

A proposal for anyon manipulation

Babak Seradjeh

In collaboration with Conan Weeks, Gili Rosenberg and Marcel Franz



Chiral SC Workshop, KITP

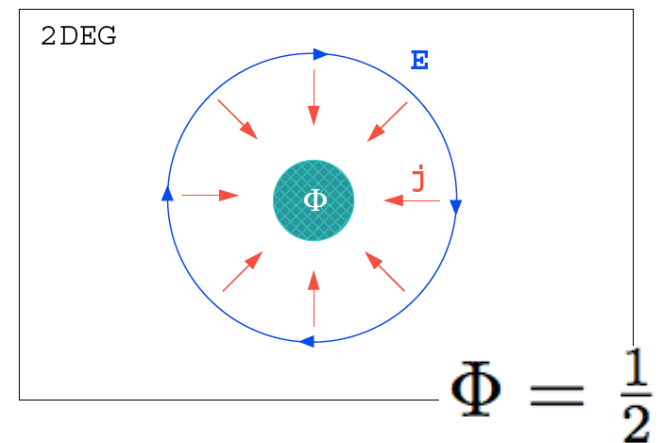
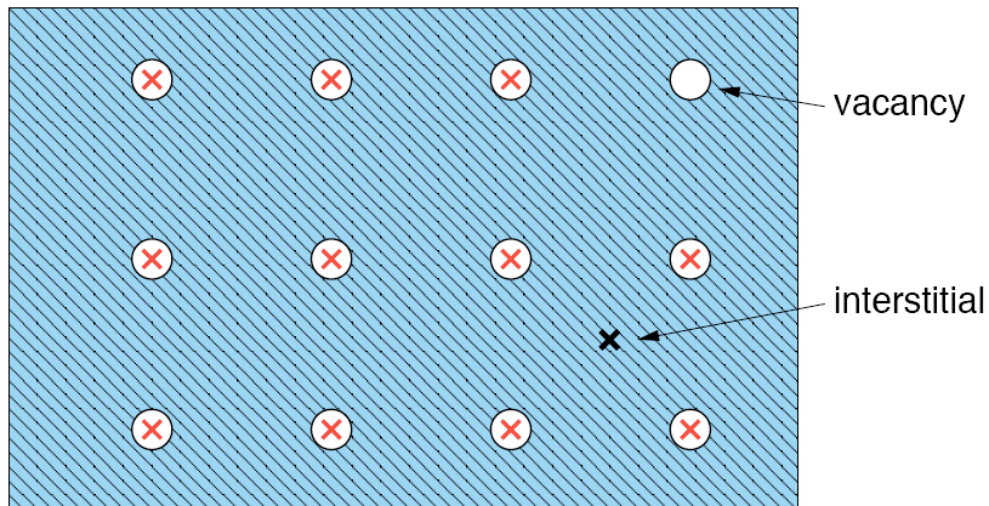
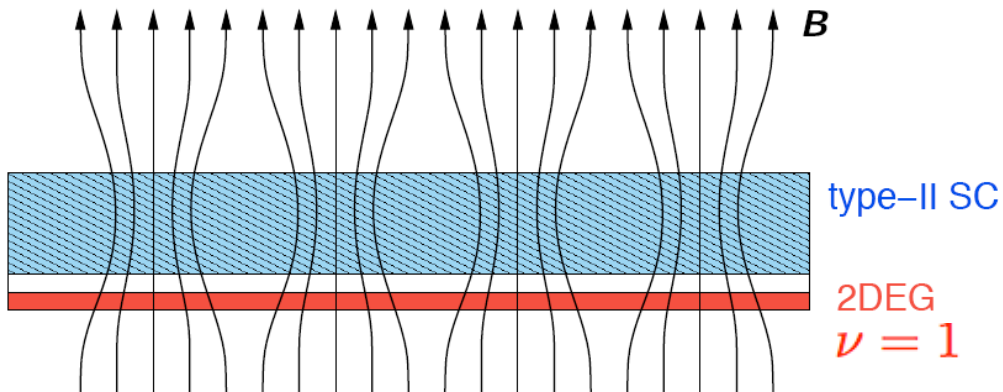
18 December 2007

Anyons in a weakly interacting system, Nature Physics **3**,796 (2007)



2DEG + SC Bilayer

Fractionalization with weak interactions



$$q = \frac{1}{2} \quad \gamma = \frac{\pi}{4}$$





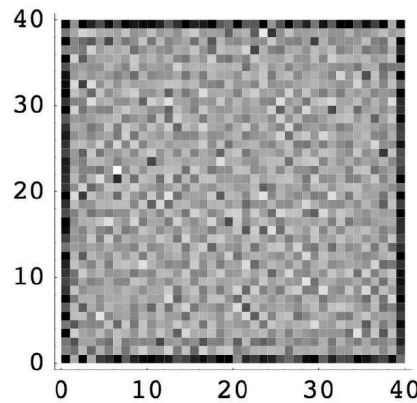
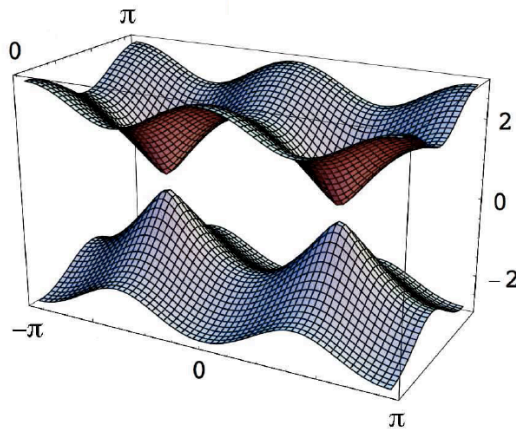
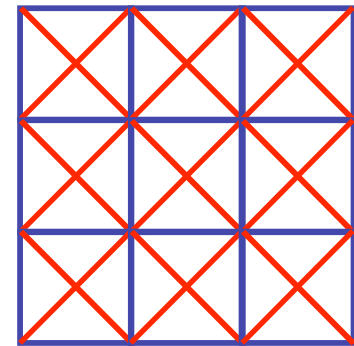
2DEG + SC Bilayer: Lattice Model

Fractionalization with weak interactions

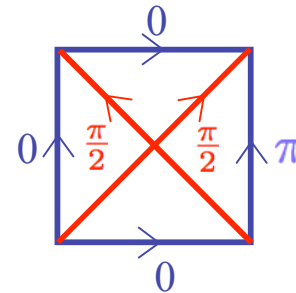
2DEG in diluted magnetic semiconductors ($\text{Ga}_{1-x}\text{Mn}_x\text{As}$)

Berciú, *et al.* Nature **435**, 71 (2005).

$$\mathcal{H} = - \sum_{ij} \left(t_{ij} e^{i\theta_{ij}} c_j^\dagger c_i + \text{h.c.} \right) + \sum_i \epsilon_i c_i^\dagger c_i$$



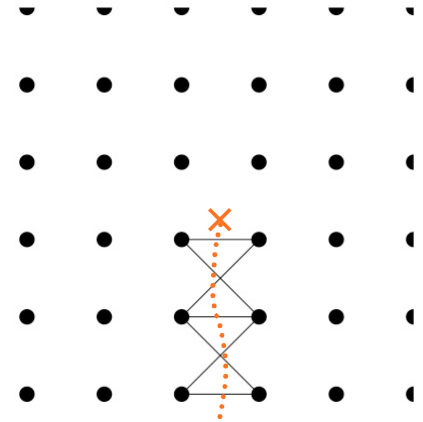
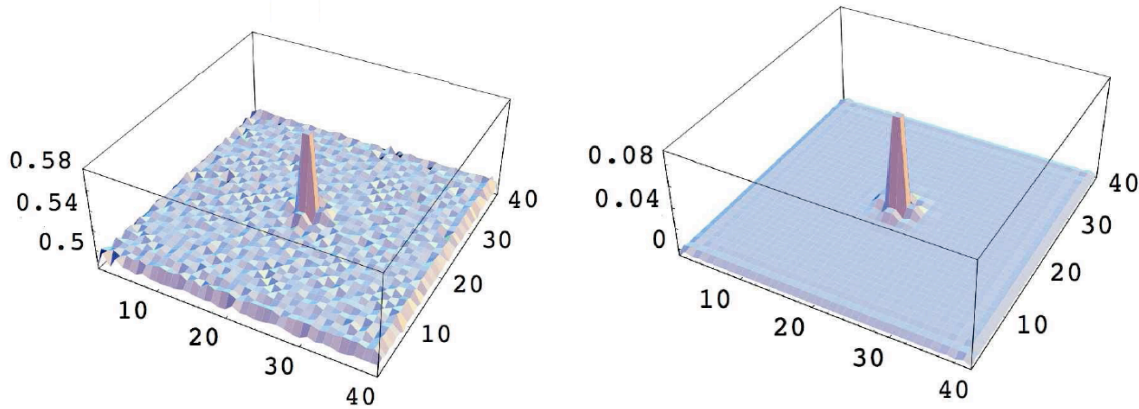
$$\theta_{ij} = \frac{2\pi}{\Phi_0} \int_{\mathbf{r}_i}^{\mathbf{r}_j} \mathbf{A} \cdot d\mathbf{l}$$



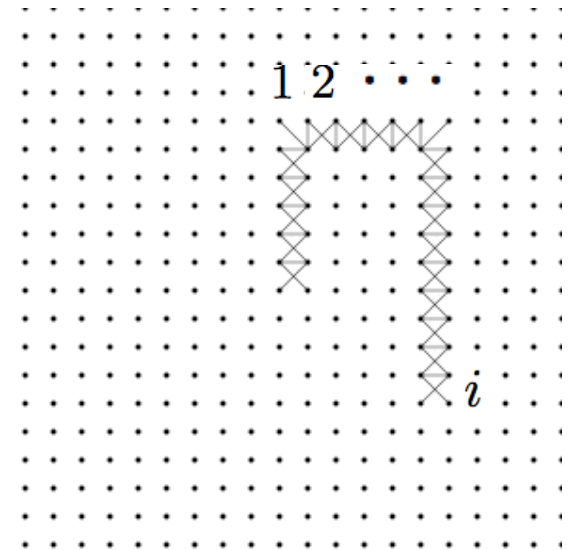
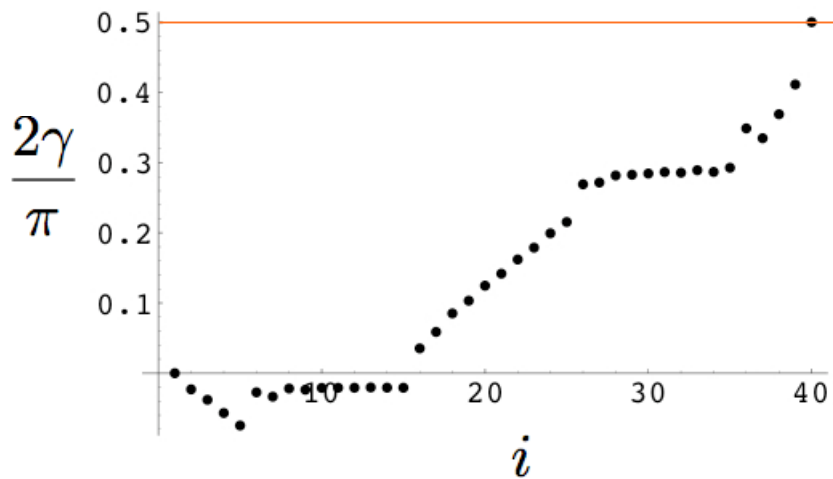


2DEG + SC Bilayer: Lattice Model

Fractionalization with weak interactions



$$\langle \Psi_1 | \Psi_2 \rangle \langle \Psi_2 | \Psi_3 \rangle \cdots \langle \Psi_{i-1} | \Psi_i \rangle \langle \Psi_i | \Psi_1 \rangle \sim e^{i2\gamma}$$





2DEG + SC Bilayer: Non-Abelian Anyons

A similar argument at filling $\nu = \frac{5}{2}$ gives $q = \frac{1}{4}$.

This is the same as the charge of the quasiparticles in the Moore–Read Pfaffian state, suggesting that the vacancies would now bind a **non-Abelian** quasiparticle.

Another way: the $\nu = \frac{5}{2}$ Pfaffian state is equivalent to a p -wave superconductor, so its natural quantum of flux is $\frac{1}{2}\Phi_0$. Then, similar to Laughlin’s argument, threading a half-flux should create a quasiparticle of the system.





Summary

Parameters:

- $a = \sqrt{\nu/2\rho_e} \approx 200\text{\AA}$ $\rho_e \approx 3 \times 10^{11}\text{cm}^{-2}$
- $H \sim 5\text{T} \ll H_{c2}$
- $\lambda_{\text{eff}} = \lambda(\lambda/d) < a$ $d \sim \lambda < a$

Necessary conditions for anyons:

- Strong interactions? *No!*
- Time-reversal symmetry? *No!*

