A Capacitive Kondo Model for an Antidot in the Integer Quantum Hall Regime

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The Kondo effect, which arises due to many-body interactions between a localized spin and free electrons, has been investigated in various mesoscopic systems such as quantum dots. Very recently, Kondo-like behavior was also observed [1] in an antidot under strong magnetic fields in the integer quantum Hall regime (see Fig. 1), where the source-drain current shows the information of the tunneling between localized antidot spin states and extended edge states as a function of magnetic field. The observed data can not be understood by a noninteracting electron picture: As a function of magnetic field the data are fitted by three dips within a h/e Aharonov-Bohm (AB) period while noninteracting electrons can give only two. As temperature or DC bias voltage increases, one of the dips becomes suppressed and then the dips with $h/(2e)$ AB periodicity are eventually found. These features resemble the Kondo signatures in quantum dots, however, their physical origin is not understood yet.

We present a Kondo model for the antidot, in which the antidot charging effects [2] and the interaction between excess charges [3] with different spins localized around the antidot, $(\delta q_\uparrow, \delta q_\downarrow)$, are taken into account as capacitive coupling. Our model explains the observed features qualitatively and predicts (i) the effective spin flips of excess charges $\delta q_\uparrow$ and $\delta q_\downarrow$ result in the Kondo effect, and (ii) within one h/e AB period, there occur one dip by the Kondo tunneling and two normal AB dips associated with the tunneling of $\delta q_\downarrow$, which is more strongly coupled to current-carrying edge states than $\delta q_\uparrow$. Possible many-body quantum Hall states of the antidot are suggested to be a pair of compressible and incompressible regions of electrons or incompressible maximum-density-droplet of holes, depending on the antidot potential. For the latter case we have performed a microscopic many body calculation. Results are in qualitative agreement with the predictions of our model.

[1] M. Kataoka *et al.*, Phys. Rev. Lett. **89**, 226803 (2002).
[2] M. Kataoka *et al.*, Phys. Rev. Lett. **83**, 160 (1999).
[3] Excess charge is a continuously varying quantity. It is accumulated with increasing magnetic fields until it is relaxed via the tunneling of an electron as antidot states shrink in area to enclose constant magnetic flux quanta.

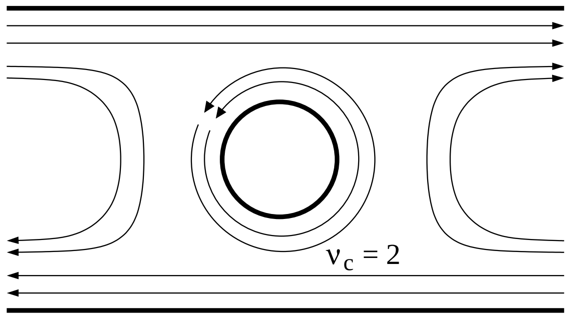

Figure 1: A schematic diagram for a quantum wire with an antidot. The arrows represent extended edge channels and localized antidot states. Since the local filling factor ν_c in the constriction between the antidot and edge is two the antidot has both spin up and down states.