Theory of Striped Hall Ferromagnets

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Recent theories and experiments suggest that the striped state appears in the quantum Hall system in various circumstances. At half-filled high Landau levels, highly anisotropic states are observed[1, 2] and explained by the anisotropic charge density wave or charge striped state. Furthermore at even integer filling, highly anisotropic states have been observed in a quantum well system.[3] Considering the spin and pseudospin degree of freedom, a very rich structure has been predicted theoretically.[4]

In this paper we consider a possibility of spin and charge striped states in an ideal 2D electron system at half filled high Landau level in the zero Zeeman energy limit. In GaAs the Zeeman energy is about one percent of not only the Landau level energy gap but also the Coulomb energy scale at a magnetic field about 1 T. Actually the the Zeeman energy can be reduced by pressure in experiments. Therefore we could ignore the Zeeman energy in the first approximation.

Using the von Neumann lattice formalism[5, 6], we calculate the Hartree-Fock energy of various striped state. We find that a fully spin polarized striped state has a lower energy than the antiferromagnetic striped state or charge striped state. We call the fully spin polarized striped state the striped Hall ferromagnet.

In the von Neumann lattice formalism, the one-particle state has a lattice 2D momentum $\mathbf{p}$ in the Brillouin zone, $|p_i| < \pi$. We investigate three types of the striped state, namely, ferromagnetic, antiferromagnetic, and charge striped state. Corresponding Fermi seas at half-filled Landau level are given in Fig. 1.

We also investigate the low-lying collective excitation using the single mode approximation[7]. There are two types of the excitations corresponding to the NG modes due to the spontaneous breakdown of translational and spin rotational symmetry. The spectra of the NG modes become highly anisotropic.

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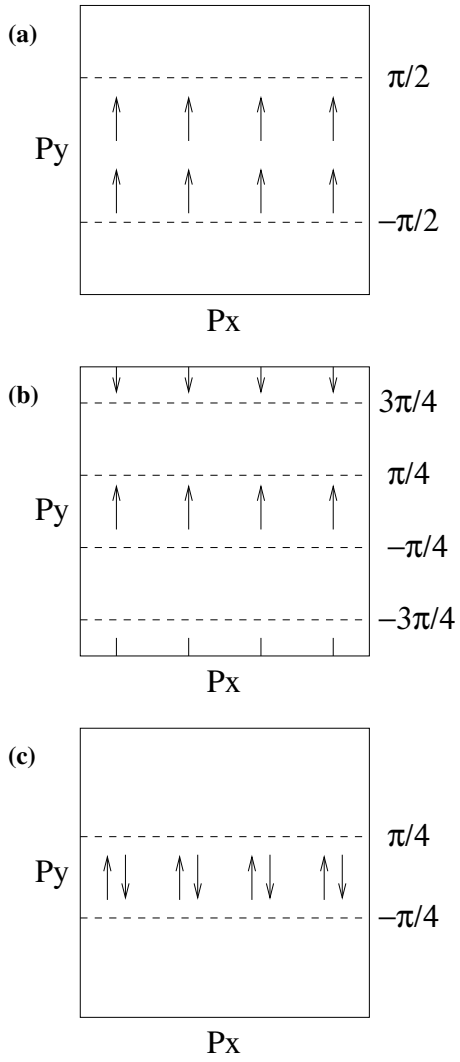

Figure 1: Schematic spin configurations in the Brillouin zone for the ferromagnetic striped state (a), antiferromagnetic striped state (b), and charge striped state (c). Dashed lines stand for Fermi surfaces.