Santa Barbara Workshop "Quantum gases" 2004 Conference

Summary and prospects

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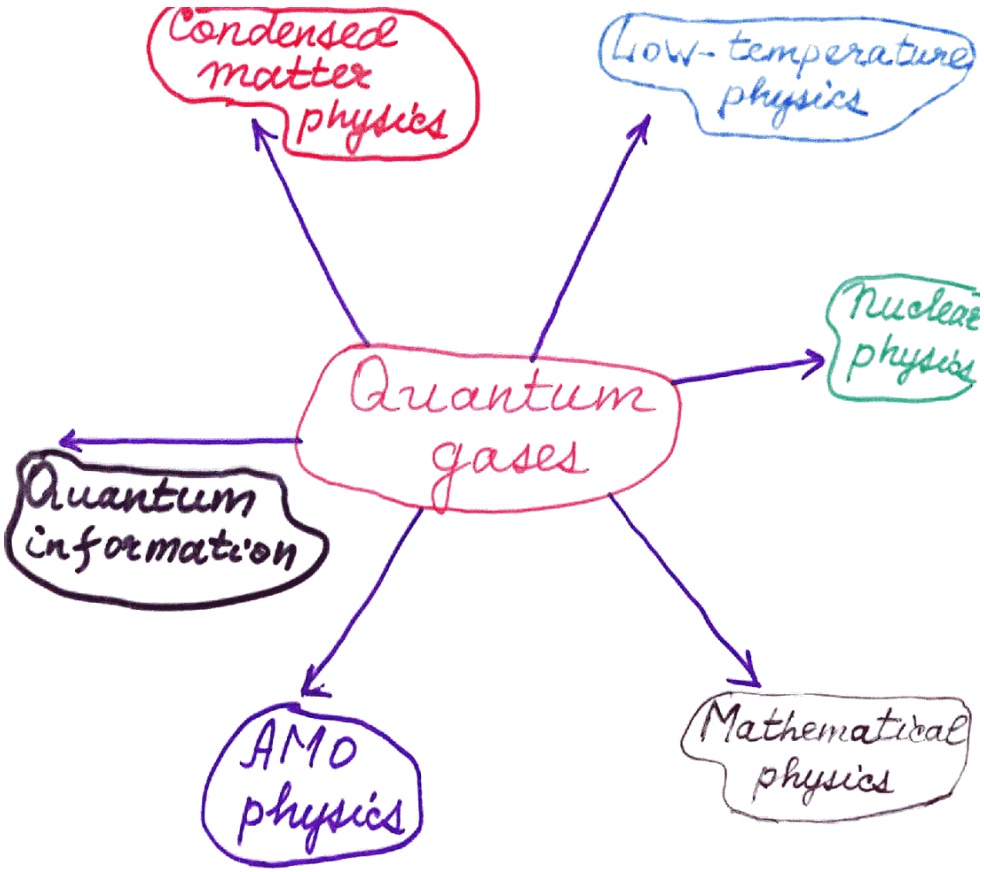


"Hot topics"

Degenerate Fermi gases

Rapidly rotating gases

Atoms in a lattice / Spinor and low-dimensional gases

Fermi gases

Experiment: Jin, Ketterle, Grimm, Thomas, Salomon, Hulet, Inguscio

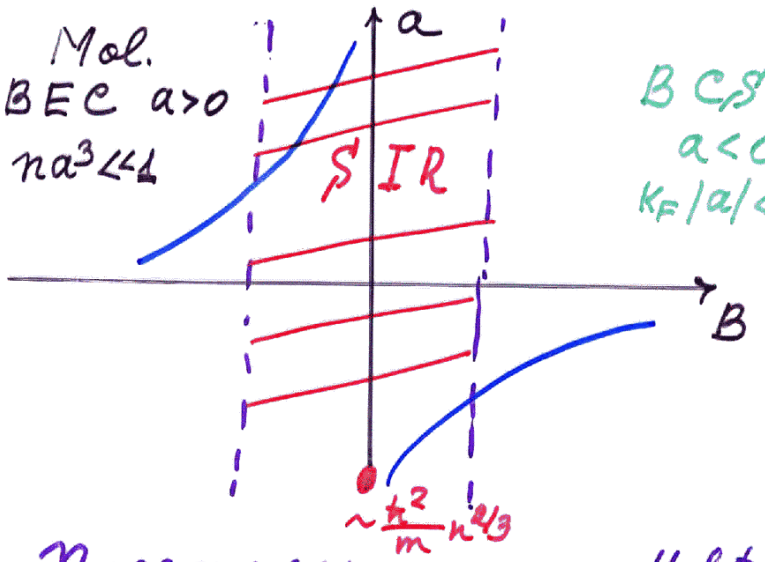
Theory: Ho, Griffin, Levin, Bulgac, Chiafalo, Stringari, Menotti, Petrov, Haldane

Eric Cornell

What do we know?

What is supposed to happen?

What do we deliver to other fields?



Narrow resonance — Hulet, Petrov

Wide resonance — others

↓

universality

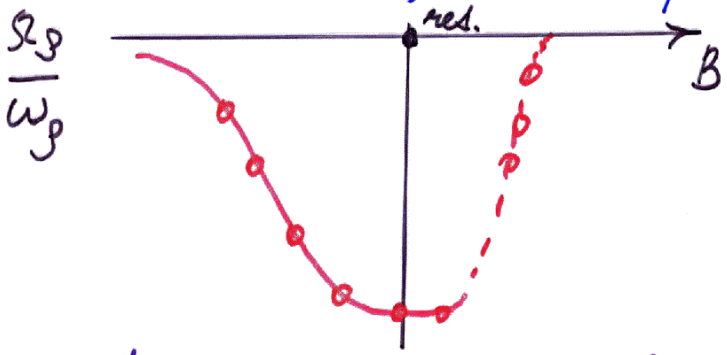
SIR

1. $\mu = (1+\beta)\varepsilon_F$; $\beta = -0.55 \div -0.65$ theory/experiment

2. JILA, MIT ⇒ "Condensation of fermionic pairs" for $k_F|a|>1$

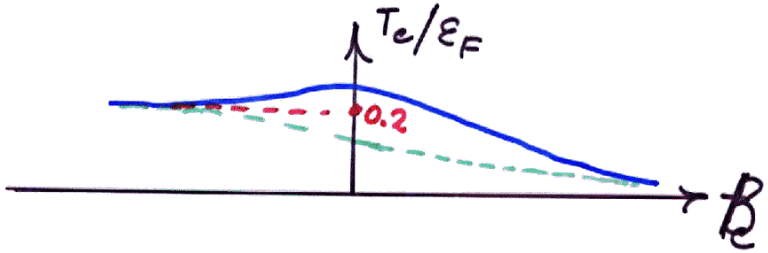
how to understand?

3. Collective frequencies
Innsbruck, Duke experiments



Superfluid–non-superfluid transition
How to detect Stringari ?

SIR → type of pairing? T_c=?
how to describe?

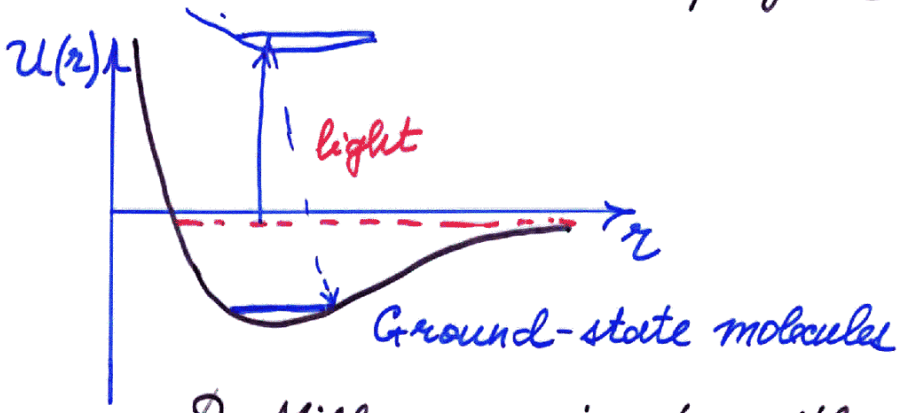


Neutron matter
High-T superconductivity

BCS ⇒ theory
experiment?

Molecular BEC

Idea ⇒ molecular physics



De Mille ; experiments with molecules of bosons; low density
Fermions → long life-time (>1,5 s)
$n \sim 10^{13}$ cm^{-3}

Mixtures (^{40}K ^{6}Li)
Heteronuclear molecules

Dipolar gases
$V_d \sim \frac{d^2}{r^3}$ → long-range, anisotropic

Fast rotation

Experiment: Cornell, ENS

Theory: Muller, Wilkin, Fetter, Pethick, Grunn, Cooper

Understanding of the behavior of vortices: JILA, ENS

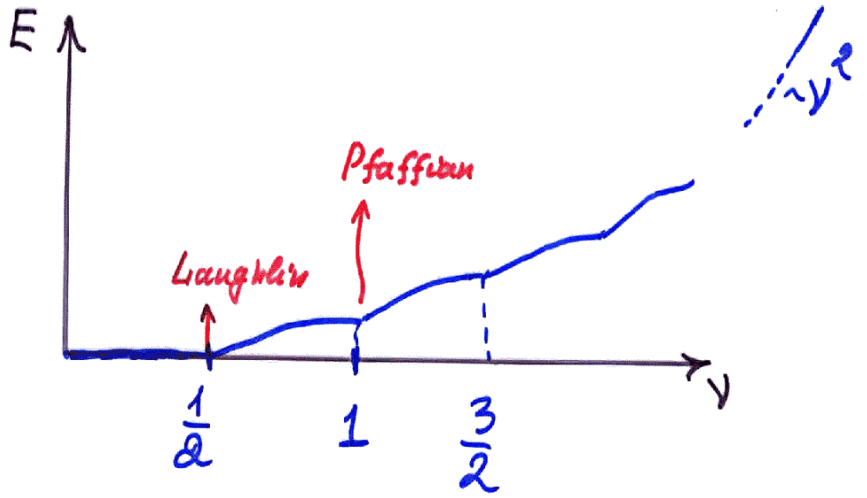
Ho, Fetter, Pethick

Quantum Hall states

Theoretical understanding

JILA experiment { 2D regime
$\Omega = 0.997\omega$

How to detect?

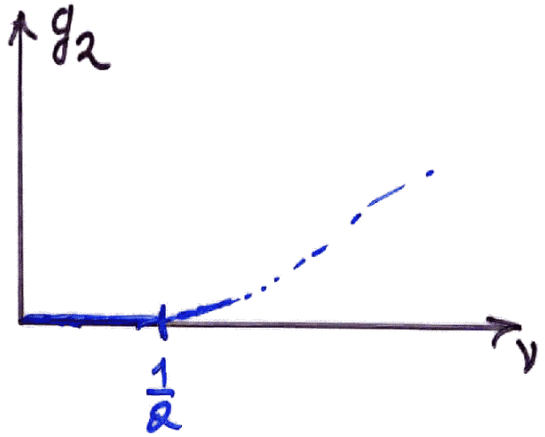


Density profile

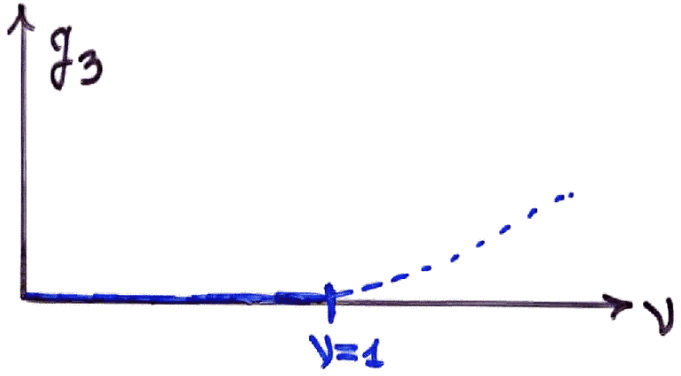
Local correlations

$$g_2 = \frac{1}{n^2}\langle \psi^+ \psi^+ \psi \psi \rangle \Rightarrow \frac{\partial E}{\partial g}$$

photoassociation



$$g_3 = \frac{1}{n^3} \langle \psi^+ \psi^+ \psi^+ \psi \psi \psi \rangle$$

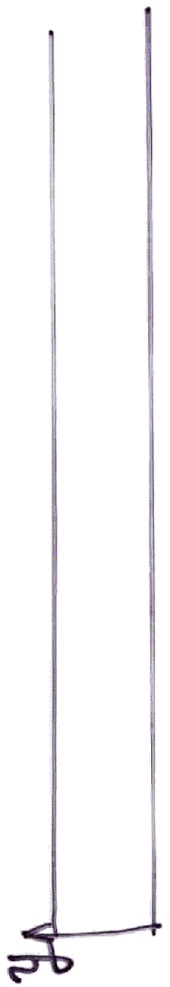


$$g_1 = \langle \psi^+(x) \psi(0) \rangle \to ?$$

$$\ell_0 = \left(\frac{\hbar}{m\Omega}\right)^{1/2}$$

Question: What happens for $\omega_x < \omega_y$?

$\Omega \to \omega_x$



2D gas in a narrow channel in the presence of a gauge field

(What kind of new 1D/2D physics is here?)

Atoms in a lattice / Low dimensions / Spinor Bose systems / Quantum information

Experiment: Bloch, Kasevich, Sengstock, Chapman, Cornell, Porto, Aspect

Theory: Cirac, Zhou, Molmer, You, Olshanii

Understanding of the formation of trapped BEC's

Understanding of the ~~formation~~ spin dynamics

Achieving the Tonks-Girardeau regime in 1D; Interference phenomena

Ideas towards quantum ~~or~~ entanglement

Simple example

Spin excitations of the ground state → Spin waves → relative oscillations of the 2 components

$$\varepsilon_k = \frac{\hbar^2 k^2}{2m_*}$$

$m_* \to m$ weakly interacting regime

$m_* \to \Phi m$; TG regime

$$\Phi = \frac{mg}{\hbar^2 n} >> 1$$

$$\Omega \sim \frac{\omega^2}{\varepsilon_F} \cdot \frac{1}{\gamma} \quad (< 0.1\,Hz)$$

THANKS TO KITP!!!

Spinor Bose gas

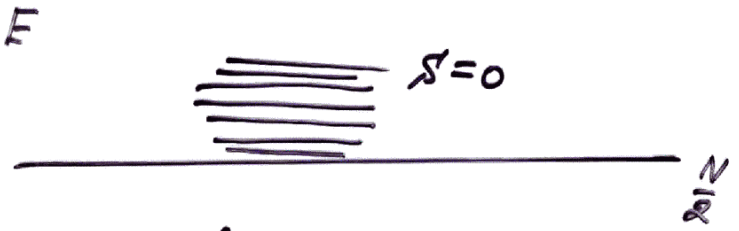
2-component (spin $\frac{1}{2}$ bosons)

1 ⊗ 2

$g_{11} = g_{12} = g_{22}$

Isotopic spin S

$0 \leq S \leq \frac{N}{2}$



Gas phase : 1D exactly solvable model. Bethe Ansatz (C.N. Yang, 1967)

What is the eigenstate for S strongly different from $N/2$. Degree of quantum entanglement