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Lattice quantum electrodynamics for graphene

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(Submitted on 24 Jul 2011)

The effects of gauge interactions in graphene have been analyzed up to now in terms of effective models of Dirac fermions. However, in several cases lattice effects play an important role and need to be taken consistently into account. In this paper we introduce and analyze a lattice gauge theory model for graphene, which describes tight binding electrons hopping on the honeycomb lattice and interacting with a three-dimensional quantum U(1) gauge field. We perform an exact Renormalization Group analysis, which leads to a renormalized expansion that is finite at all orders. The flow of the effective parameters is controlled thanks to Ward Identities and a careful analysis of the discrete lattice symmetry properties of the model. We show that the Fermi velocity increases up to the speed of light and Lorentz invariance spontaneously emerges in the infrared. The interaction produces critical exponents in the response functions; this removes the degeneracy present in the non interacting case and allow us to identify the dominant excitations. Finally we add mass terms to the Hamiltonian and derive by a variational argument the correspondent gap equations, which have an anomalous non-BCS form, due to the non trivial effects of the interaction.

Comments:	44 pages, 6 figures
Subjects:	**Strongly Correlated Electrons (cond-mat.str-el)**; Statistical Mechanics (cond-mat.stat-mech); Mathematical Physics (math-ph)
Journal reference:	Annals of Phys. 327, 461-511 (2012)
DOI:	10.1016/j.aop.2011.10.007
Cite as:	**arXiv:1107.4741 [cond-mat.str-el]**
	(or **arXiv:1107.4741v1 [cond-mat.str-el]** for this version)

Submission history

From: Alessandro Giuliani [view email]
[v1] Sun, 24 Jul 2011 09:54:10 GMT (125kb)

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