Efimov spectrum in bosonic and fermionic systems with increasing number of particles

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When the two-body scattering length a of two identical bosons goes to $\pm\infty$, the three-boson spectrum shows the Efimov effect. In this limit, the unitary limit, an infinite set of bound states, E_3^n, appears approaching zero in a geometrical progression. In other words, the $L = 0$ sector of three identical bosons presents a discrete scaling invariance (DSI). As the absolute value of a takes finite values, the highest bound states disappear into the atom-dimer continuum ($a > 0$) or in the three-atom continuum ($a < 0$). In recent years the spectrum of the three-boson system has been extensively studied in the $(1/a, \kappa)$ plane, with $\kappa^2 = mE/\hbar^2$ [1]. When one boson is added to the system, the four-body system at the unitary limit presents two bound states, one deep (E_4^0) and one shallow (E_4^1) with the following ratios, $E_4^0/E_3^0 \approx 4.6$ and $E_4^1/E_3^0 \approx 1.001$, having an universal character [2]. This particular form of the spectrum has been recently studied up to six bosons [3].

In the present work we will show the spectrum of A bosons for $A \leq 16$ and we will analyze the case of fermions up to $A \leq 6$. For bosons, we compute different universal ratios, E_A^0/E_3^0 and E_A^1/E_A^0, in the region $-\infty < a < 0$ to see the consequence of the three-boson DSI in the A-body system. For the $a > 0$ case, as $a \rightarrow r_0$ with r_0 the interaction range, we will show how the Efimov picture changes, losing the DSI.

In the case of fermions we will analyze the Efimov spectrum in terms of the singlet $S = 0$ and triplet $S = 1$ scattering lengths a_S. Considering spin-isospin degrees of freedom we will show how the nuclear spectrum emerges naturally by fixing a_S to the physical values. Following the indications of the Effective Field Theory at leading order, we introduce a three-body force fixed to reproduce the ^{3}H binding energy and we compute the ^{4}He, ^{6}He and ^{6}Li binding energies. This study links the binding energy of light nuclei to the Efimov picture.

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