

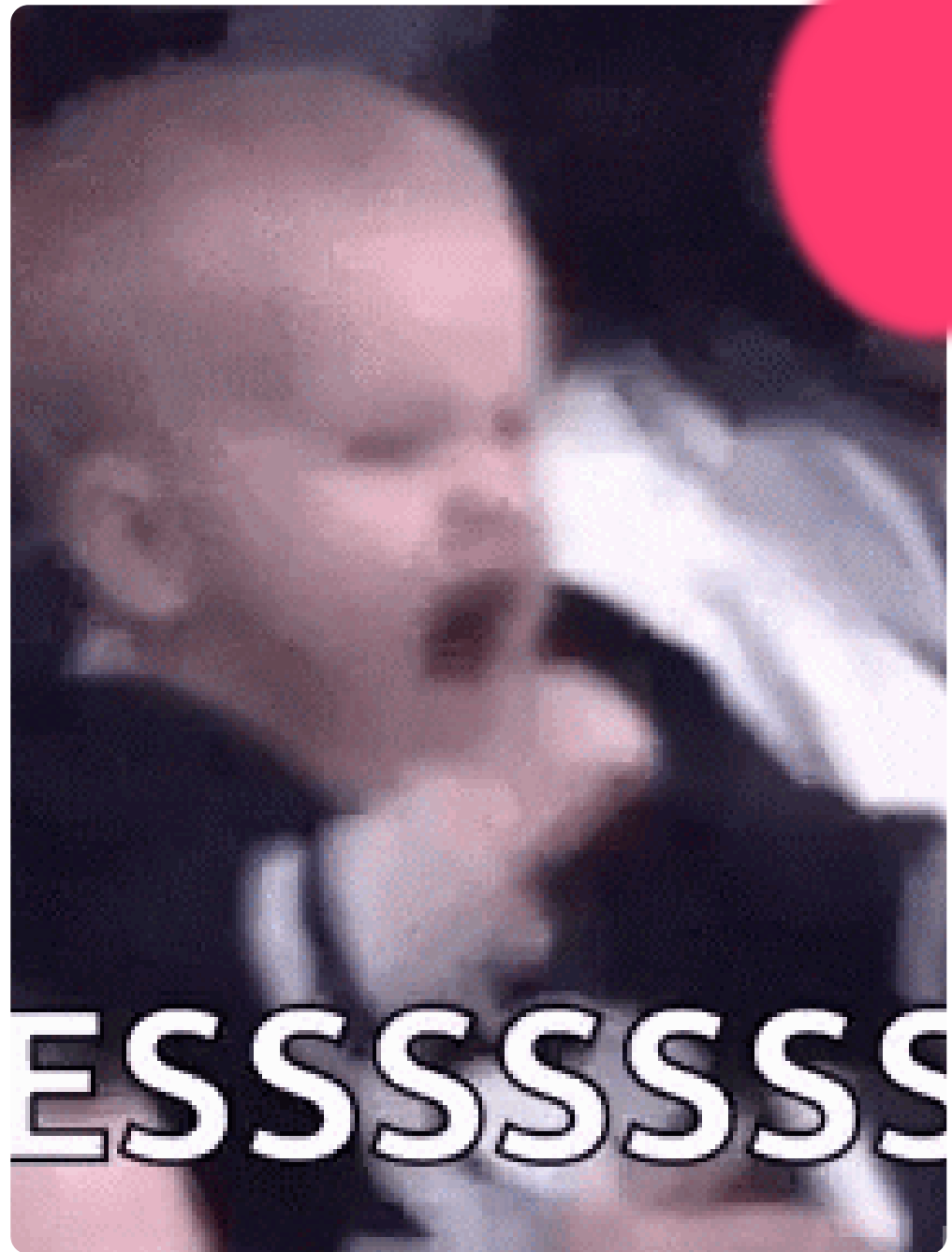
Programming Quantum Computers

Software tools zoo.

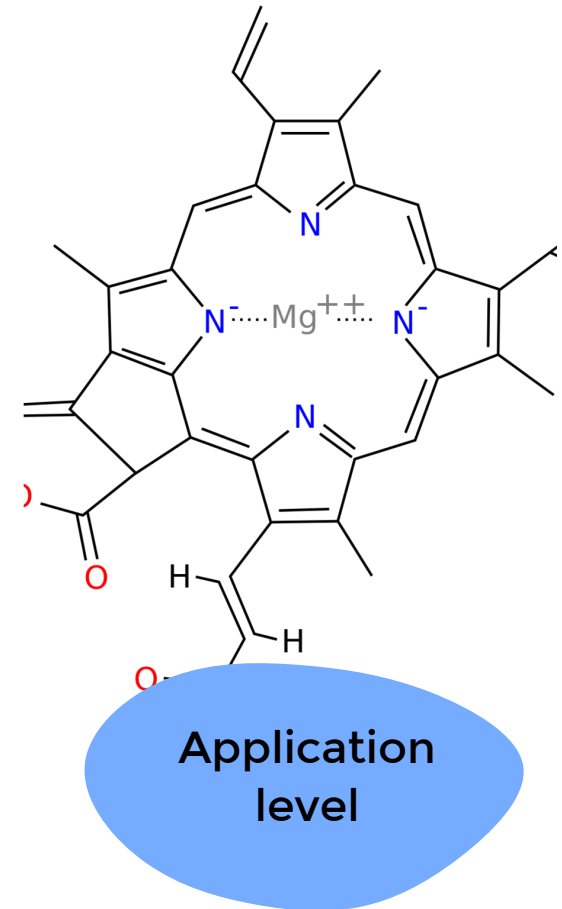
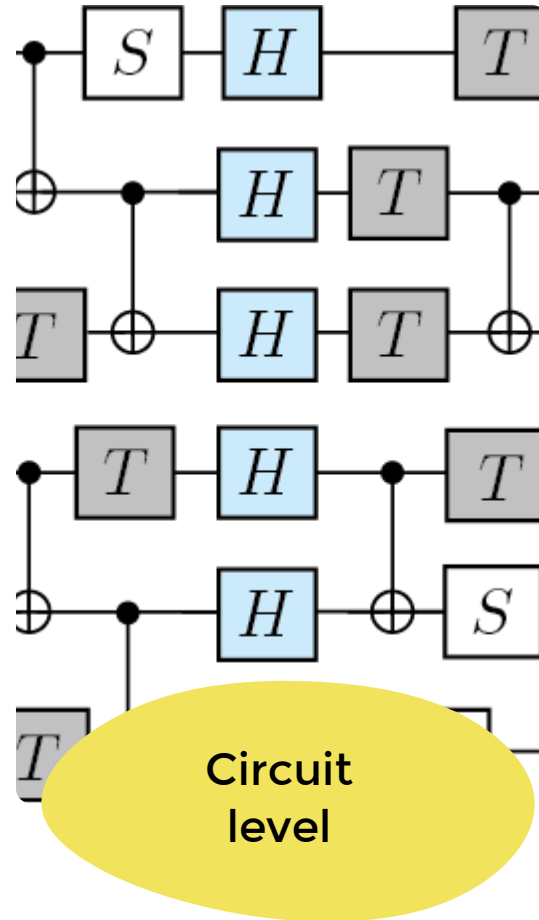
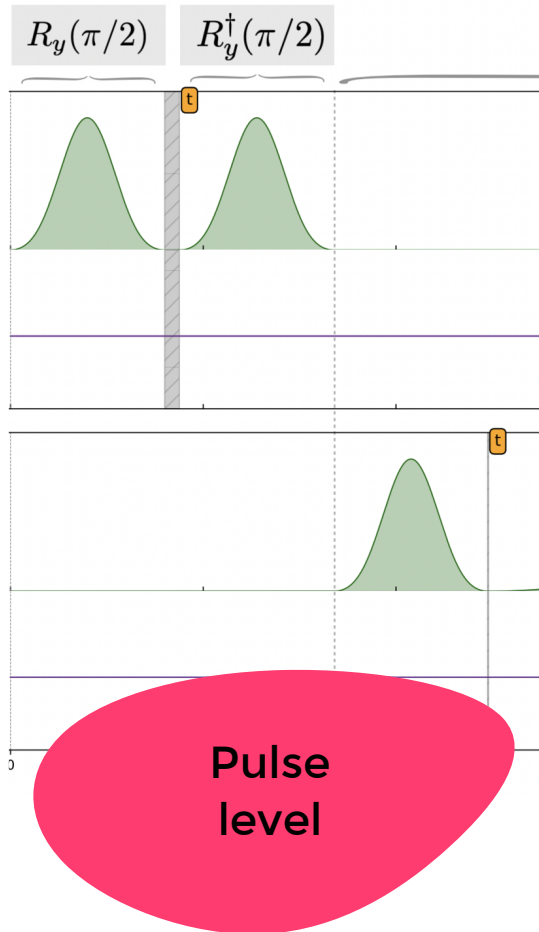
Ready?

In a moment you'll learn how to write quantum computer programs in one software framework, *Qiskit*.

Before that, we briefly present some other software frameworks.



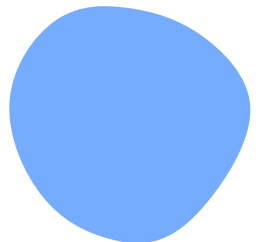
Software Levels





Overview

Name	Pulse level?	Circuit level?	Application layer?
Microsoft			
Google			
IBM			
Startup			
Startup			

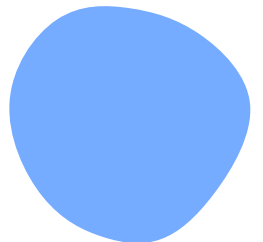





Microsoft Q#

Name	Pulse level?	Circuit level?	Application layer?
Q# (Microsoft)		✓	FT algorithms

- Programming language
- Integrated in MS development universe
 - E.g., quantum code can be called from C#
- Emphasis on fault tolerant QC
- Use on quantum device: No.





Google Cirq

Name	Pulse level?	Circuit level?	Application layer?
Cirq (Google)		✓	OpenFermion, TensorFlowQuantum

- Python based
- **Research tool** used in Google's publications
- OpenFermion: Package for electronic structure
 - Many cutting-edge methods (by Google) are implemented
- Integration with **TensorFlow** for quantum AI.
- Use on quantum device: E.g., AQT's trapped ions (www.aqt.eu)

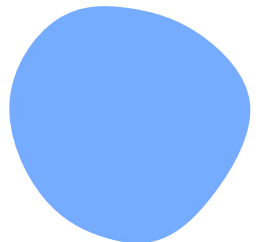


IBM's Qiskit

Name	Pulse level?	Circuit level?	Application layer?
Qiskit (IBM)	✓	✓	Machine Learning, "Nature", Finance, Optimization

- Python based
- Community tool
- *Very wide use*

- Use on quantum device by many companies





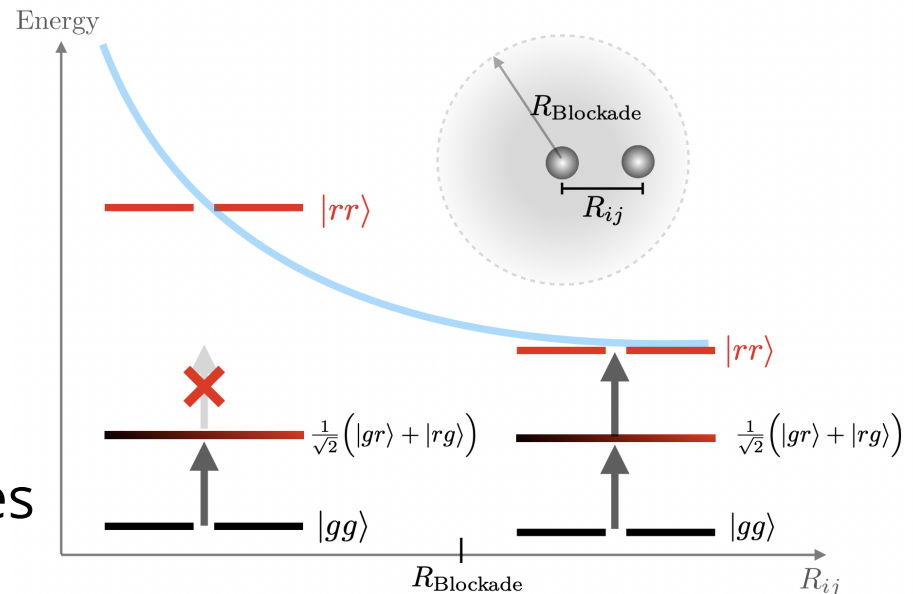
Pasqal's Pulser

Name	Pulse level?	Circuit level?	Application layer?
Pulser (Pasqal)	✔		

- *Pasqal* is a French startup
- `Pulser` is Python based
- Control Rydberg atoms

$$\mathcal{H}(t) = \sum_i \left(\frac{\hbar\Omega(t)}{2} \sigma_i^x - \hbar\delta(t) \hat{n}_i + \sum_{j < i} \frac{C_6}{(R_{ij})^6} \hat{n}_i \hat{n}_j \right)$$

- Use on Pasqal's quantum devices (up to ~250 qubits)





QuEra's Bloqade.jl

Name	Pulse level?	Circuit level?	Application layer?
Bloqade.jl (QuEra)	<input checked="" type="checkbox"/>		



- *QuEra* is a US startup
- Bloqade.jl is Julia based (not Python!)
- Control Rydberg atoms

- Use on quantum devices: Currently not.



Summary

Name	Pulse level?	Circuit level?	Application layer?
Q# (Microsoft)		✓	FT algorithms
Cirq (Google)		✓	OpenFermion, TensorFlowQuantum
Qiskit (IBM)	✓	✓	Machine Learning, "Nature", Finance, Optimization
Pulser (Pasqal)	✓		
Bloqade.jl (QuEra)	✓		

