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Towards quantum systems with customized inter-particle interactions

Recent experiments with ultra-cold polarized clouds of chromium ^{52}Cr dysprosium ^{164}Dy and erbium ^{168}Er can be considered as a very successful step towards control and manipulation of the overall shape of the inter-particle interaction potentials. The perspective of working with quantum systems where the inter-particle interaction is customized encourages us to get a deeper insight on a role it plays. The role of the sign is evident: if it is negative - the system is attractive, if it is positive - repulsive, but what roles are playing its range and tails? What physical phenomena or properties they are envisioned to impact? Here we theoretically show that strong inter-particle repulsion inevitably leads to macroscopic multi-hump fragmentation of trapped Bose-Einstein condensates in the ground state. The fragmentation phenomenon is universal - it takes place in traps of different dimensionality and topologies and for very broad classes of repulsive inter-particle potentials. A particular scenario of fragmentation, namely, the number of fragments, their shapes and occupations, is controlled by the ratio between the length of the trap and width of the inter-particle interaction function. The tails of the interaction function are found to be responsible for melting or blurring of the fragmentation.

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