The problem of two interacting Dirac electrons

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Motivation

- The existence of strong coupling phases in graphene has recently drawn a lot of attention. The possibilty of a phase transition, for strong enough coupling, to an insulating phase, has been addressed with a pletora of techniques.

- The simple two particle problem can already give insights into the many-body behavior of the system

- However, it is an interesting problem itself, as it shows peculiarities not present in the conventional Schrödinger problem

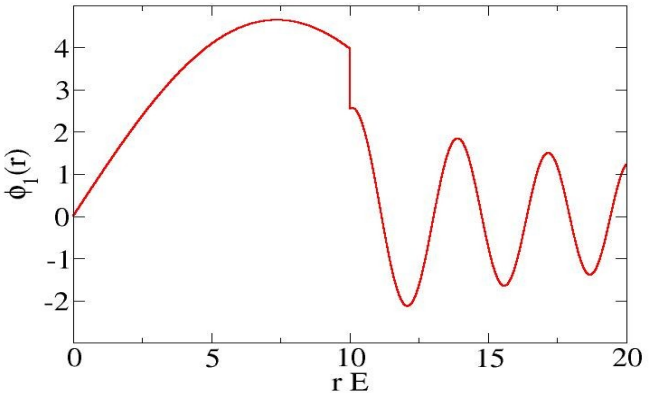
Main features

• Center-of-mass and relative coordinate do not decouple. A general exact solution for arbitrary center-of-mass momentum, K, has not be found.

• The case K = 0 is the most interesting when studying strong coupling phases. It also simplifies the problem, and allows to find exact solutions.

• Zero energy states have a non-trivial effect on the matching conditions of the wave functions, inducing jumps:

Step potential →



• For the Coulomb potential, there is also a critical coupling for which the vacuum breaks down, pointing at a possible instability (as already was found in the Coulomb impurity problem):

$$g_c = \sqrt{1+4(l+1)^2}$$