Fractional Topological Excitations and Quantum Phase Transition in a Bilayer 2DEG Adjacent to a Superconductor Film

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We study a bilayer two-dimension-electron-gas (2DEG) adjacent to a type-II superconductor thin film with a pinned vortex lattice. We find that with increasing interlayer tunneling, the system of half-filling presents three phases: gapped phase-I (topological insulator), gapless critical phase-II (metal), and gapped phase-III (band insulator). The total Hall conductance for phase-I/III is $2/0$ e^2/h, and has nonquantized values in phase-II. The excitation (response to topological defect, a local vortex defect) in these three phases shows different behaviors due to the topological property of the system, including fractional charge $e/2$ for each layer in phase-I. While in the case of quarter-filling, the system undergoes a quantum phase transition from metallic phase to topological insulator phase.