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Few-body physics in ultracold gases

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The physics of few body systems plays a fundamental role in the understanding of ultracold atoms loaded in traps or optical lattices. Whereas the ultracold three-body physics can be considered to a large extent as understood, the next step in complexity –four interacting particles– remains largely unsolved. My talk presents new solutions of the challenging four-body problem, focusing mainly on the behavior of strongly interacting fermions and bosons. These accurate solutions are extended to different regimes and systems by combining a number of powerful numerical techniques: correlated -Gaussian basis-set expansion, diffusion Monte Carlo and the hyperspherical method. First, the spectrum and dynamics are analyzed for two spin-up and two spin-down fermions in the "BCS-BEC" crossover, which reveals the nature of dimer-dimer interactions. The calculations at unitarity show that systems with up to N=6 particles follow universal behavior that manifests in the spectrum and wave functions. The calculations are then extended to larger systems, which connects few- and many-body physics. Next, in the context of the four-boson problem, the four-body physics is shown to be intimately related to three-body Efimov physics, which leads to a universal picture for bosons and makes concrete predictions of dimer-dimer collisions and four-body recombination processes.