Elastic Collision Phenomena in Quantum Gases

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Abstract

This course consist of five lectures on elastic collision phenomena of neutral atoms under conditions typical for quantum gases. The atoms are presumed to move slowly, typically at large separation, and to interact pair wise through a potential of the Van der Waals type.

1. *Relative motion of interacting particles I.*
   We introduce model potentials our analysis of the collisional motion two characteristic length scales will appear, the *interaction range* r_0, the *scattering length* a, each expressing a different aspect of the interaction. The s-wave scattering length is the central parameter for the theoretical description of quantum gases. It determines both the *thermodynamic* and the *collisional properties* of these gases.

2. *Relative motion of interacting particles II.*
   Continuing with model potentials we introduce the *effective range* r_e as a measure for the energy dependence of the collision properties. Of particular importance for ultracold gases are resonance phenomena near threshold. We distinguish between s-wave resonances in the presence of a weakly-bound or virtual level near threshold.

3. *Scattering of interacting particles*
   In this lecture we introduce the scattering amplitude as well as the differential and total cross section. We see how these properties depend on the statistical nature of indentical particles. This determines the basic collisional physics of bosonic and fermionic quantum gases.

4. *Scattering of atoms*
   When dealing with atoms the collisions are affected by the internal structure of the particles. We discuss how the interactions are affected by the internal structure and illustrate this for the case of alkali atoms.

5. *Feshbach Resonances*
   Taking advantage of the internal structure of the atoms it is possible to vary *in situ* the interaction between atoms using a magnetic field. We discus this in detail for the example between lithium and potassium atoms.

The lectures are given in the form of Powerpoint resentations and are acompanied by a detailed set of lecture notes where lots of additional information can be found. Both the presentations and the lecture notes are made available during the School.