



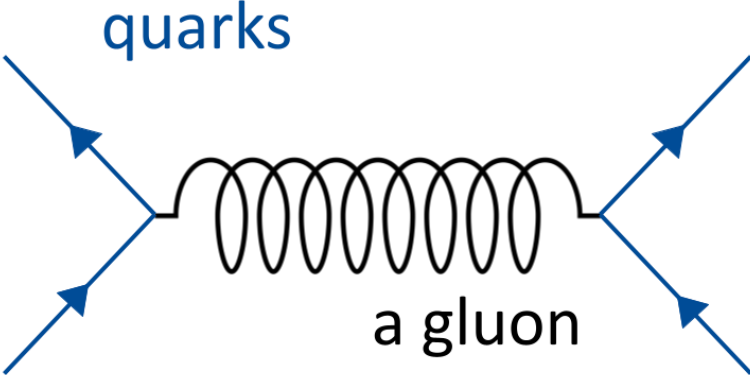
## **Gluon Digitization for Lattice QCD Simulations on Quantum Computers**

Anna Janni

Supervisors: Hank Lamm and Ruth Van de Water

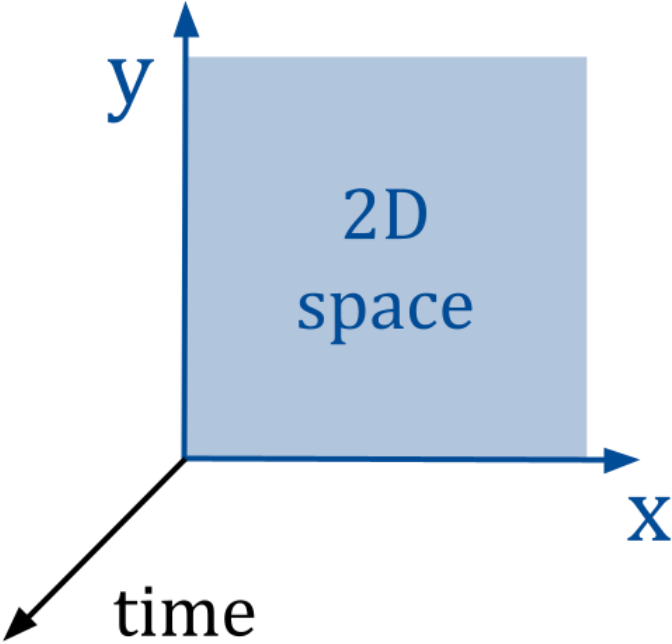
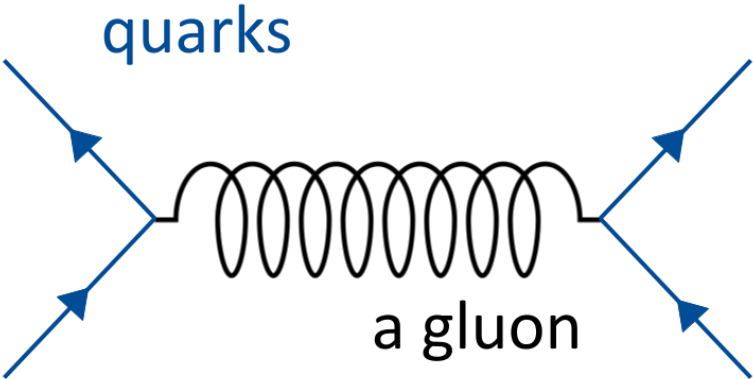
June 15<sup>th</sup>, 2022

# Lattice QCD



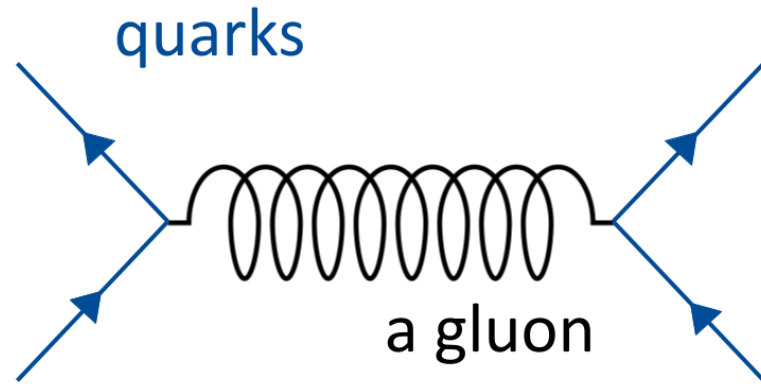
Quarks exchange gluons, an example of **strong interaction**.

# Lattice QCD

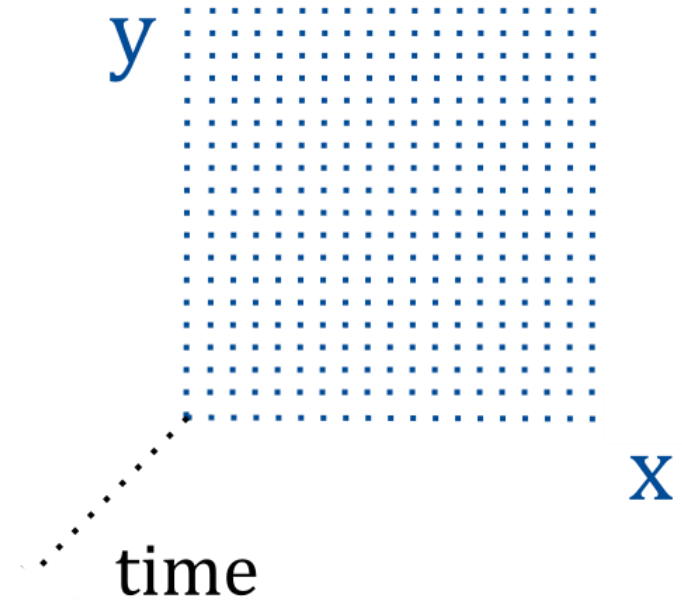


Quarks exchange gluons, an example of **strong interaction**.

# Lattice QCD



Quarks exchange gluons, an example of **strong interaction**.



Discretized space and time, also called a **lattice**.

# Computer Simulations

Currently, lattice QCD simulations run on **classical computers**.

# Computer Simulations

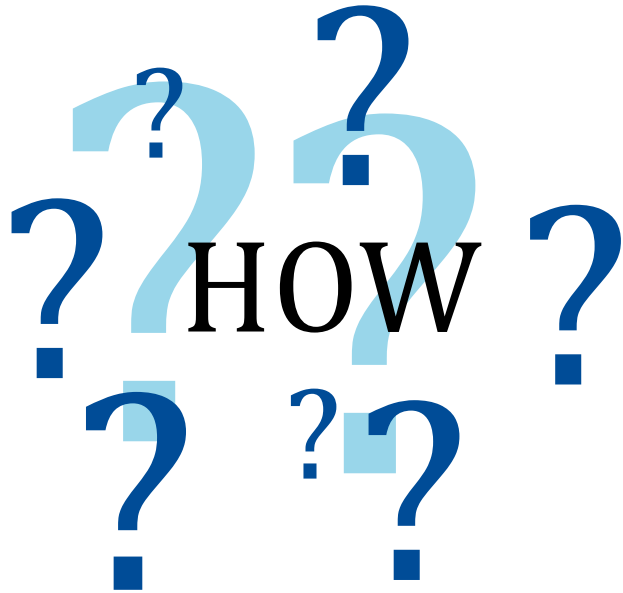
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We want to be able to run lattice QCD simulations on **quantum computers** to solve previously unsolvable problems in physics.

# Computer Simulations

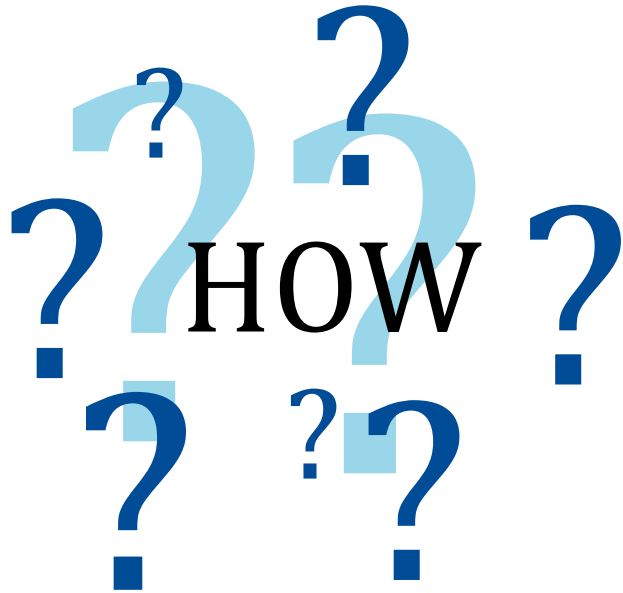
Currently, lattice QCD simulations run on **classical computers**.

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# Computer Simulations

Currently, lattice QCD simulations run on **classical computers**.



We want to be able to run lattice QCD simulations on **quantum computers** to solve previously unsolvable problems in physics.

**Motivating question:** How should gluons be digitized for lattice QCD simulations run on quantum computers?



# The Problem

The **gluon field** representation in current lattice QCD simulations for **classical computers** require lots of storage—even petabytes of storage.



$$M_{ab} \in SU(3)$$

I require too  
much storage!

# The Problem

The **gluon field** representation in current lattice QCD simulations for **classical computers** require lots of storage—even petabytes of storage. **Gluon field** representations that require less storage output incorrect physics.



$$M_{ab} \in SU(3)$$

I require too  
much storage!



$$N_{ab} \in S(1080)$$

I output  
incorrect physics.

# A Solution



$$N_{ab} \in S(1080)$$

I output incorrect physics.

# A Solution

**Gluon field** representations that require less storage may output correct physics if we modify the **gluon action**.

$$S_G \rightarrow S'_G$$



$$N_{ab} \in S(1080)$$

# My Task

```
code code code code code code
code code code code code code
code code code code code code
code gluon action code code
code code code code code code
code code code code code code
```

# My Task

Write **gluon actions** into lattice QCD simulations.

```
code code code code code code
code code code code code code
code code code code code code
code modified gluon action
code code code code code code
code code code code code code
```

# My Task

Write **gluon actions** into lattice QCD simulations.

Analyze and **compare simulation results** with known physics.

```
code code code code code code
code code code code code code
code code code code code code
code modified gluon action
code code code code code code
code code code code code code
```

```
>> output = correct physics?
```

# My Task

Write **gluon actions** into lattice QCD simulations.

Analyze and **compare simulation results** with known physics.

Once known, gluon digitization can be used for QCD simulations run on quantum computers to run **new simulations** and solve previously unsolvable problems.

```
code code code code code code
code code code code code code
code code code code code code
code modified gluon action
code code code code code code
code code code code code code

>> new solutions!
```