Research Interests

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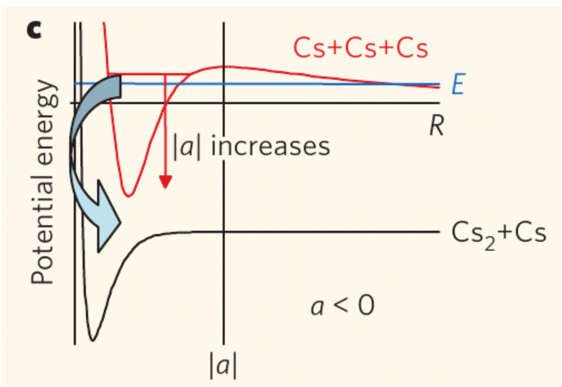
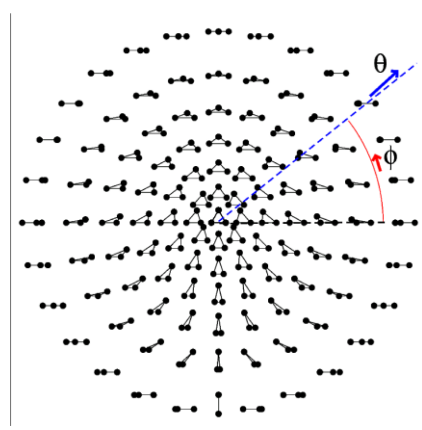
My research interests revolve around developing computational and theoretical methods to study three-body scattering in cold and ultracold molecular and atomic systems. Three-body collisions are important to ultracold quantum gases because they place a limit on the lifetime of Bose-Einstein condensates (BECs – a state of matter where a large fraction of the bosonic particles occupy the lowest quantum state available, and can be described by a single wavefunction). At the same time, three-body phenomena in these gases have exhibited novel physics such as Efimov states (where the existence of an infinite set of loosely bound three-body states is possible in the absence of two-body bound states), production of molecular Bose-Einstein condensates, and magnetically controlled chemistry. As a postdoc, I worked with Prof. Gregory Parker and other collaborators on developing theoretical and computational methods to study Efimov physics. Efimov physics was experimentally observed for the first time in 2006, over three decades after its original prediction. With regards to this work, I have co-authored a National Science Foundation three-year proposal with Prof. Parker.



Proposed mechanism for three-body recombination in BECs. Esry et al. Nature 440, 289 (2006)

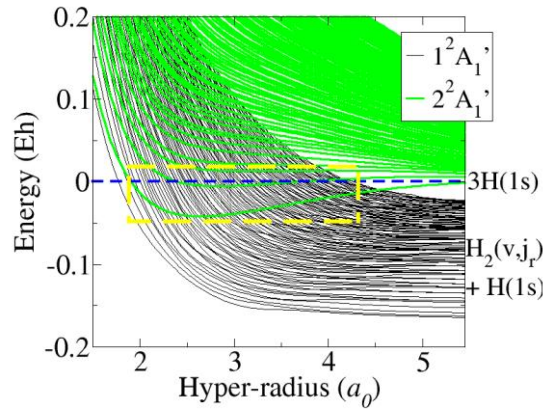
Topics I have worked on during my PhD include the effect of the geometric (Berry phase) on three-body quantum dynamics, calculations of three-body Efimov resonances and bound states in ultracold systems, and developing methods to calculate three-body recombination rates using the coupled-channel approach, which is of special interest in astrophysics where recombination of hydrogen plays a prominent role. To develop these methods, we rely consistently on the use of hyperspherical coordinates, with symmetry considerations, coupled with the slow-variable discretization method to solve the three-body Schrodinger equation. Other methods employed are



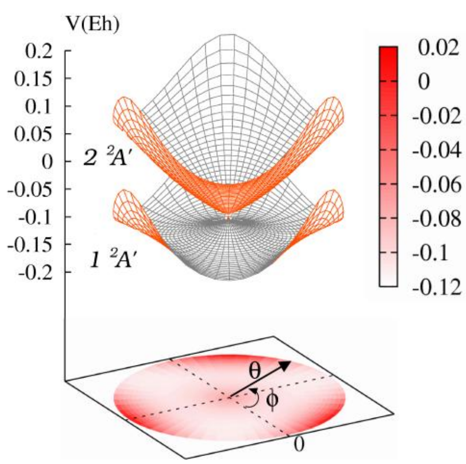
Hypersphere, at fixed hyper-radius, displaying hyperangles (θ, φ)

the scattering matrix calculations using the R-matrix and a Numerov propagator.

In future work, I would like to continue developing the aforementioned areas of study and to delve into the coherent control of atomic/molecular processes using photoassociation and magnetic Feshbach resonances. This latter topic may turn out to be a viable route for achieving ultracold molecular quantum gases. In addition, I have recently started looking at developing software on graphics cards using CUDA for the purposes of high performance parallel computations. I am also interested in the use of android devices to enhance classroom experience or for medical applications.



Hyperspherical adiabatic potentials for H_3



Two lowest Born-Oppenheimer approximation doublet electronic potentials of H_3 are degenerate at equilateral configuration.

Involving undergraduate students in this research work is quite straightforward. It will require learning some computer programming language (most of my work is in Fortran, but I am able to work with students that prefer other languages such as Python, C++, etc...), and the level of involvement will depend on the level of physics and mathematics background of the student. A student with a first semester of physics and a willingness to learn computer programming will be able to get involved at the most basic level. More detailed information and references (including my thesis and related publications) may be found at www.nhn.ou.edu/~blandon. Please send any inquiries to blandon@nhn.ou.edu