A Reconfigurable Quantum Computer

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IonQ Highlights

Full Stack Quantum Computing Company

Venture Capital Backing from NEA, Google Ventures, Amazon

Spinoff from Duke and University of Maryland

Industry Leading Team in Trapped Ions

Proven Technology Operating Today with >50 Qubits
Qubits: The Challenges

- Stable, well-characterized physical system
- Ability to implement all "computing operations"
- Efficient algorithm execution
- Scalable beyond individual modules
IonQ: Demonstrated Full-Stack Solution

Fully-Functional Proof-of-Concept Quantum Computer

“The work represents a leap in the field of so-called quantum computers”

“The new prototype...is a step in that direction – a ‘very clear demonstration of flexible programmability and universality on a single hardware platform’”

“Previous attempts have made strides toward, but haven’t quite achieved, such versatility”
Ions: Nature’s Qubits

Each ion stores a qubit as a simple two-state system

Ions make impeccable qubits
  - Fundamentally quantum
  - Inherently identical & immutable
  - Highest demonstrated performance

Ions are “trapped” by classical electric fields in a vacuum
  - Perfect isolation using Si technology
  - Programmable and reconfigurable
  - At room temperature
Ion Qubit Computation

Laser beams are used to manipulate ion qubits (i.e. prepare any qubit state)
Ion Qubit Computation

Laser beams can also perform logic operations between qubits (e.g. manipulating pairs of ions)
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This also allows multi-qubit gates, e.g.
3-qubit gates...
Ion Qubit Computation

...and N-qubit gates!
IonQ vs Alternatives

System

Connectivity

Algorithm Success Probability*

TRAPPED IONS
Fully Connected

Superconducting Loops
Star Connected

Superconducting Loops
Adjacent Connected

*2017 Proceedings of the National Academy of Sciences, “Experimental Comparison of Two Quantum Computing Architectures”
Connectivity Matters

Not all 20-qubit systems are created equally.
Fully Integrated System

**Software**
Program, Control, UX

**Hardware**
Controlling Qubits

- Focused development on “Quantum OS”
- Quantum-computing programing language and compiler
- Customer-optimized user interface
- Hardware control system

- Fully Connected System
- High Fidelity Qubit Hardware
- Lab-scale Prototype: Today
Software Strategy

Simple | Elegant, Easy-to-use, Approachable API and SDK

Extensible | Evolving Domain-Specific Libraries

Manageable | All the Benefits of a Cloud-based Service

Powerful | Unmatched Tools, Simulation and Hardware

Flexible | Developer-first, Developer-friendly
Cloud Integrated Development Environment
Iterative programs are executed in a **classical sandbox** co-located with the quantum computer.
IonQ Design System

Fully programmable, general purpose machine

Supports engaging with a broad set of potential users

Best-in-kind performance on algorithm execution

Compelling roadmap for future scalability
The Full Power of Quantum