columbia University), Ursula Wurstbauer (Technische Uni. Munchen), Ken. W. West, Loren N. Pfeiffer (Princeton), Michael J. Manfra, Geoff C. Gardner, John D. Watson (Purdue University).

Overview Second Landau Level displays

1. FQHS

2. Ordered phases (partially). RIQHE $\overset{from}{\Leftarrow}$ Electron stalids.
3. Competition & Coexistance

   Anisotropic FQHS arise from coorelation when anisotropic $\overset{from}{\Leftarrow}$ magneti field

Advanage of Optial

1. Direct probes bulk
2. Distinguish between charge and spin modes

Sample Omitted.

RRS

light $\longrightarrow \bullet \underset{\text{quasihole}}{\overset{\text{quasiparticle}}{\rightleftarrows}} \bullet$ scattered photon

• Easy to probe Single Partical excitation and collective excitation.
... (Skipped)

2 Hyperspherical Adiabatic Approximation

By: Rachel Wooten (Purdue University)

Outline

1. QHS
2. Motivation
3. Hyperspherical adiabatic approximation (**HAA**)
4. The role of degeneracy
5. Hyperradial breathing mode
6. Results and Discussion

Table 1: Two Schemes

Conventional	$\approx$	Neutral Atom gass
2D Landau levels		2D Rotation(Ω)
ω_c		$\omega = 2\Omega$

QHS (Other schemes are also available, not treated).

Motivation

- QHS: prototype of *Strongly correlated systems*
- Nature of few-body states
- insights from collectively coordinates
- use ... ?

Few body, adiabatic hypershperical approach(AHA)

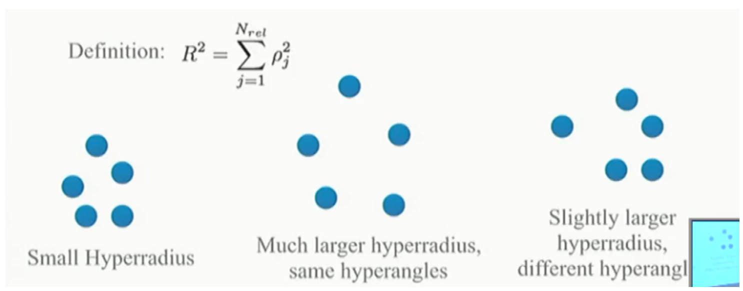
- intrinsic collective coordinates
- length scale $R \overset{\text{from}}{\Leftarrow}$ geometry
- E potential $\Leftarrow$ length scale
- introduce Grand Angular momentum K - quantum number

AHA background Joe Macek, 1968 JPB.

Scheme Sch-Ep $\overset{recast}{\Rightarrow}$ relative coordinates $\overset{diagonalize}{\Rightarrow}$ solve.

Hyperspherical Coordinates

$2N-2$ Jacobi coordinates $\Rightarrow$ $2N-3$ angular coordinates Ω + 1 length coordinates Hyperradial R.



Hyperradius

$$\rho = \left(\frac{\pi\mu \langle R^2 \rangle}{N(N-1)} \right)$$

$$\mathscr{H}_{\text{rel}} = (R, \Omega, \cdots) + \text{Colomb} V(R) = \frac{1}{R} + \text{Polarized dipoles} V(R) = \frac{1}{R^3}$$

AHA (Non-interacting case) Omitted.

AHA (Interacting case)

Treat R as an adiabatic parameter.

Interaction $\overset{\text{introduct}}{\Rightarrow}$ degeneracies

Accuracy check Omitted.

Exceptional degeneracy

3 ? (Wick Haxton)

(1995) Algebraic classification of general 4 fermion problem (Joe Ginocchio) $\Rightarrow$ has FQHE implications

Jain & Laughlin work (numerically succesful)

(No audio available for this lecture recording!, Skipped)

4 Perspectives on the half-fill Landau Level

By B.I. Halperin, N. Copper, Chong Wong, Adey Stern.

Question : What ahppens to half-filled Landau Level when there is **NO** magnetic field.

Motivation

- New research on half-filled Landau level
- Describe system by "Dirac Fermion" is simpler, generated different theories $\Rightarrow$ doubt whether they are equivalent.
- Particle-hole symmetry in explicit in "Dirac Fermion", not explicit in HLR framwork.

Physical Setup

Half-filled Landau level: in a semiconductor.

$$H_0 = \sum_i \frac{|P_i - A(r_i)|^2}{2m} + V_2(\text{interactions})$$

Units: $e = \hbar = 1$.

PH Symmetry

- $m \to 0$, e-e interactions are fixed -¿ exact PH symmetry
- For $v = 1/2$, PHS requires that $\sigma_{xy}(\sigma) = (1/2)e^2/h$

HLR Approach (Halperin, Lee, Read. PRB 1993)

- Singular gauge transformation $\Rightarrow$ Chern-Simons Gauge Field
- Transformed Hamiltonian will have fermion terms, interactions, gauge field (chern-simons interaction in it). Also the curl of a fact vector is constrained.

Antecednets

- Fractional Quantized Hall states by Jain; Lopez and Fradkin; others.
- Simultaneous work by Kalmeyer and Zhang had some features of HLR.

HLR Hypothesis

- Do mean field theory on this problem: the ground state and low energy properties of quantum hall system at $v = 1/2$. And use perturbation theory and take into account of fluctuations in gauge field and Coulomb interactions
- ...

HLR consequences

- with $1/r$ interactions, the ground state is a "marginal fermi liquid". With mass diverges *log* at fermi serface, eue to infrared divergence.
- assume interactions that fall off slower than $1/r$.

HLR-RPA predications

- ground state at $v = 1/2$ should be compressible
- energy gaps, FQH states, occur at Jain fractions $v = p/(2p+2)$.
- relative sizes of energy gaps close to 1/2
- transport in absence of impurities: DC hall conductance
- Longitudianl conductivity at finite $q, \omega \to 0$:

$$\sigma_{xx}(q) = q/(8\pi k_f)$$

  in the presence impurities: formula holds for $q > l_{cf}$.

Related work: Kalmeyer & Zhang.

5 Anchor

References

[1] `https://www.youtube.com/playlist?list=PLCoSh1h28ieLIaD-HGi5aUQzunOTtxHTC`

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