I. How many repulsive bosons will a short-ranged potential accept into a bound state?

II. Methods of calculation

The two regimes highlighted in Fig. 2 are qualitatively correct, but there are a couple of obvious shortcomings with the simple heuristic model (1) that one would like to be able to improve upon. For one thing, the simple model makes no mention of the dependence of the results on the spatial dimension. In three dimensions, the binding properties of short-ranged potentials depend on dimension, we treat the cases of general dimension between d/3 and d/2. We also expect that a localization length, or the size of the bound state, will swell in size as more and more repulsive bosons are added to it. This change of the localization length with the number of bound particles is also addressed in our calculation.

To address these issues our main method of attack is to be a self-consistent (or Hume-R Programming) treatment of the problem. Since the many-body problem is in general intractable, we deal with the problem using a novel approach. Here we introduce a simple heuristic model that encapsulates the key physics. Consider a short-ranged potential with a single particle energy level (1), as shown in Fig. 1. For a more realistic interaction between bosons, we can add N bosons into that same single-particle state for a net energy gain of N times the energy per particle (2).

III. The Bose interaction blockade and the atomic pipette

A short-ranged optical trap created by a laser acts as a pipette that withdraws atoms from the reservoir as a parameter Z is experimentally tunable.

Fig. 2b. The energy vs. particle number, for bosons in a short-ranged potential. In 2a, the short-ranged potential accepts a finite number of particles from the reservoir in order to minimize its energy. In 2b, the potential accepts a single particle to minimize its energy.

Fig. 3. A ‘piecemeal’ process of the atomic pipette. A Bose Einstein Condensate is used as a reservoir for atoms.

Fig. 4. A plot of the particle occupation number vs. tuning parameter Z (see Fig. 3 for an example of what Z can be for three different regions). The blue markers is the benchmark of the strong form of the Bose interaction blockade.