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Observation of the quantum capacitance in a Cooper-pair transistor TIM DUTY, GOERAN JOHANSSON, KEVIN BLADH, DAVID GUNNARSSON, CHRIS WILSON, PER DELSING, Chalmers University of Technology — The effective capacitance of a single Cooper-pair box (SCB) can be defined as the second derivative of its energy with respect to gate voltage. This capacitance has two parts, the geometric capacitance, C_{geom}, and the quantum capacitance, C_Q. C_Q is due to the anti-level crossing caused by the Josephson coupling energy E_J, and depends parametrically on the gate voltage. This capacitance, which is dual to the Josephson inductance, can be substantially larger than C_{geom} as well as negative. To detect C_Q, we have measured the in- phase and out-of-phase rf-signal reflected from a Cooper-pair transistor (CPT), embedded in a resonant circuit. Under suitable biasing conditions the CPT acts as a SCB in series with a capacitance. It can be shown that the imaginary part of the reflected signal depends linearly on C_Q, and we can thus measure C_Q directly from the reflected signal as a function of the gate voltage. The measured data agrees well with the theoretical prediction assuming that the system is in the ground state. We can extract the ratio E_J/E_C for each of the two junctions in the CPT, where E_C is the charging energy of the CPT.

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