**Spinless Composite Fermions in an Ultrahigh-Quality Strained Ge Quantum Well**

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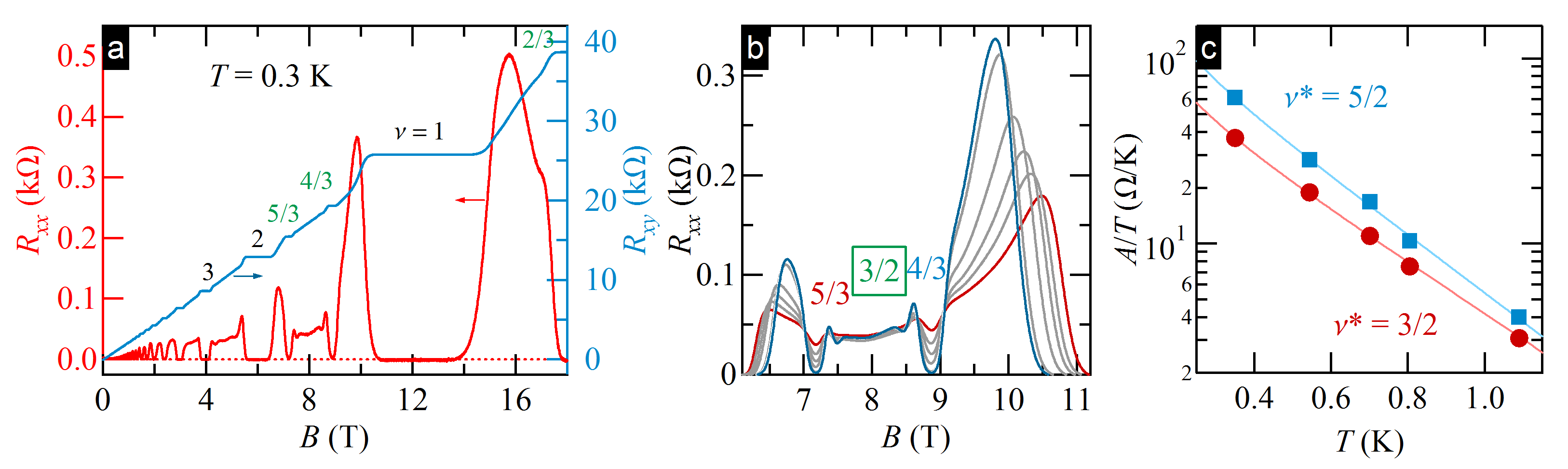
**Introduction**

Fractional quantum Hall (FQH) effect has been realized only in a few select materials since its first discovery in a two-dimensional gas in GaAs/AlGaAs heterostructure [1]. FQH states in these materials are usually strongly influenced by spin and/or valley degrees of freedom, due to comparable energy scales. Here we report on observation of FQH states in an ultrahigh-quality Ge/SiGe quantum well [2] which can be described in terms of composite fermions with only the orbital degree of freedom.

**Experimental**

Our sample is fabricated from a Ge/SiGe quantum well with the density 2.9 x 1011 cm-2 and the mobility 1.3 x 106 cm2/Vs. Measurements were performed in SCM-2.

**Results and Discussion**

Longitudinal resistance and Hall resistance demonstrate fully-developed FQH states at fractional filling factors 2/3, 4/3 and 5/3, see Fig.1(a). The data in Fig.1(b) further reveal that the resistances at the minima at 5/3 and 4/3 grow with increasing *T* in a very similar fashion. This behavior suggests that the energy gaps at these filling factors are close to each other, indicating anticipated full spin polarization of both FQH states. From the *T*-dependence of Shubnikov-de Haas oscillations at composite fermion filling factor 5/2 and 3/2 (the closest resistance maxima to 5/3 and 4/3 at smaller effective fields), see Fig.1(c), we obtain the effective mass of the composite fermions, , where is the free electron mass. 

**Fig. 1** (a) and vs. . Integers and fractions next to the traces mark filling factors. (b) vs. , at different temperatures from 0.3 K to 1.1 K. (c) Resistance oscillation amplitude normalized to temperature , at and , as a function of Solid lines are fits with , where is the cyclotron frequency of composite fermions.

**Conclusions**

We have observed and investigated the fractional quantum Hall effect in an ultrahigh-quality 2D hole

gas hosted in strained Ge quantum well. Due to large Zeeman energy, all observed states are spin polarized and can be described in terms of spinless composite fermions.

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**References**

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