Acoustic phonons and spin coherence in graphene nanoribbons

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A spintronics approach to quantum information science is considered promising due to the readily available expertise in solid state physics and possibly long coherence times [1]. We investigate a qubit implementation as real electron spin in graphene nanoribbon quantum dots. This system is particularly interesting because it allows for non-local coupling of qubits [2]. Spin coherence is determined by the coupling to nuclear spins and the lattice and the relaxation time T_1 depends on interaction with phonons. Starting from a continuum model, we derive a full phonon field theory for acoustical phonon modes in a graphene nanoribbon and at the center of the Brillouin zone. We consider fixed boundary conditions at the edges of the quasi-one-dimensional nanoribbon as well as open boundaries. In the latter case, the usual q^2-dependence for out-of-plane modes in bulk is cut off at the zone center (near $q = 0$), where we find a linear dispersion. The transverse and longitudinal sound velocities of the in-plane modes match the literature values for comparable systems [3] and, as expected, all modes approach bulk behavior for wavelengths much smaller than the ribbon width.

[1] D. Loss and D. P. DiVincenzo, Phys. Rev. A **57**, 120-126 (1998).
[2] B. Trauzettel et al., Nature Physics **3**, 192-196 (2007).
[3] L. A. Falkovsky, Phys. Lett. A **372**, 5189-5192 (2008).

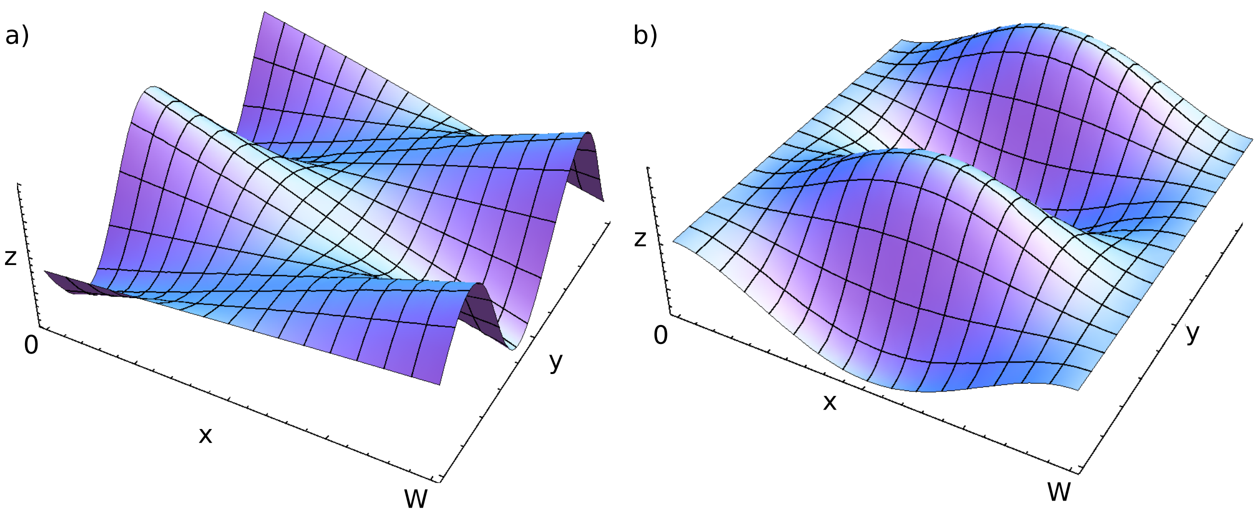

Figure: The graphene nanoribbon lies in the x-y-plane, with free (a) and fixed (b) boundaries at $x = 0, W$. The ribbon length is assumed to be much larger than the ribbon width, thus allowing for periodic boundaries in the y-direction. a) Acoustic out-of-plane mode for free boundaries. b) Acoustic out-of-plane mode for fixed boundaries. We also discuss in-plane modes.