Role of the interaction core in the excitation spectrum of 1D gases and liquids

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We consider a zero-temperature 1D continuous system of bosons interacting via various short-range potentials. We employ Path Integral Ground State simulations, which allow for the exact calculation of many-body static and imaginary-time correlations, and a stochastic analytic continuation method (GIFT) to extract the dynamical structure factor. When the interaction potential features a hard core of size a, such as in the hard-rods model or in liquid helium, the high-density regime is characterized by a typical quasi-periodic spectrum, with uniform bands at momenta which are multiple of $2\pi/a$. If the potential is instead flat at short distances, such as in the shoulder interaction of Rydberg gases, the system enters a high-density cluster phase. This is characterized by the spectrum of a harmonic chain, which is gapless at the multiples of a momentum depending on the range of the potential. Luttinger theory is adapted to describe this phase. In the homogeneous regime, a rotonic spectrum marks the tendency to clusterization.

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