Infrared Problem in Cold Atom Adsorption on Graphene

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There has been some controversy [1] concerning the phonon-assisted adsorption of atomic hydrogen to suspended graphene at low energies; one numerical calculation predicts an enhancement of the adsorption rate in comparison to the rate on graphite [2], while another work has argued for a suppression of adsorption [3]. Recent theoretical results of the adsorption rate of atomic hydrogen to suspended graphene are presented using four different methods that include contributions from processes with multiphonon emission. We compare the numerical results of the atom self-energy obtained by: (1) the loop expansion of the atom self-energy, (2) the non-crossing approximation (NCA) [4], (3) the independent boson model approximation (IBMA) [5], and (4) a leading-order soft-phonon resummation method (SPR) [6].

The loop expansion reveals an infrared problem, analogous to the infamous infrared problem in QED. The 2-loop contribution to the sticking rate gives a result that tends to diverge for large membranes. The latter three methods remedy this infrared problem for a membrane at zero temperature and give results that are finite in the limit of an infinite membrane. At finite temperature, the divergence problems are exacerbated; only SPR gives a finite adsorption rate in the limit of an infinite membrane. For micromembranes (sizes ranging 100 nm to 10 μm) at zero temperature, the latter three methods give results that are in good agreement with each other and yield sticking rates that are mildly *suppressed* relative to the lowest-order golden rule rate; however, the SPR sticking rate decreases to *zero* with increasing membrane size for all temperatures. Thus, approximations to the sticking rate are sensitive to the effects of soft-phonon emission for large membranes, and multiphonon processes suppress the rate.

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