RVM trial functions.

It is remarkable that the numerical results of the present theory were found in all tested cases to be amenable (if so desired) to an agreement within machine precision with exact-diagonalization (EXD) results, including energies, wave functions, and overlaps. This numerical behavior points toward a deeper mathematical finding, i.e., that the RVM trial functions for both statistics provide a *complete* and *correlated* basis (see below) that spans the translationally invariant (TI) subspace [5] of the LLL spectrum. An uncorrelated basis, without physical meaning, built out of products of elementary symmetric polynomials is also known to span the (bosonic) TI subspace [38].

For the sake of clarity, we comment here on the use of the terms "correlated functions" and/or "correlated basis." Indeed, the exact many-body eigenstates are customarily called correlated when interactions play a dominant role. Consequently, a basis is called correlated when its members incorporate/anticipate effects of the strong two-body interaction a priori (before the explicit use of the two-body interaction in an exact diagonalization). In this respect, Jastrow-type basis wavefunctions (e.g., the Feenberg-Clark method of correlated-basis functions [39–41] and/or the composite-fermion basis [18, 19, 42, 43]) are described as correlated, since the Jastrow factors incorporate the effect of a strong two-body repulsion in keeping the interacting particles apart on the average. Our RVM basis is referred to as correlated since, in addition to keeping the interacting particles away from each other, the RVM functions incorporate the strong-two-body-repulsion effect of particle localization in concentric polygonal rings and formation of Wigner molecules; this localization effect has been repeatedly demonstrated via EXD calculations in the past decade (see, e.g., the review in Ref. [15] and references therein). In this spirit, we describe the basis of elementary symmetric polynomials as "uncorrelated," since the elementary symmetric polynomials do not incorporate/anticipate this dominant effect of a strong two-body repulsion, i.e., that of keeping the interacting particles apart.

We are unaware of any other strongly-correlated functions which span the TI subspace. Indeed, although the Jastrow-Laughlin function (used for describing yrast states) is translationally invariant, its quasi-hole and quasi-electron excitations are not [5]. Similarly, the compact composite-fermion trial functions are translationally invariant [30], but the CF excitations which are needed to complete the CF basis are not [18, 19, 42, 44]. The shortcoming of the above well known correlated LLL theories to satisfy fundamental symmetries of the many-body Hamiltonian represents an unsatisfactory state of affairs, and the present paper provides a remedy to this effect. In this context, we note that although the Moore-Read functions [7] are also translationally invariant, they address only certain specific LLL states and they do not form a basis spanning the TI subspace.

Our introduction of a correlated basis that spans the

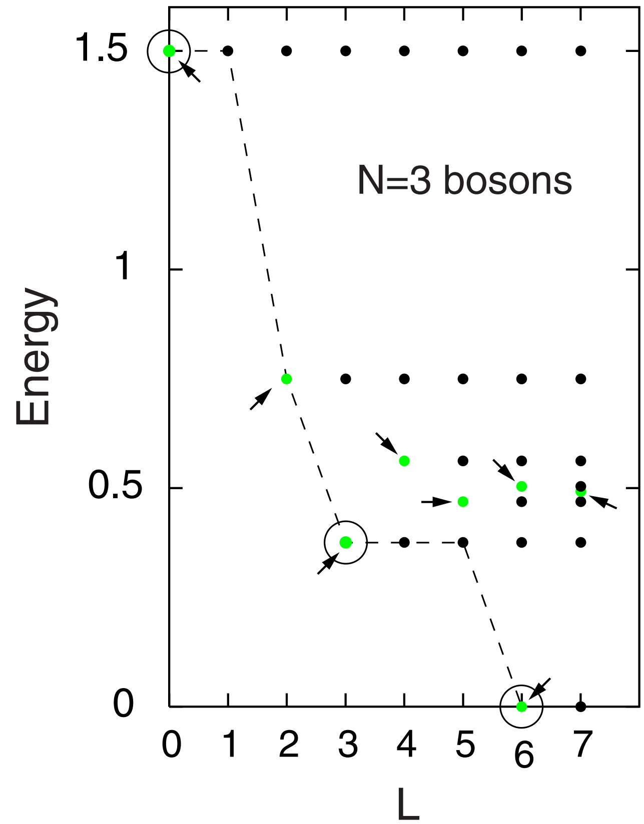

FIG. 1: (Color online) LLL spectra for $N = 3$ scalar bosons calculated using exact diagonalization. Only the Hamiltonian term containing the two-body repulsive contact interaction, $g\delta(z_i - z_j)$, [see Eq. (3)] was considered in the exact diagonalization. The gray solid dots (marked by arrows; green online) denote the translationally invariant states. The dark solid dots are the spurious states (see text). The dashed line denotes the yrast band, while the cusp states are marked by a circle. Energies in units of $g/(\pi\Lambda^2)$. The number of translationally invariant states is much smaller than the total number of LLL states.

TI subspace is of importance in the following two ways: (1) From a practical (and calculational) viewpoint, one can perform controlled and systematic stepwise improvements of the original strongly-correlated variational wave function, e.g., the pure REM or RBM. (For detailed illustrative examples of the rapid-convergence properties of the RVM basis, see the Appendix.) This calculational viewpoint was also the motivation behind the introduction of other correlated bases in many-body physics; see, e.g., the treatment of quantum liquids and nuclear matter in Refs. [39–41] and the composite-fermion correlated basis in Refs. [18, 19, 42, 43]. (2) Conceptually, it guarantees that the properties of the RVM functions, and in particular the molecular point-group symmetries, are irrevocably incorporated in the properties of the exact LLL wave functions. Furthermore, it follows that all other translationally invariant trial functions (e.g., the JL, compact CF, or Moore-Read functions), are reducible