1. Res. Assoc. Amy Nicholson

A. *Lattice Method for Many-Body Systems*

The experimental study of trapped, ultracold atoms has provided impetus to explore such systems computationally, particularly near the limit of "unitarity", where the two-particle s-wave scattering length diverges relative to the inter-particle spacing, which in turn is much greater than the range of the interaction. In this regime, all scales relevant to the interaction vanish and the system is strongly interacting and conformal. This insensitivity to the scale of the interaction allows one to extract physical quantities which are universal in nature. Thus, in addition to being directly relevant to cold atom experiments, numerical studies of this system serve as a stepping stone to more complicated systems such as nuclei, where s-wave scattering lengths are unnaturally large compared to the range of the interaction.

A recently developed lattice method for describing unitary fermions allows us to explore several issues of wide interest in lattice field theory: in particular, how to extract the properties of conformal systems from calculations at finite lattice spacing, volume, and particle density, and how to construct optimal interpolating fields for strongly interacting, many-fermion systems. In addition, we've developed a method for extracting observables from quantities with long-tailed distributions, which may be ubiquitous in lattice calculations involving large numbers of particles. We have used these methods to calculate the ground state energies of up to N=66 unitary fermions in a box and up to N=70 unitary fermions in a harmonic potential for even N. Details of this work may be found in PoS LATTICE2010 (2010) 182, e-Print: arXiv:1011.3089 [hep-lat], PoS LATTICE2010 (2010) 206, e-Print: arXiv:1011.2804 [hep-lat], PoS LATTICE2010 (2010) 197, e-Print: arXiv:1011.3026 [hep-lat], e-Print: arXiv:1106.0073 [hep-lat], "Unitary fermions on the lattice", Endres, M. G., Kaplan, D. B., Lee, J-W, Nicholson, A. N. (*in preparation*).

Our next step will be to extend this study to odd numbers of particles. By combining the results for odd and even N we will be able to calculate the pairing gap, which gives insight into the superfluid properties of the system. Then, we will relax the constraint of infinite scattering length to extract a quantity known as the integrated contact density, which has been shown to have relevance for a wide variety of observables in cold atom experiments. Following, we would like to explore the possibilities of studies of bound states using our new method, beginning with N-body clusters of unitary bosons, known as Efimov states. We will then consider more complicated interactions to study systems of nucleons and nuclei.

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