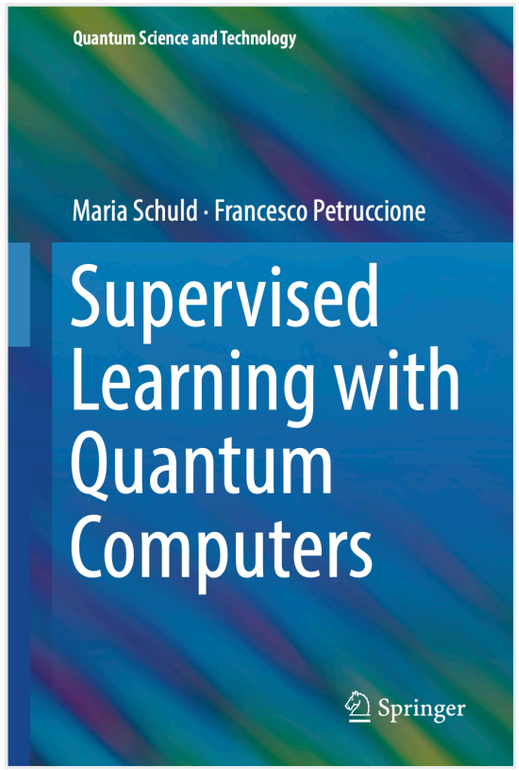
Introduction to Quantum Machine Learning

Ieva Čepaitė



Machine Learning

- **Learning**: finding patterns in previous experience which help us to deal with an unknown situation.

- *“Art and science of making computers learn from data how to solve problems instead of being explicitly programmed.”*

	Supervised	**Unsupervised**
Discrete	Classification, Categorisation	Clustering
Continuous	Regression	Dimensionality Reduction

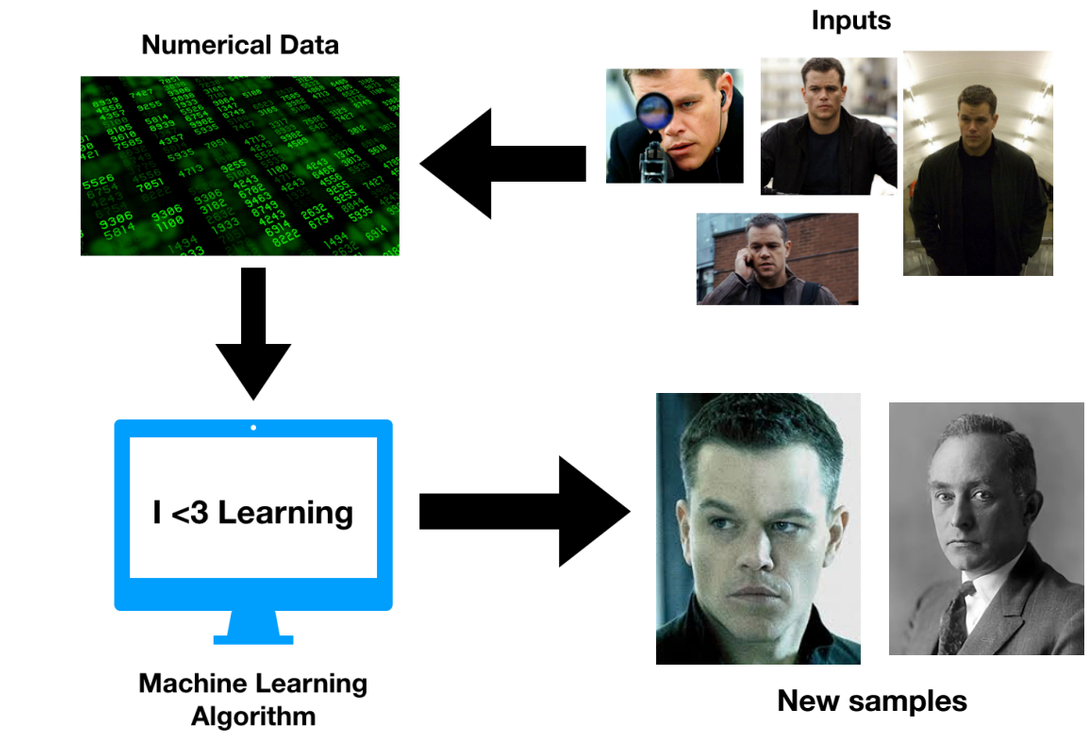
Generative models

vs.

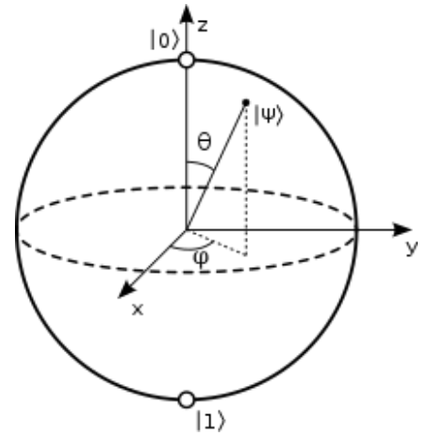
Classifiers

Machine Learning

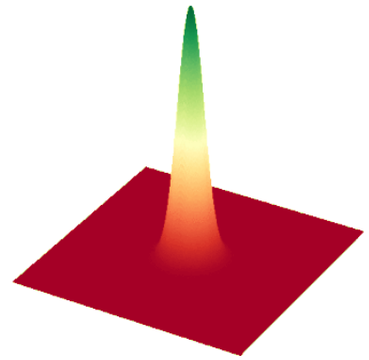
- **TRAINING DATA**:
    - Information we have that can help us reach the correct solution
- **MODEL**:
    - Spits out solutions: generator, classifier, etc.
- **PARAMETERS**
- **METRIC**
    - How close is the model to behaving in a way that we want it to?
- **TRAINING**

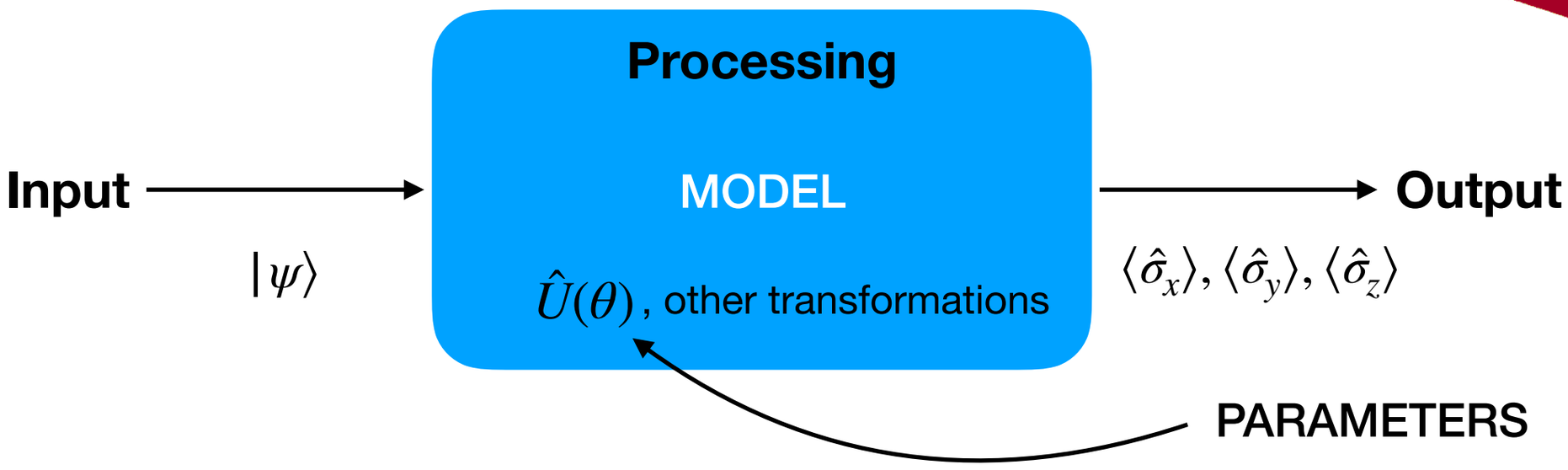


Reframing: Quantum Information



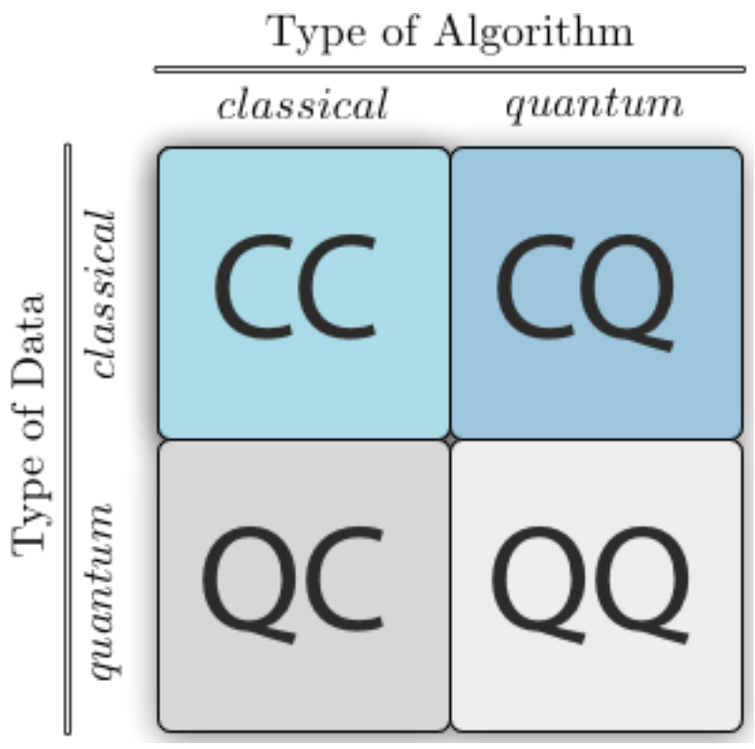
- New context for ML algorithms: **QC is a MODEL**.
- What can we do to the quantum state? (**Algorithms**)
  - *Hamiltonians, Unitary transformations*
- What information can we extract from it?
  - *Measurement: which observables?*



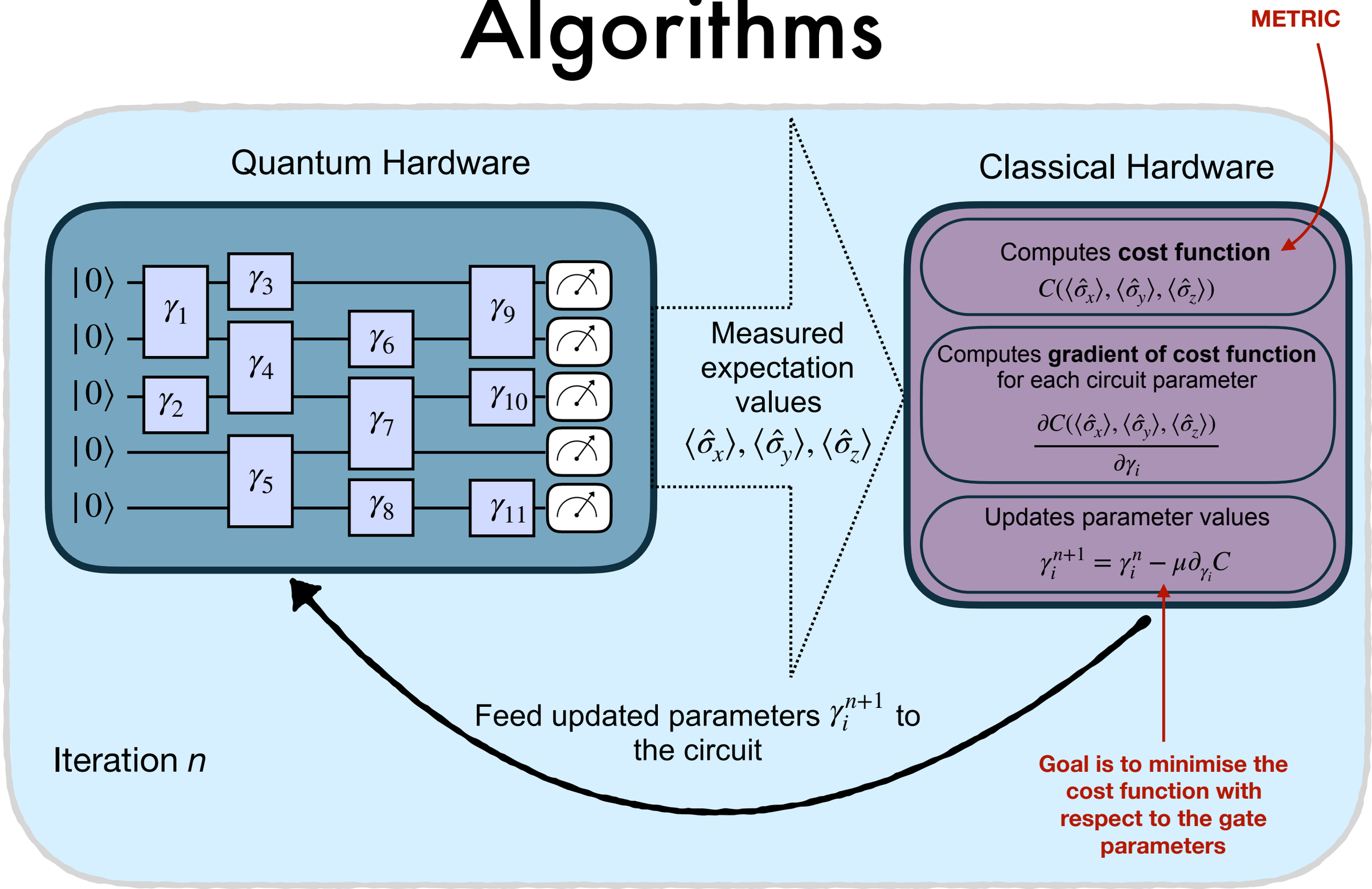


Quantum vs. Classical

- **CC**: Tensor Networks, Quantum-inspired ML algorithms
- **QC**: ML aided processing of Quantum data
- **CQ**: Quantum algorithms for processing classical data sources: basically ML with a quantum ‘touch’.
- **QQ**: ‘Quantum’ data (measurement outcomes OR states) fed into another quantum system.

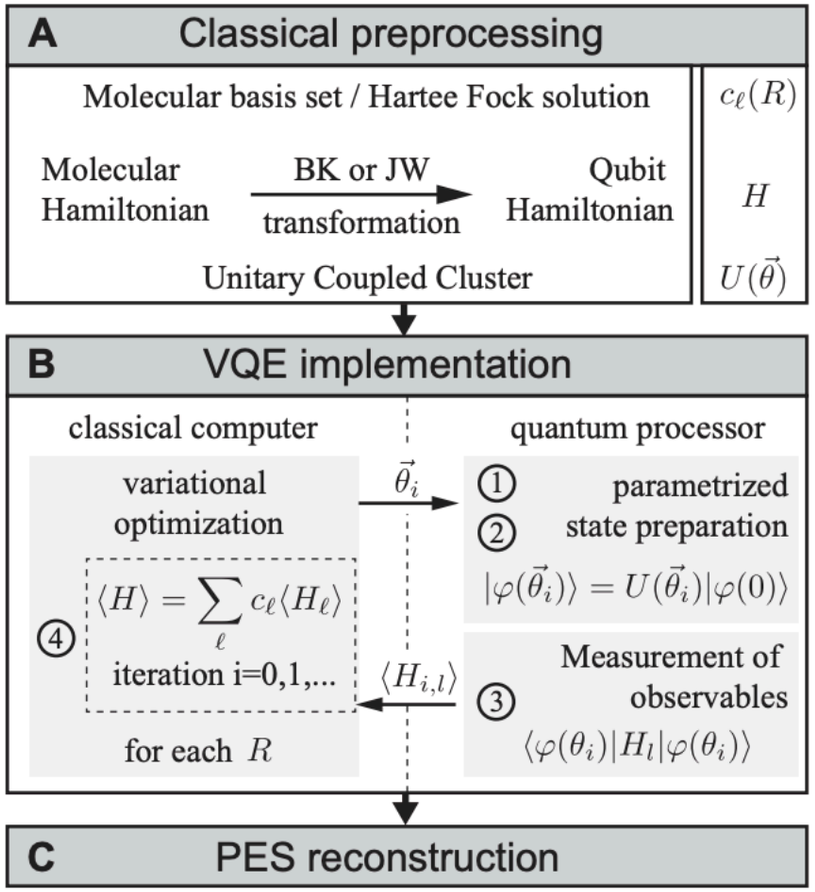


Variational Quantum Algorithms



Variational Quantum Eigensolver: An Example

1.



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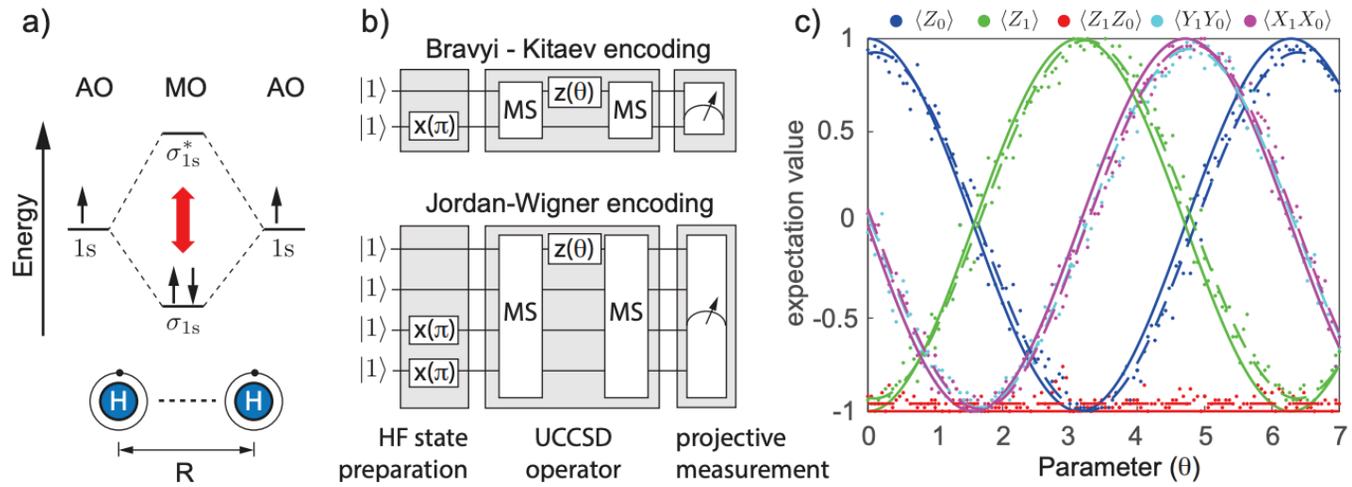

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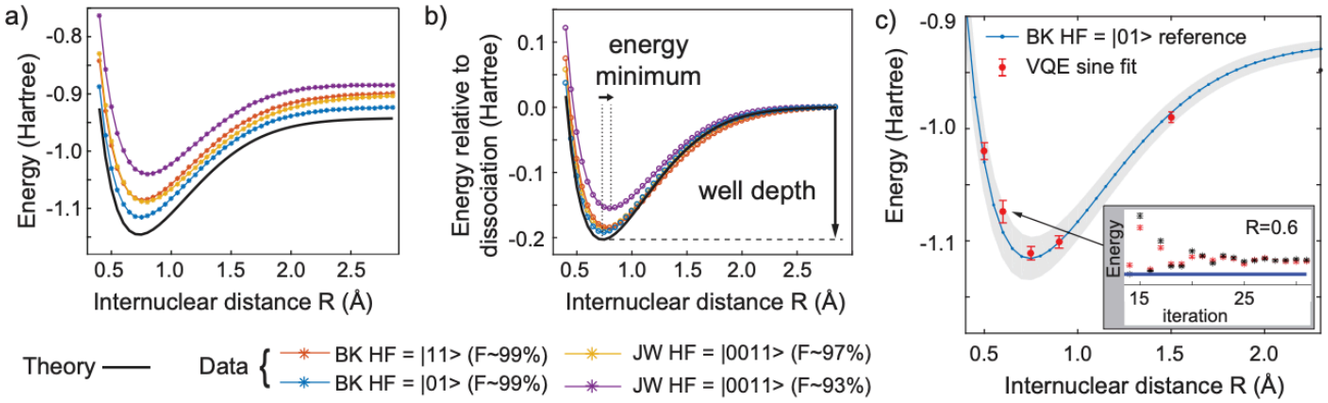

Quantum Chemistry Calculations on a Trapped-Ion Quantum Simulator

Cornelius Hempel, Christine Maier, Jonathan Romero, Jarrod McClean, Thomas Monz, Heng Shen, Petar Jurcevic, Ben P. Lanyon, Peter Love, Ryan Babbush, Alán Aspuru-Guzik, Rainer Blatt, and Christian F. Roos

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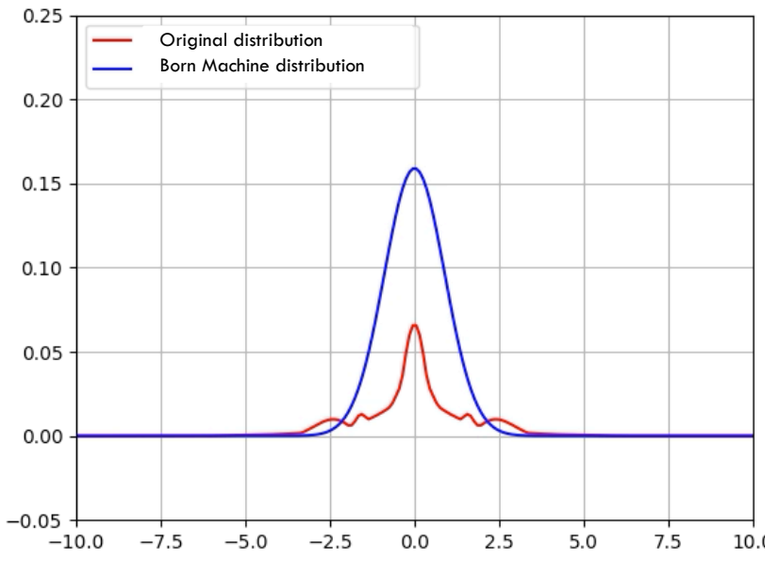
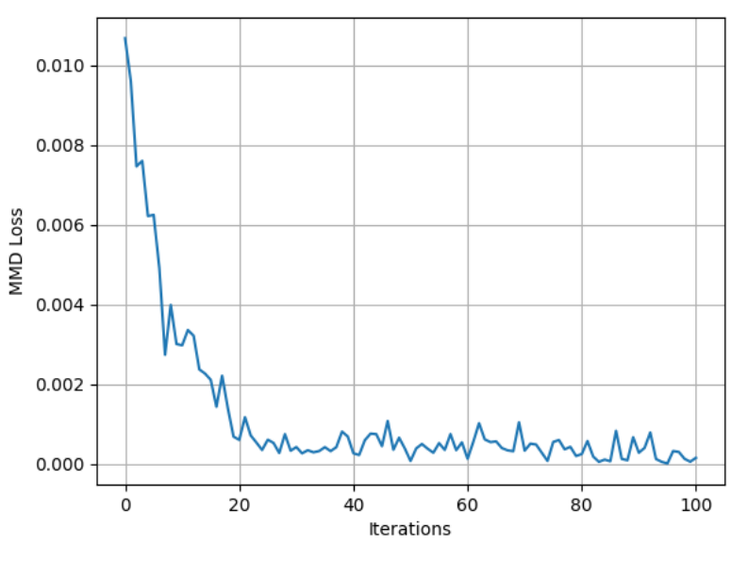
A Qumode Example:





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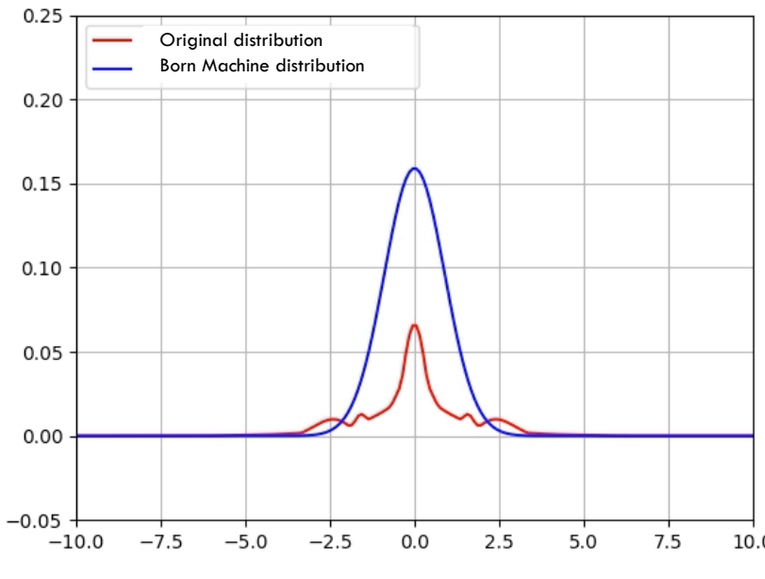

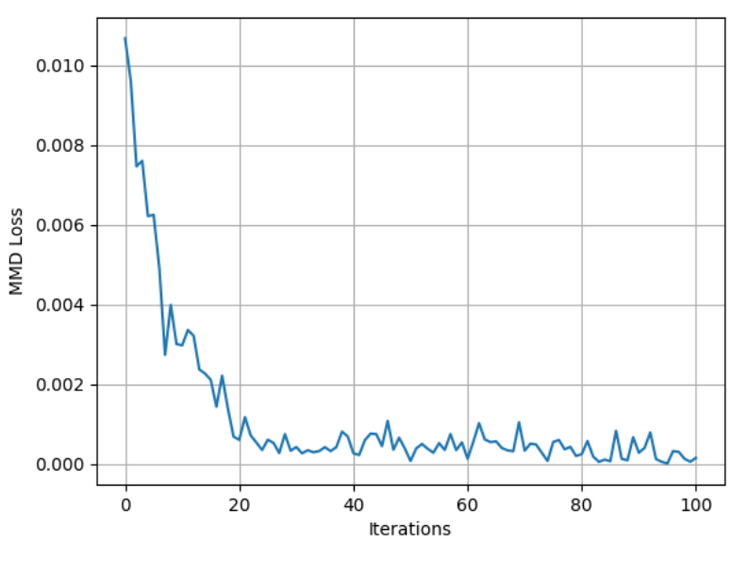

Questions?

References and further reading material:

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*Killoran, Nathan et al. "**Continuous-Variable Quantum Neural Networks**." Physical Review Research 1.3 (2019)*

*Hempel, Cornelius et al. "**Quantum Chemistry Calculations on a Trapped-Ion Quantum Simulator.**" Physical Review X 8.3 (2018)*

*Schuld, Maria & Petruccione, Francesco "**Supervised Learning with Quantum Computers**" Springer (2018)*

*Schuld, Maria et al. "**Evaluating Analytic Gradients on Quantum Hardware.**" Physical Review A 99.3 (2019)*

*Liu, Jin-Guo, and Lei Wang. "**Differentiable Learning of Quantum Circuit Born Machines**." Physical Review A 98.6 (2018)*

… and many, MANY more.