Rapidly rotating few bosons with long or short range repulsion: An exact diagonalization study

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Phys. Rev. A ***75***, 023620 (2007)

Hamiltonian in the LLL

We diagonalize:

$$H_{LLL} = \hbar(\omega_\perp - \Omega)\hat{L} + \sum_{i<j}^{N} v(\,\mathbf{r}_i - \mathbf{r}_j\,)$$

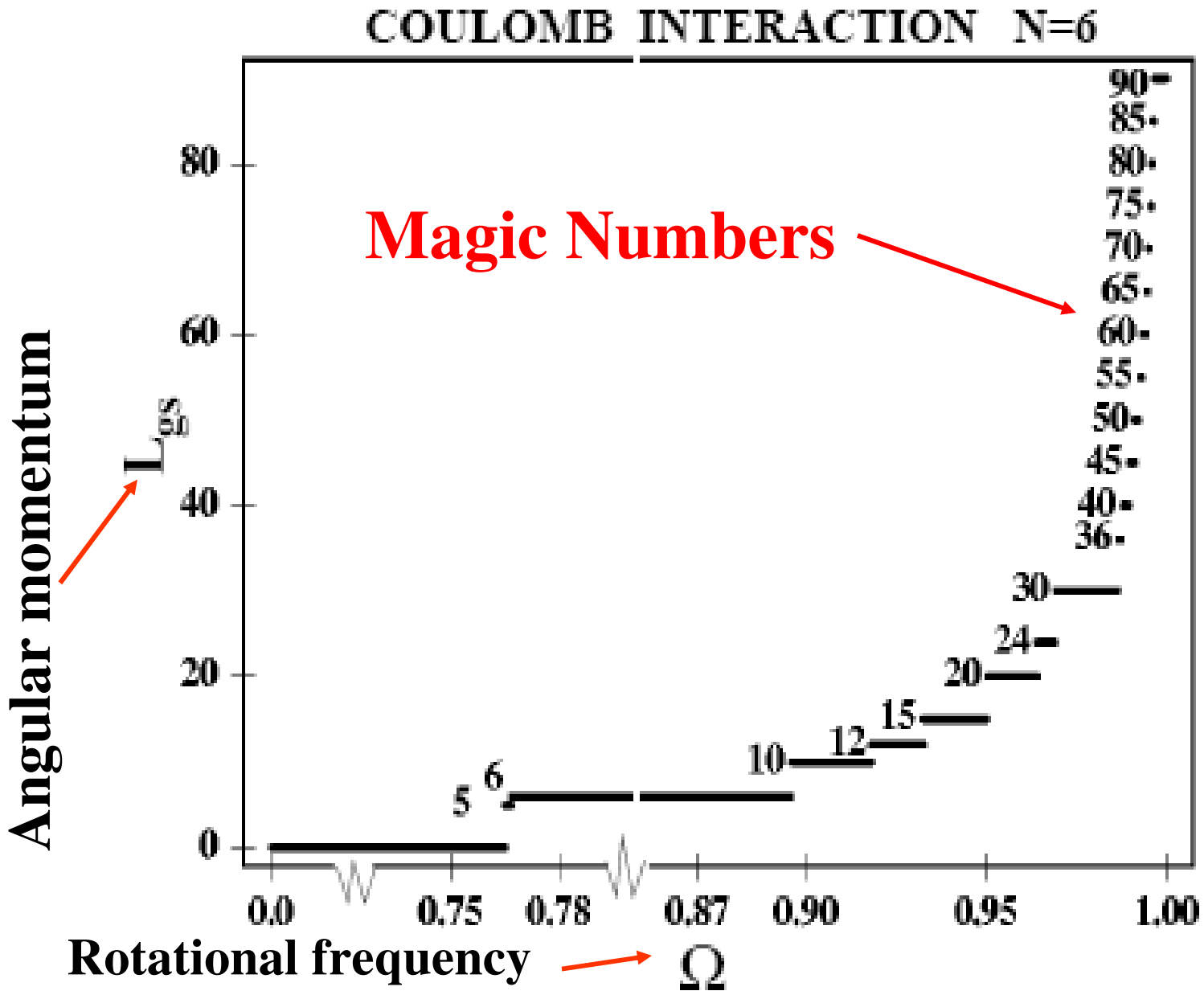
where $v(\mathbf{r}) = g\delta^2(\mathbf{r})$ OR $v(r) = \dfrac{c}{|\mathbf{r}|}$

using the basis of symmetrized wave functions (Permanents):

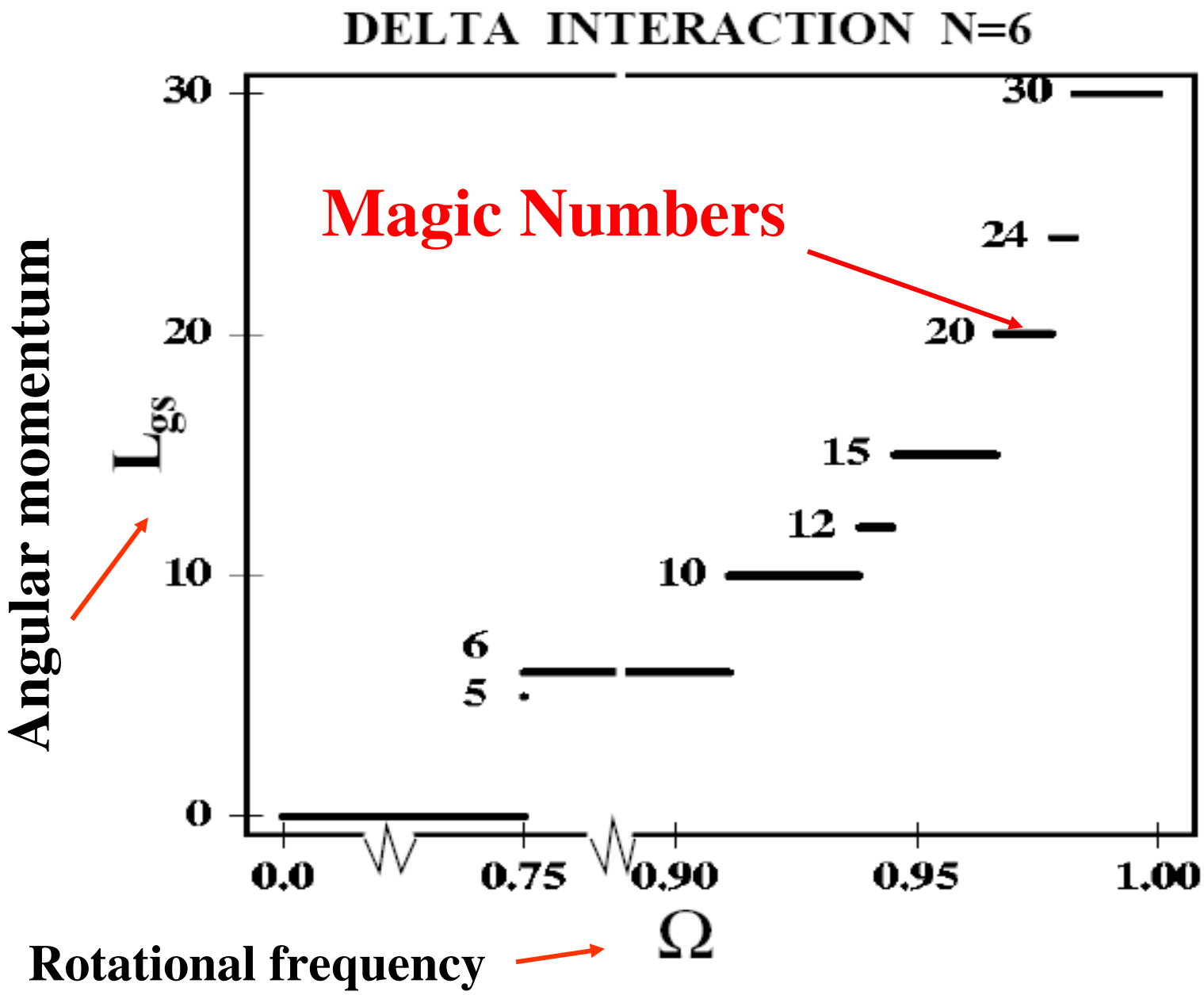
$$\Phi_A = \sqrt{\frac{n_1!n_2!\ldots n_M!}{N!}} \sum_P u_{P_{\alpha 1}}(1)u_{P_{\alpha 2}}(2)\ldots u_{P_{\alpha N}}(N)$$

Filling factor: ν=N(N-1)/(2L)

Ground states & Magic numbers

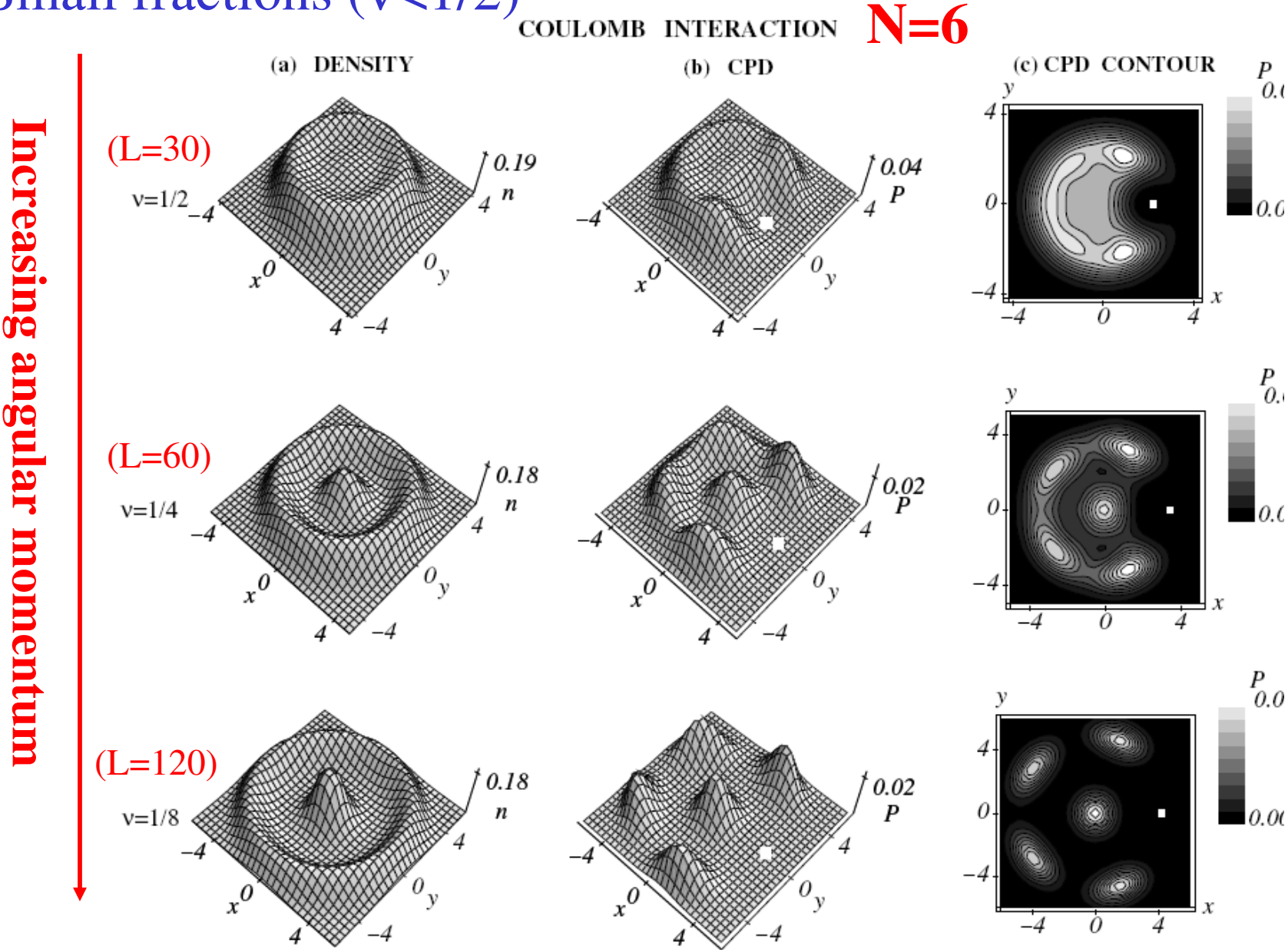


Ground states & Magic numbers

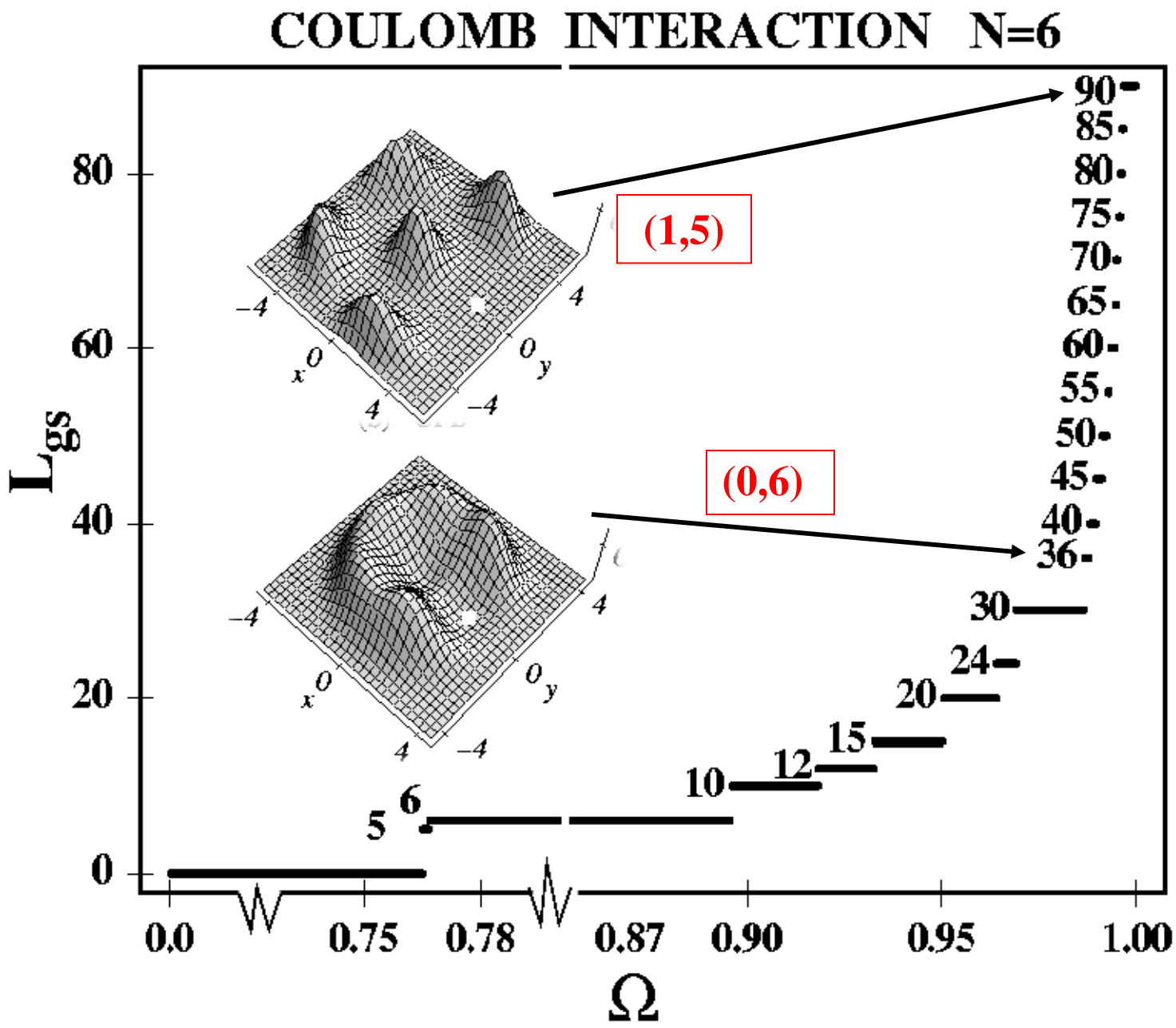


Formation of Rotating Boson Molecules (RBMs):

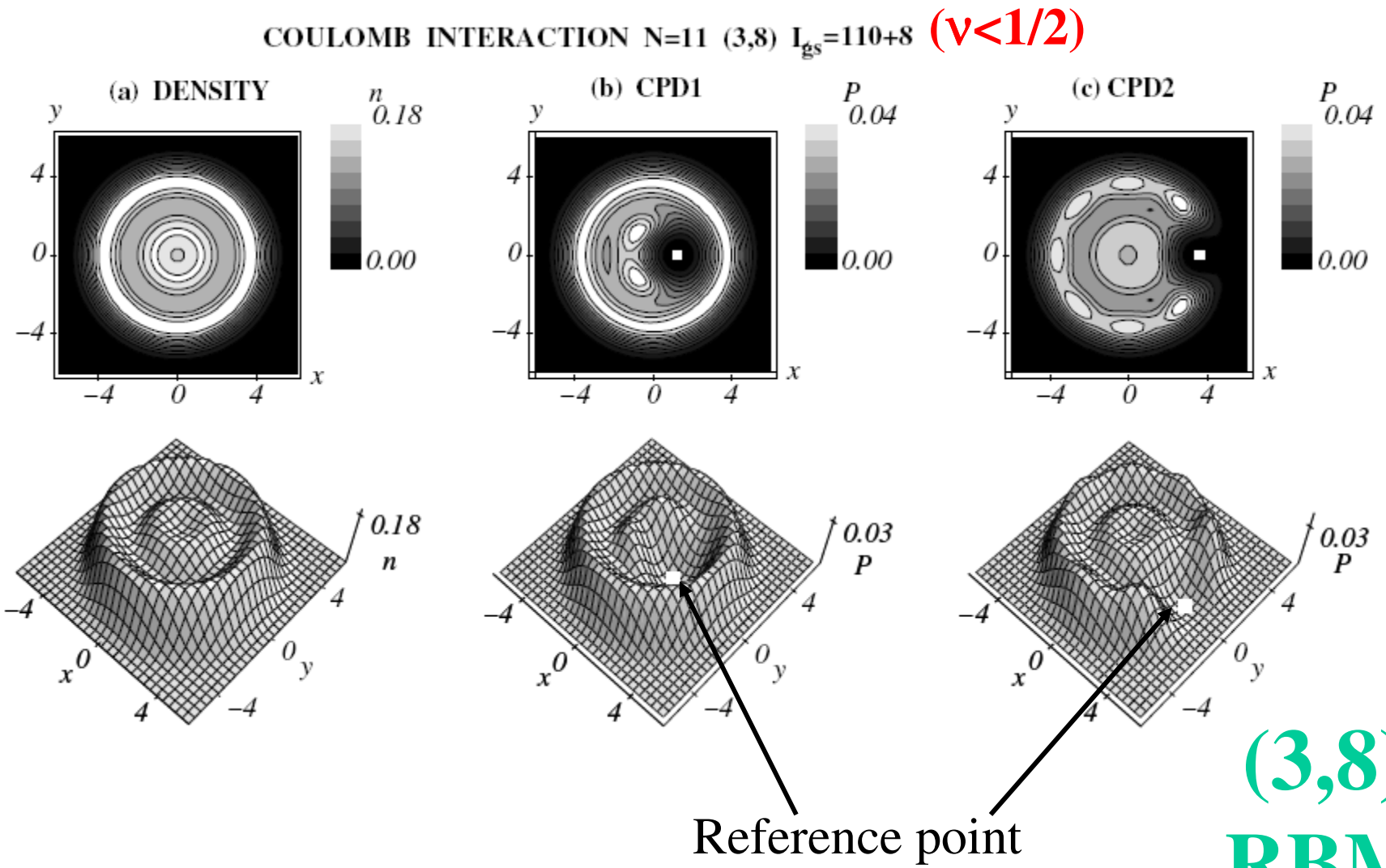
Small fractions (ν<1/2)



RBMs, isomers, and the spectrum



Larger size N: multiple rings (Coulomb)



(ν<1/2)

(3,8)

RBM

Particles on different rings rotate independently

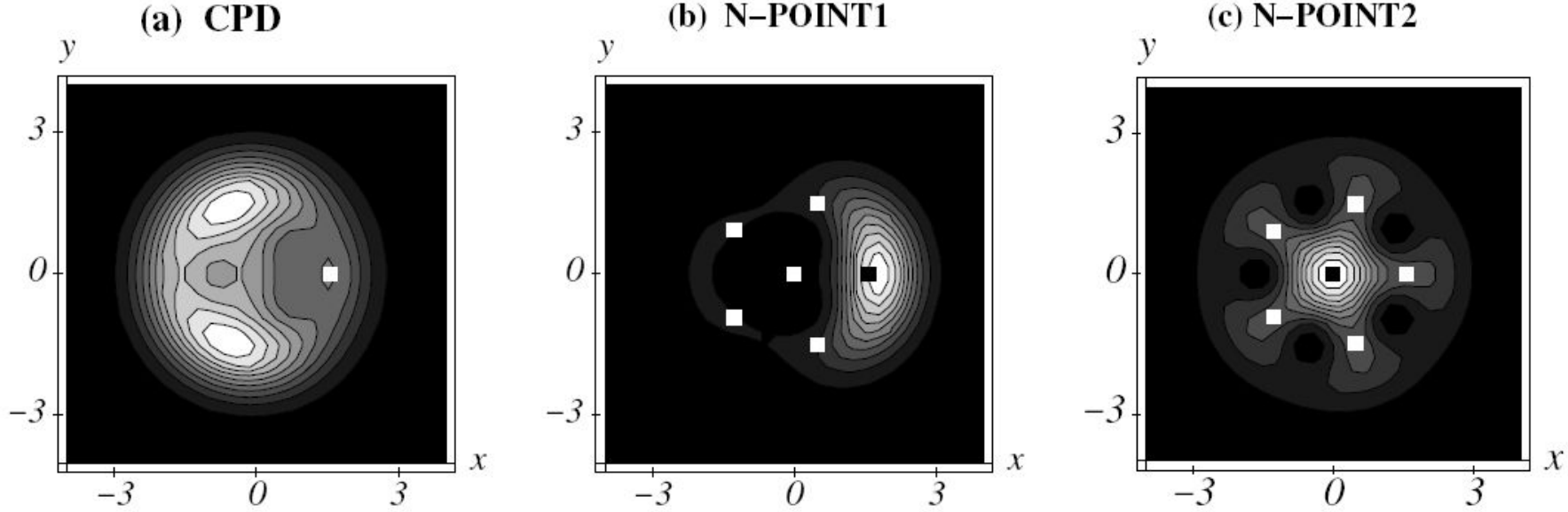
Higher order correlation functions

N-point correlation is calculated by:

$$P(\mathbf{r};\mathbf{r}_1,\mathbf{r}_2,\ldots,\mathbf{r}_{N-1}) = \left|\Psi(\mathbf{r};\mathbf{r}_1,\mathbf{r}_2,\ldots,\mathbf{r}_{N-1})\right|^2$$

Reveals formation of RMB at low angular momenta (large fractions: ν>1/2) even when 2-point (CPD) does not

a)2-POINT COULOMB INTERACTION N=6 L_{gs}=15 (ν=1)

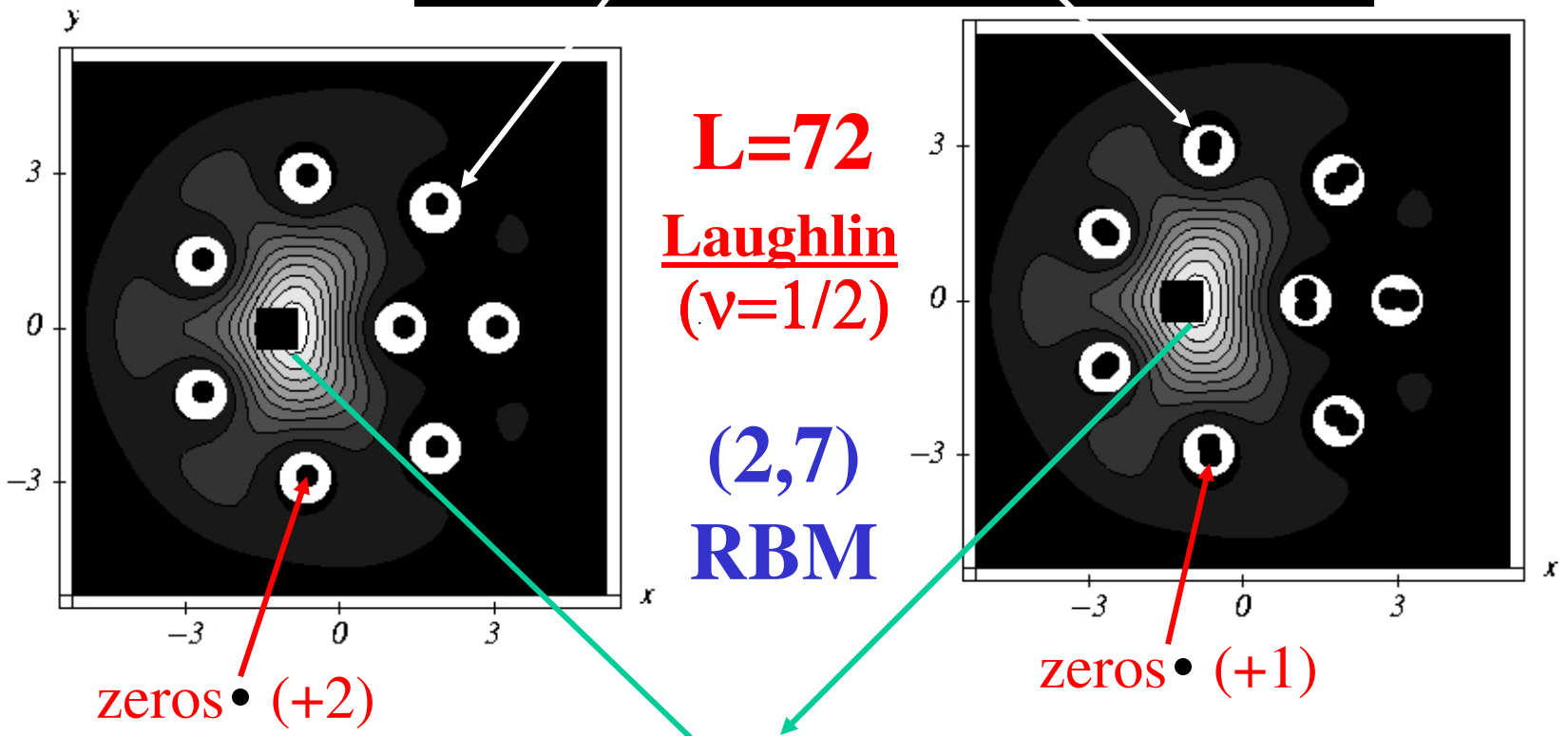


N=9; Zeros of N-point correlation

Delta interaction

Coulomb interaction

Fixed particle positions (●)



L=72

Laughlin

(ν=1/2)

(2,7)

RBM

Calculated position of the 9-th particle (■)

Zeros for the 2 different interactions differ in charge

Conclusions

- The emerging crystalline structure (RBMs) in finite systems of rotating bosons does not depend strongly on range of interaction.

- For crystalline structures with multiple rings the rings rotate independently of each other.

- For larger fractions (smaller angular momenta) identification of crystalline structures requires higher-order (e.g. N-point) correlation functions.

- The ground states for various interaction ranges may be distinguished by the behaviour of the zeros of the N-point correlation.

For references see: Phys. Rev. A ***75***, 023620 (2007)