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Universality of quantum halo states

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Abstract

The results of the recent research in quantum halo systems will be presented. Ground state of weakly bound systems consisting of few particles with a radius extending well into the classically forbidden region is explored, with the goal to test the universality of quantum halo states. The focus of the study are clusters consisting of Tâ†“, Dâ†“, 3He, 4He and alkali atoms, where interaction between particles is much better known than in the case of nuclei, which are traditional examples of quantum halos. The study of realistic systems is supplemented by model calculations in order to analyze how low-energy properties depend on the interaction potential. The use of variational and diffusion Monte Carlo methods enabled very precise calculation of both size and binding energy of the trimers and tetramers. Using dimensionless measures of the binding energy and cluster size, studied atomic clusters are compared to other known halos in different fields of physics. Characteristic scaling lengths, which make size-energy ratio to be universal, are selected. In the quantum halo regime, and for large values of scaled binding energies, all dimers and trimers follow almost the same universal line. As the scaled binding energy decreases, tango type trimers separate from Borromean type. Research is extended to tetramers. Furthermore, the structural properties of different trimers are compared with recently published experimental results obtained by Coulomb explosion imaging of diffracted clusters.