Topological phonons trapped Rydberg atoms

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Consider a system of N atoms interacting through some interaction potential V_{int}. Each atom is confined in a optical tweezer in which they perform quantized oscillatory motion characterized by the trap frequency ω.

$$H = V_{\text{int}} + H_0 = V_{\text{int}} + \frac{1}{2m}\sum_i \sum_\alpha (p_i^\alpha)^2 + \frac{m}{2}\sum_i \sum_\alpha \omega^2 (q_i^\alpha)^2, \tag{1}$$

where q_i^α is the displacement around the equilibrium position in the α-direction.

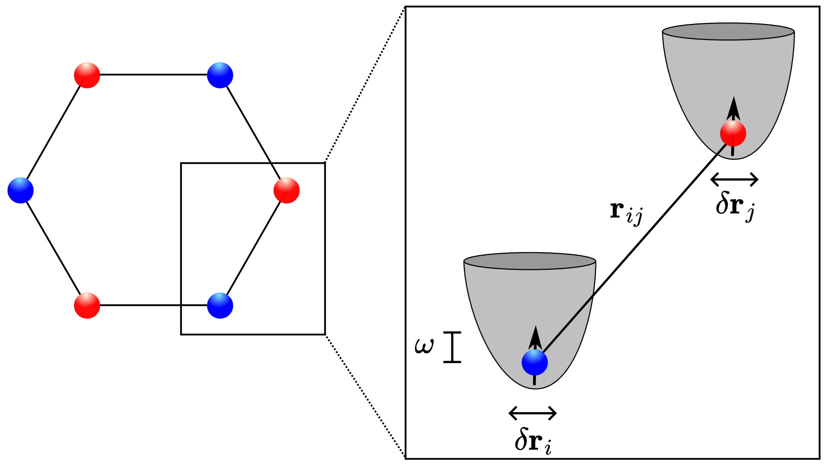

FIG. 1. *Rydberg atoms in a hexagonal lattice.*

Assuming that the displacement around the equilibrium positions are small, we can introduce the so-called dynamical matrix describing the vibrations

$$D_{ij}^{\alpha\beta} = m\omega^2 \delta_{\alpha\beta}\delta_{ij} + \left.\frac{\partial^2 V_{\text{int}}}{\partial r_i^\alpha \partial r_j^\beta}\right|_{\mathbf{r}_{i,j}=\mathbf{r}_{i,j}^{(0)}}. \tag{2}$$

The Hamiltonian can now be written in terms of the dynamical matrix as

$$H = \frac{1}{2m}\sum_i \sum_\alpha (p_i^\alpha)^2 + \frac{m}{2}\sum_{ij}\sum_{\alpha\beta} D_{ij}^{\alpha\beta} q_i^\alpha q_j^\beta, \tag{3}$$

Introducing the phonon operators

$$a_i^\alpha = \sqrt{\frac{M\omega}{2}} q_i^\alpha + i\sqrt{\frac{1}{2M\omega}} p_i^\alpha, \tag{4}$$

we can write the Hamiltonian describing the vibrations as

$$H = \sum_{ij}\sum_{\alpha\beta} D_{ij}^{\alpha\beta\prime} a_i^{\alpha\dagger} a_j^\beta, \tag{5}$$

describes "hopping" of phonons. Can look at Chern number of the phonon bands, phonon edge modes etc.