Intra-Landau Level Polarization Effect for the Striped Hall States

Takahiro Aoyama[1], **Kenzo Ishikawa**[1], **Yumiko Ishizuka**[1] **and Nobuki Maeda**[1]

[1] *Department of Physics, Hokkaido University, Sapporo, 060-0810, Japan*

At the half-filled higher Landau level (LL), the anisotropic longitudinal resistivity has been observed in ultra-high mobility sample [1, 2]. A striped state has been studied as a candidate of the anisotropic electron state. Since the striped state has an anisotropic Fermi surface, this state has anisotropic compressible properties [3]. The low energy collective excitation of the striped state is derived by a single mode approximation [4]. In this paper, we study a quantum fluctuation effect by applying a random phase approximation (RPA) to the striped state.

We estimate higher order corrections to the striped state due to the intra-Landau level (LL) quantum fluctuation effect through the polarization function at one-loop order. The dielectric function and the plasma frequency (plasmon) are computed numerically in the RPA and in the generalized RPA (GRPA). These physical properties are also discussed. In the RPA, bubble diagrams are included, and in the GRPA, bubble and ladder diagrams are included (Eq. (1, 2)). The correlation energy is estimated in the RPA. In our von-Neumann lattice (vNL) formalism [5], it is possible to apply the systematic perturbative calculation.

The dielectric function and plasma frequency reflect the anisotropic feature of the striped state. The plasmon becomes a massless mode due to the Coulomb interaction $1/r$ in two-dimensional space. The attractive interaction in the GRPA causes the drastic changes of the dielectric function and the plasmon mode (Fig. 1, 2). In contrast to the RPA, the plasmon's energy becomes small at the GRPA. The total energy including the RPA correlation energy is smaller than the Hartree-Fock (HF) energy, so the magnitude of the quantum fluctuation to the striped state becomes significant in the RPA. Our value of the total energy is close to the value of the numerical calculation for the small finite system. The mean-field theory of the striped state for the anisotropic compressible state at the half-filled higher LLs will be confirmed experimentally by the observation of the anisotropic gapless plasmon mode.

References

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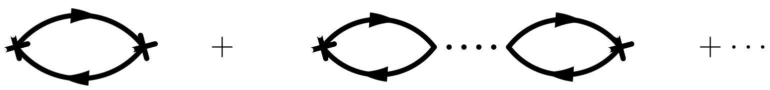
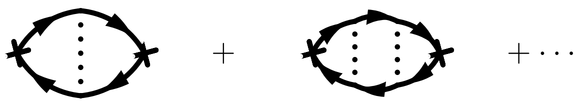
$$\tilde{\pi}^{\mu\nu}_{\text{bubble}}(\hat{\mathbf{k}},\omega) =$$



(1)

$$\tilde{\pi}^{\mu\nu}_{\text{ladder}}(\hat{\mathbf{k}},\omega) =$$



(2)

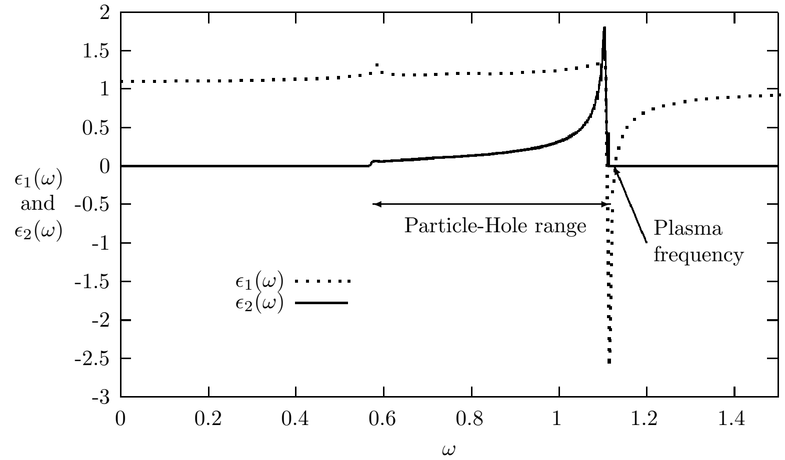


Figure 1: ω-dependence of ϵ^{RPA} for including only bubble diagram for $(k_x, k_y) = (\pi/4, 1.5)$. The unit of ω and k_i is $q^2/(a\hbar)$. and $1/a$, respectively. Here $a = \sqrt{\frac{2\pi\hbar}{eB}}$ is the magnetic length.

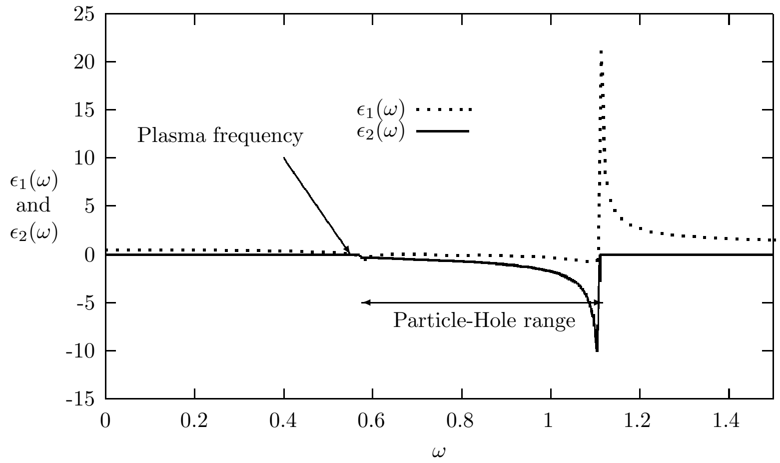


Figure 2: ω-dependence of ϵ^{GRPA} for including both bubble and ladder diagram for $(k_x, k_y) = (\pi/4, 1.5)$. The unit of ω is $q^2/(a\hbar)$.