Journée des nouveaux entrants du Pôle Théorie

Implementation of nuclear and many-body problems on Rydberg atoms quantum computers

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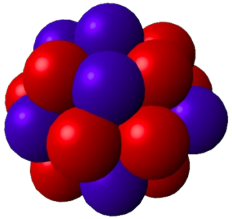
Supervisors :
Denis Lacroix (IJCLab)
Vittorio Somà (CEA Saclay)

Before starting a PhD

- M2 QLMN (about quantum physics)
- M2 ICFP (about theoretical physics)

The PhD project

Implementation of nuclear and many-body problems
on Rydberg atoms quantum computers



Physical system

The PhD project

$$\hat{H} = \sum_{ij} h_{ij}^{(1B)} a_i^\dagger a_j + \sum_{ijkl} h_{ijkl}^{(2B)} a_i^\dagger a_j^\dagger a_l a_k + \ldots$$

Hamiltonian in second quantization form

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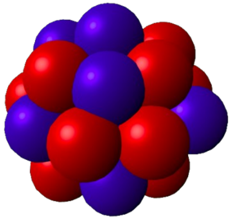

Physical system

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Jordan-Wigner Transformation :

$$a_\nu^\dagger \longrightarrow \left(\prod_{k=1}^{\nu-1}(-Z_k)\right)\left(X_\nu + iY_\nu\right)$$

$$a_\nu \longrightarrow \left(\prod_{k=1}^{\nu-1}(-Z_k)\right)\left(X_\nu - iY_\nu\right)$$

Conserve fermionic commutation relations :

$$\{a_\mu^\dagger, a_\nu\} = \delta_{\mu\nu} \ , \quad \{a_\mu^\dagger, a_\nu^\dagger\} = 0 \ , \quad \{a_\mu, a_\nu\} = 0$$

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Hamiltonian in second quantization form

X_ν, Y_ν, Z_ν : Pauli operators

$$X = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad Y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \quad Z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

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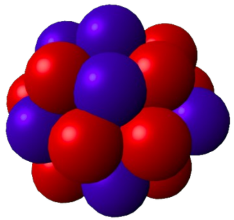

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Hamiltonian in second quantization form

$$JWT[\hat{H}] = \sum_{\sigma_1 \dots \sigma_N \in \{I,X,Y,Z\}} \lambda_{\sigma_1 \dots \sigma_N} \hat{\sigma}_1 \dots \hat{\sigma}_N$$

Transformed Hamiltonian as combination of Pauli terms

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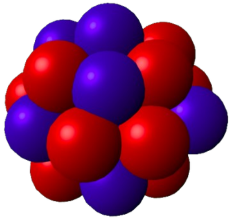

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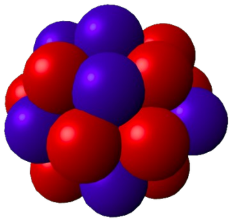
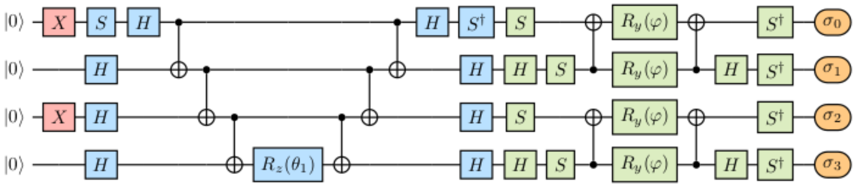


Physical system



Quantum circuits

The PhD project

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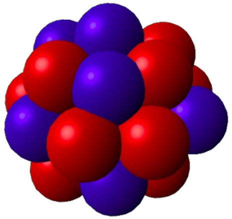
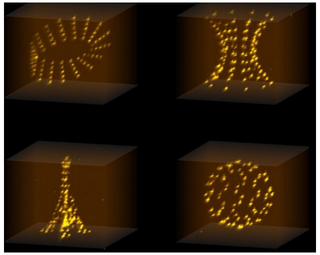
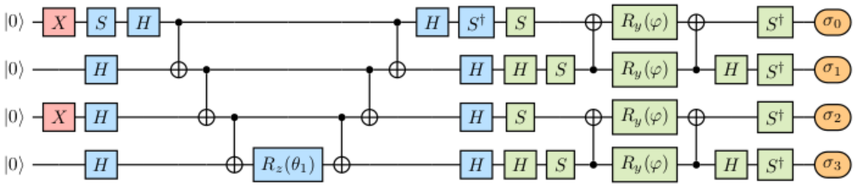


Physical system

PASQAL





Quantum circuits

Thanks for your attention