Johnny Hooyberghs

Microsoft Q# & Azure Quantum

ABN·AMRO

Microsoft Capgemini ORDINA

THE IT CONFERENCE FOR
MICROSOFT TECHNOLOGIES

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Johnny Hooyberghs

MVP Microsoft® Most Valuable Professional

@djohnnieke
github.com/Djohnnie
johnny.hooyberghs@involved-it.be

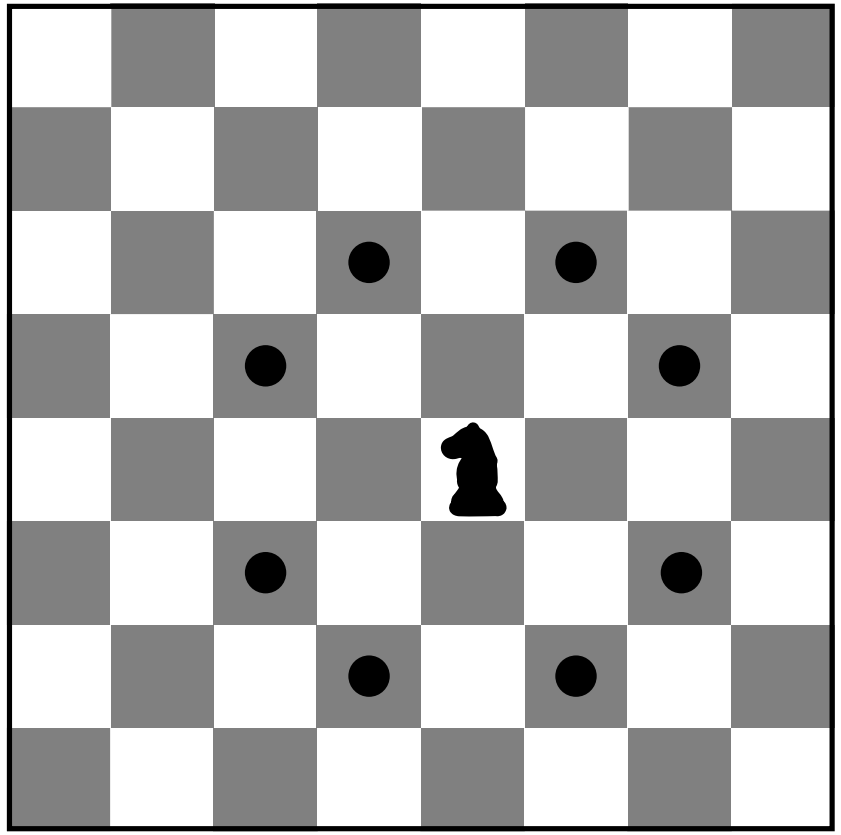
involved

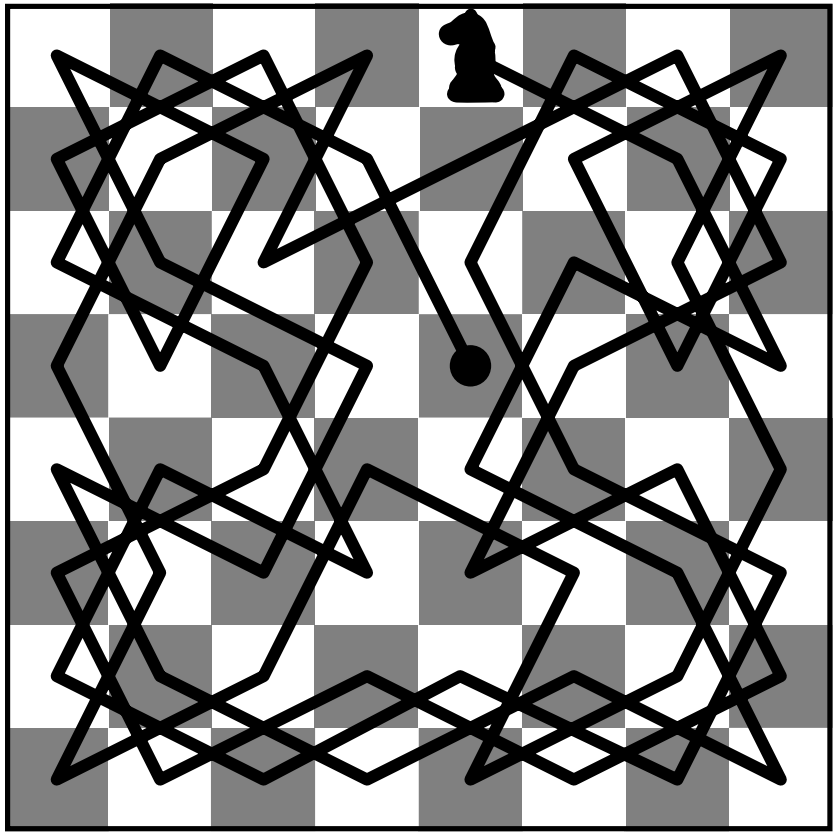
ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Why Quantum Computing?

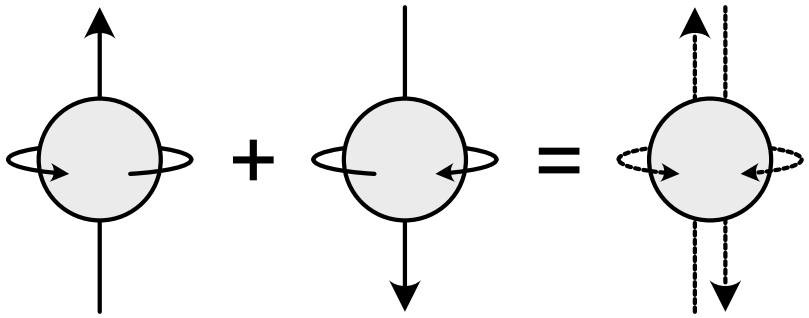


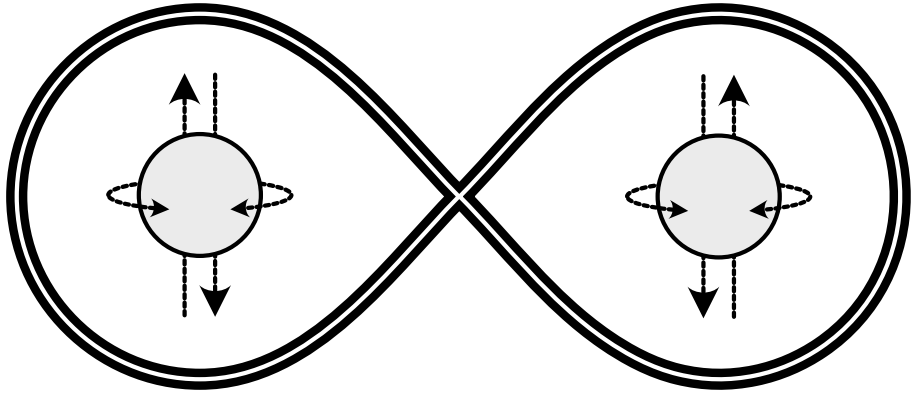


github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

Superposition and Entanglement

- Quantum mechanics describes superposition and entanglement of quantum particles
- Quantum computing can use these phenomena to its advantage





github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Why Quantum Computing?

- Security
  - Public/private key encryption?
  - Could make current RSA encryption obsolete
  - QKD (Quantum Key Distribution)

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Why Quantum Computing?

- Drug development
  - It takes a quantum system to simulate a quantum system
  - Interactions between molecules
  - Gene sequencing
  - Protein folding

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Why Quantum Computing?

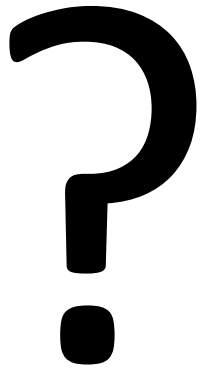
- Machine Learning
  - Analyze large quantities of data
  - Fast feedback
  - Emulate human mind

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Why Quantum Computing?



github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

CAN IT RUN CRYSIS?

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Bits vs. Qubits

0 1

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Bits vs. Qubits

1 0 0 1 1 0

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Bits vs. Qubits

$$|0\rangle \qquad |1\rangle$$

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Bits vs. Qubits

$$|100110\rangle$$

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state

$$\alpha|0\rangle + \beta|1\rangle$$

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state

$$\alpha|0\rangle + \beta|1\rangle$$

$$|\alpha|^2 + |\beta|^2 = 1$$

$$\alpha = a + bi$$

$$\beta = c + di$$

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state

$$\frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{2}}|1\rangle$$

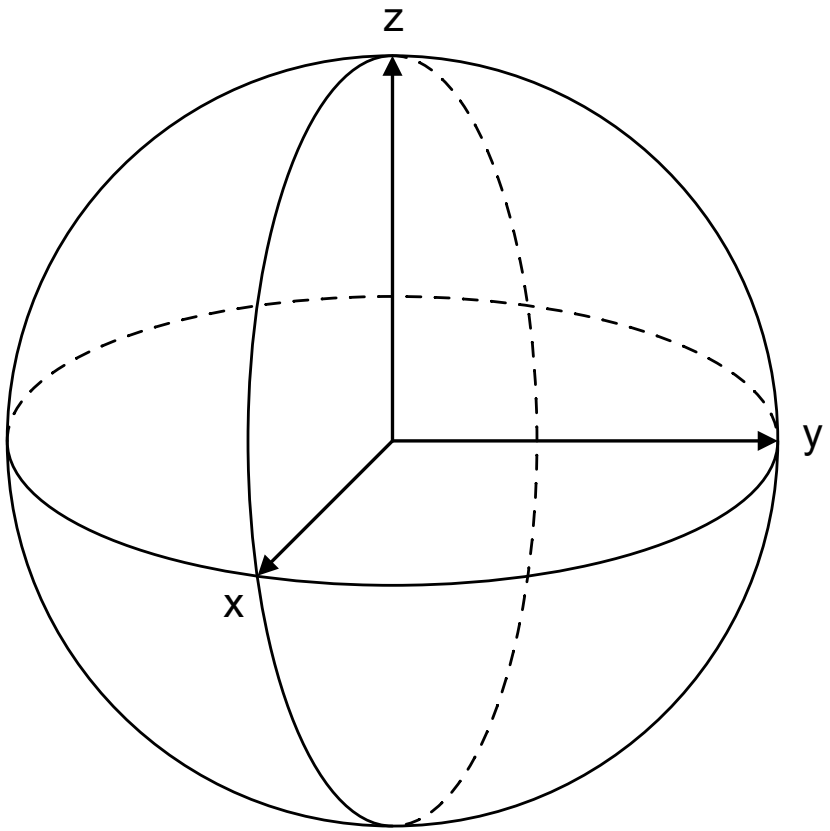
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

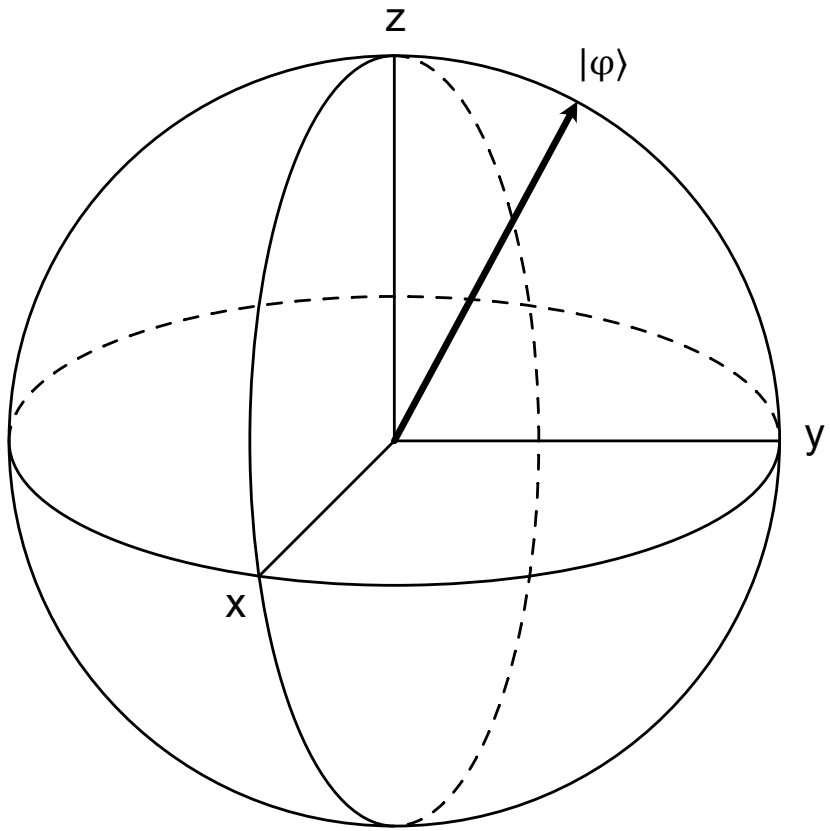
ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state





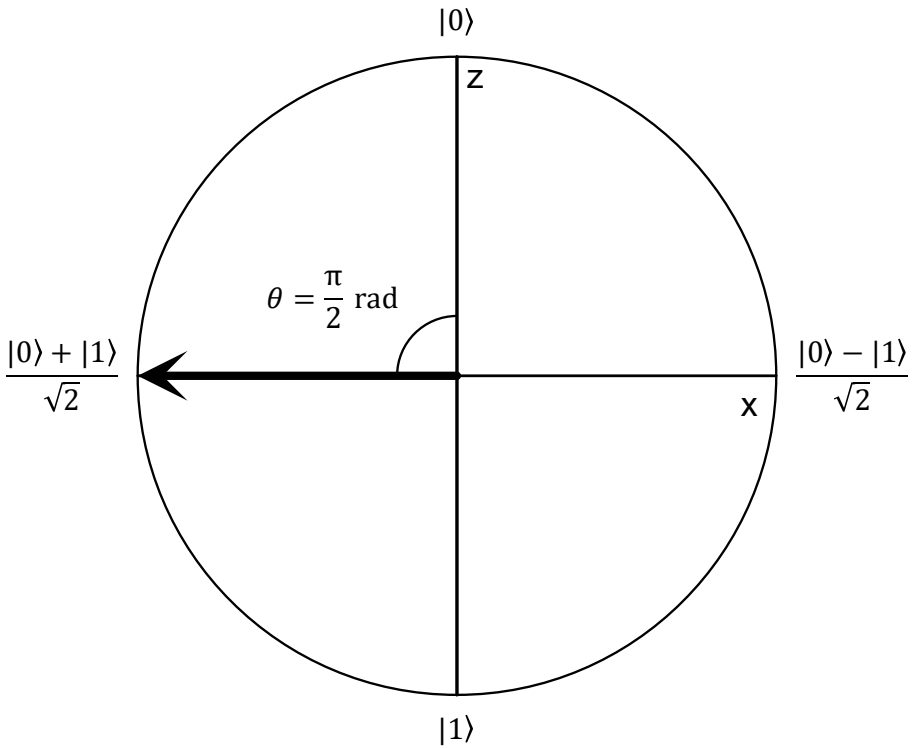
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

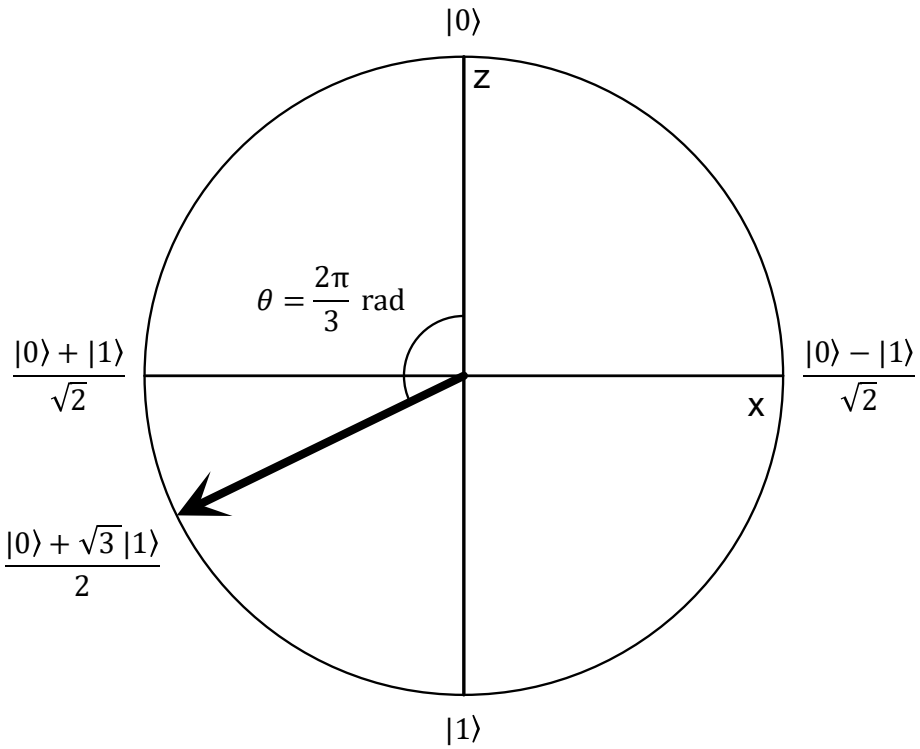
ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state





github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state

2 Qubit system (4 probabilities):

$$\boldsymbol{\alpha}|00\rangle + \boldsymbol{\beta}|01\rangle + \boldsymbol{\gamma}|10\rangle + \boldsymbol{\delta}|11\rangle$$

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum state

2 Qubit system (4 probabilities):

$$\boldsymbol{\alpha}|00\rangle + \boldsymbol{\beta}|01\rangle + \boldsymbol{\gamma}|10\rangle + \boldsymbol{\delta}|11\rangle$$

3 Qubit system (8 probabilities):

$$\boldsymbol{\alpha}|000\rangle + \boldsymbol{\beta}|001\rangle + \boldsymbol{\gamma}|010\rangle + \boldsymbol{\delta}|011\rangle + \boldsymbol{\varepsilon}|100\rangle + \boldsymbol{\epsilon}|110\rangle + \boldsymbol{\zeta}|101\rangle + \boldsymbol{\eta}|111\rangle$$

4 Qubit system (16 probabilities):

…

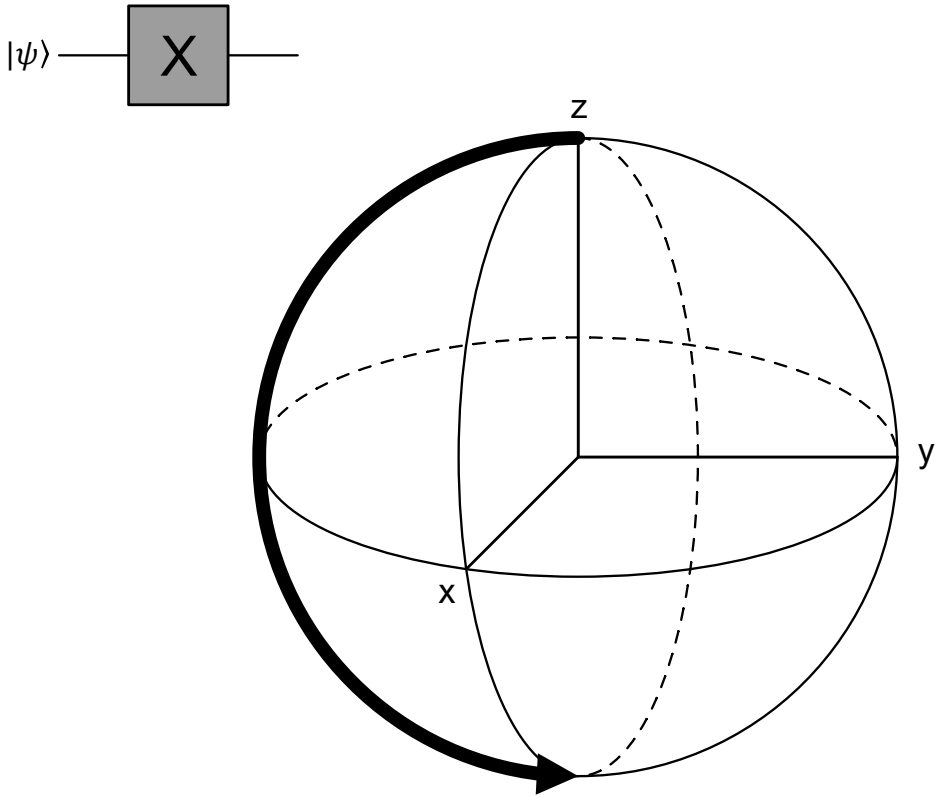
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

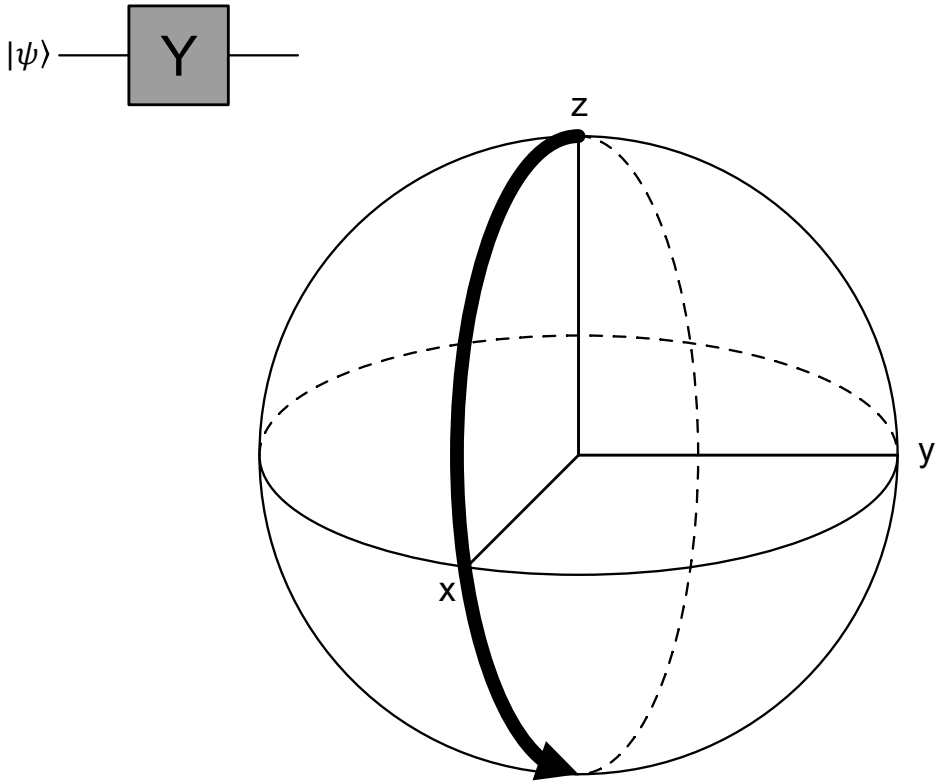
ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum Gates





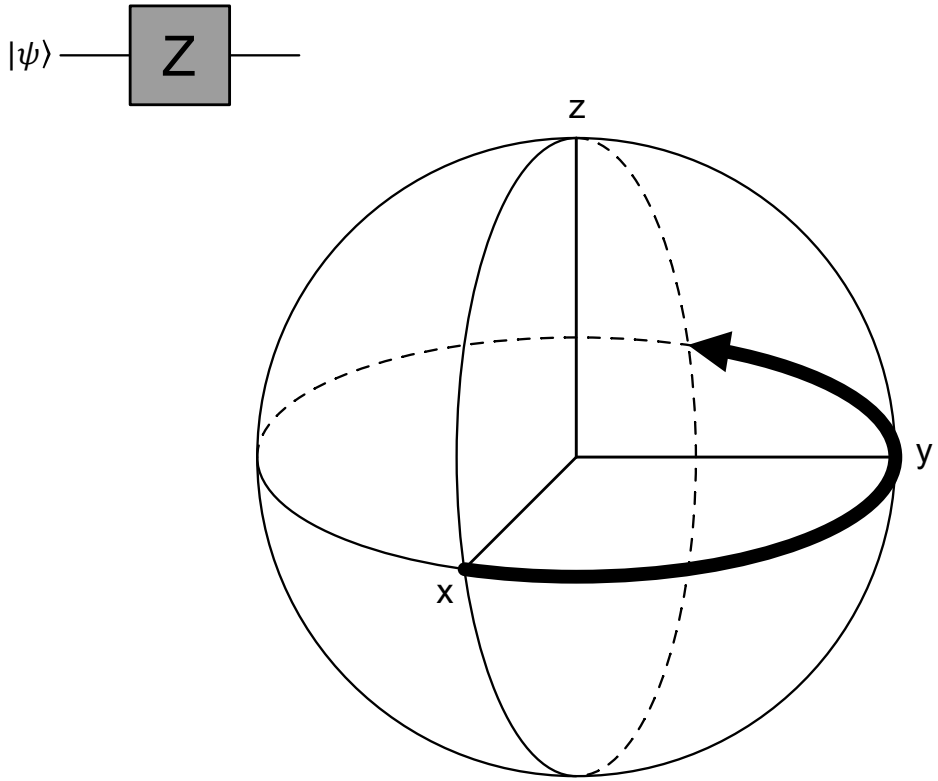
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

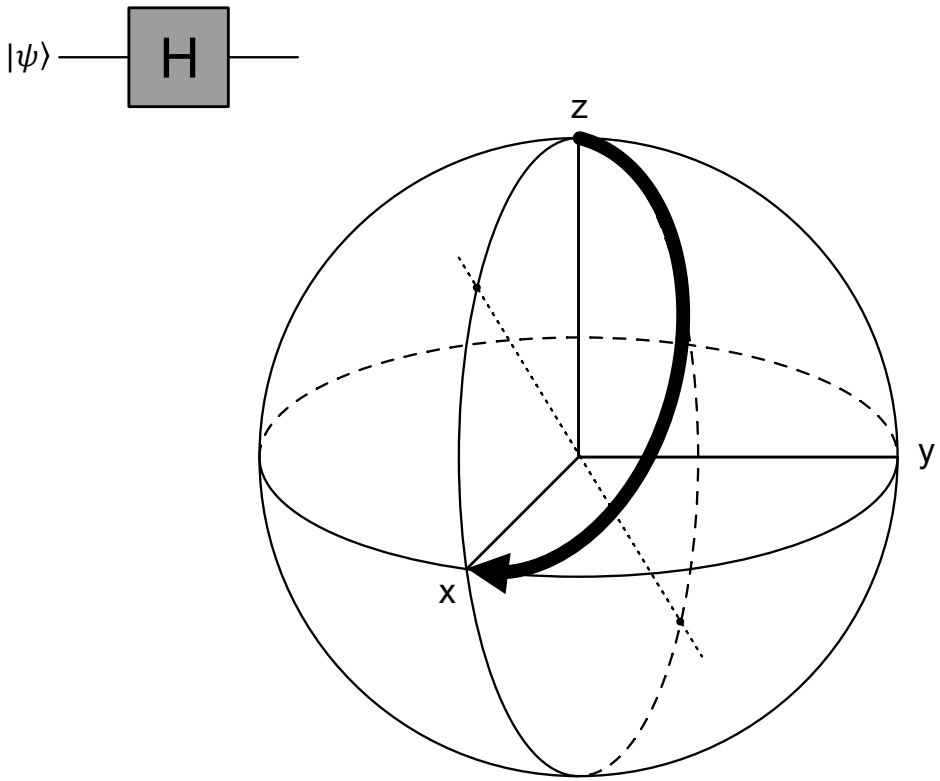
ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Quantum Gates





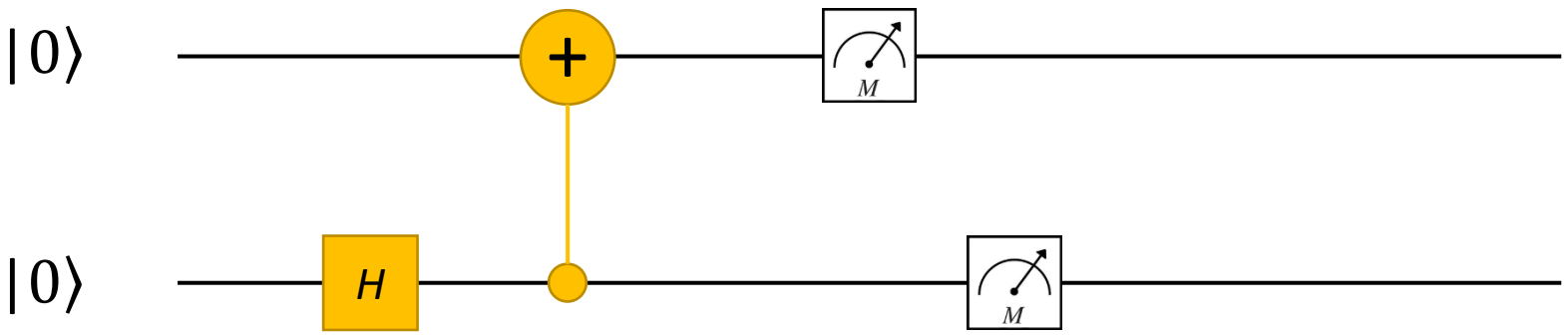
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Entanglement



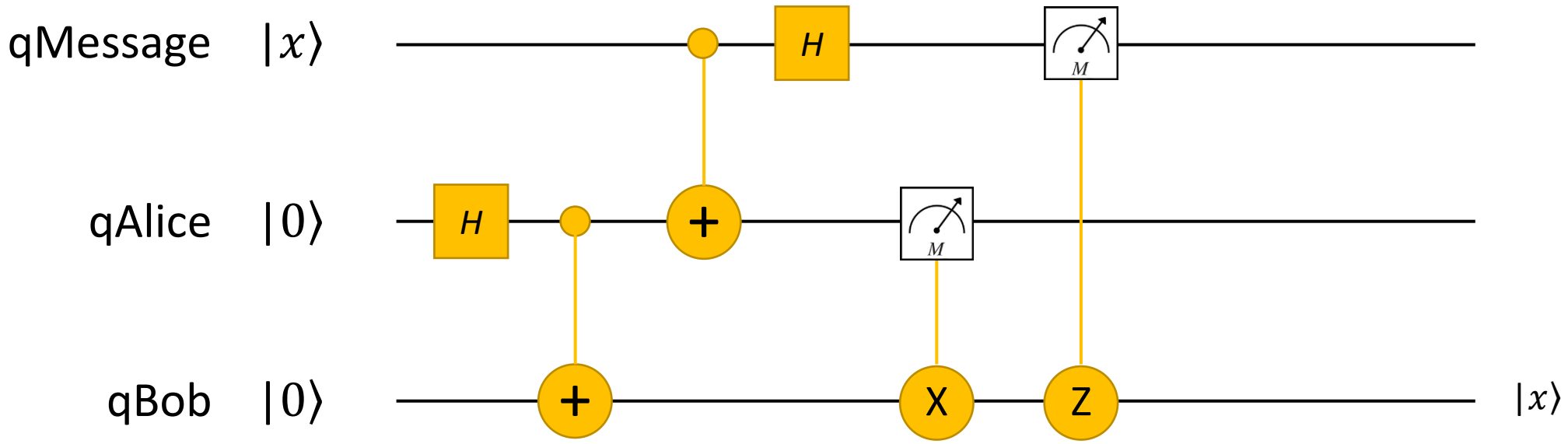
github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Entanglement



github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Azure Quantum

- Quantum in the cloud
  - Optimization
  - Machine Learning
  - Quantum Simulation
- Access to quantum hardware
  - Microsoft (Topological)
  - IonQ & Honeywell (Ion Traps)
  - QCI (Superconducting)
- Q# & QDK
  - Quantum Intermediate Representation (QIR)

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

Azure Quantum

- Quantum in the cloud
  - Optimization
  - Machine Learning
  - Quantum Simulation
- Access to quantum hardware
  - Microsoft (Topological)
  - IonQ & Honeywell (Ion Traps)
  - QCI (Superconducting)
- Q# & QDK
  - Quantum Intermediate Representation (QIR)

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

Thank You

github.com/Djohnnie/QSharp-and-AzureQuantum-FutureTech-2021

ABN·AMRO

Microsoft Capgemini ORDINA

FUTURE TECH 2021

THE IT CONFERENCE FOR MICROSOFT TECHNOLOGIES