Euler buckling instability and enhanced current blockade in suspended single-electron transistors

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Single-electron transistors embedded in a suspended nanobeam or carbon nanotube may exhibit effects originating from the coupling of the electronic degrees of freedom to the mechanical oscillations of the suspended structure. Here, we investigate theoretically the consequences of a capacitive electromechanical interaction when the supporting beam is brought close to the Euler buckling instability by a lateral compressive strain (see Fig.1). Our central result is that the low-bias current blockade, originating from the electromechanical coupling for the classical resonator, is strongly enhanced near the Euler instability. We predict that the bias voltage below which transport is blocked increases by orders of magnitude for typical parameters (see Fig. 2). This mechanism may make the otherwise elusive classical current blockade experimentally observable.

References

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Figures

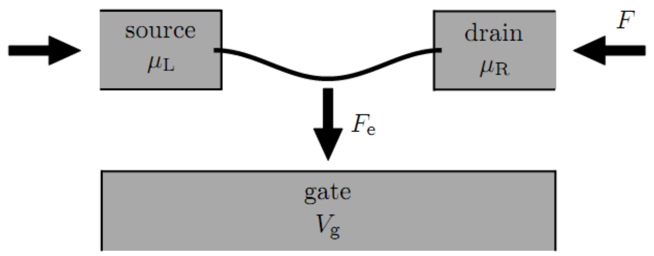

Fig. 1 Sketch of the considered system: a suspended doubly- clamped beam forming a quantum dot electrically connected to source and drain electrodes. The beam is capacitively coupled to a metallic gate kept at a voltage V_g, which induces a force F_e that attracts the beam towards the gate electrode. An additional, externally controlled compressional force F acts on the beam and induces a buckling instability

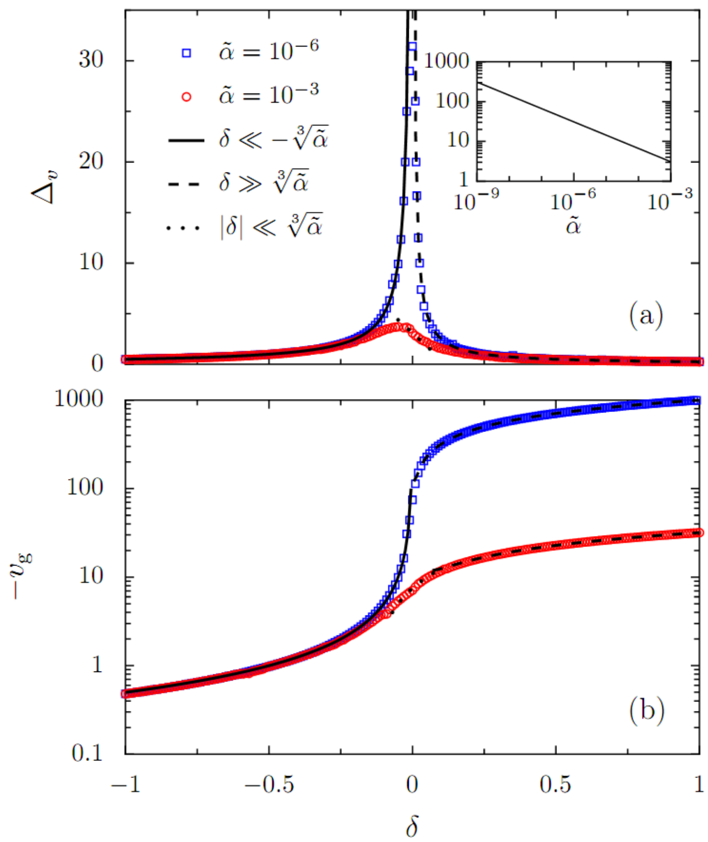

Fig. 2 Gap (a) and gate voltage position of the minimum gap in dimensionless units (b) as a function of the dimensionless distance from the transition point: $\delta = F/F_c - 1$, where F is the force acting on the rod, and F_c is the critical force. One can clearly see a great enhancement of the gap of the order of 30 times the original value at the transition point. The red and blue curves correspond to different values of the non-linear coupling.