

# Superconducting Technologies for Quantum Information Science

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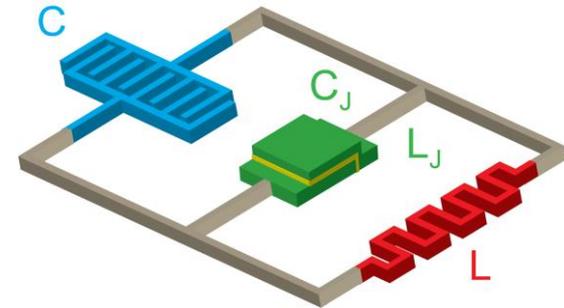
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# Superconducting QIS Toolbox: Evolution

## Classical Precursors

- **High-Q cavities**  $\bar{n} \gg 1$
- **Nonlinear Osc.**  $\bar{n} \gg 1$
- **Bolometers**  $S \gg \bar{n} = 1$
- **Amplifiers**  $T_N \gg \bar{n} = 1$



## Single Quantum Devices

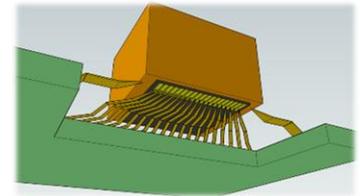
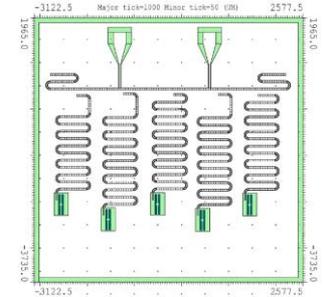
- **High-Q cavities**
  - i. Fock states, Cat states
  - ii. Squeezed states
- **Qudits (1-10)**
- **Single Photon Detectors**
  - i. SNSPD (IR-Optical)
  - ii. Microwave devices...
- **“Quantum-Noise” Limited Amps**
  - i. SQUID/SLUG
  - ii. Parametric Amplifiers



Many-Body Quantum States of Microwave Light and Engineered Matter with Long-Lived Coherence

# Grand Challenges for Superconducting Circuits

- Development of 10-10,000 coupled, coherent qubits
  - Advanced fabrication & packaging of 3D structures
  - Efficient means for classical control (pulses, readout, ...)
- Development of quantum control / feedback protocols
  - Efficient measurement of many-body entanglement
  - Interface with optical devices



# On the Horizon for Circuits...

- **Single Microwave Photonics**
  - Sources, detectors, interface with mechanics & optics, ...
- **Metrology with Squeezed Microwave Light**
  - Light-matter interaction, multimode squeezing, ...
- **Interface with Astronomy/Cosmology**
  - Multiplexed low-noise arrays, Axion detectors, ...
- **Quantum Simulation**
  - Quantum chemistry, topological matter, gauge fields, ...
- **Quantum Thermodynamics**
  - Energy transfer, thermalization, entanglement entropy, ...
- **Quantum Control & Complexity**
  - Cross-fertilization with condensed matter physics, cosmology, high-energy physics, (biology ?), ...

# General Recommendations for Progress

- **Support Hardware Development of Quantum Machines for Basic Science**  
(e.g. Specialized computing, user facilities, advanced materials,... )
- **Support Quantum Software Development for Basic Science**  
(e.g. QVV for simulations)
- **Support Development of Quantum Enhanced Sensors**  
(c.f. DOE & NSF support for astronomy)
- **Support Multidisciplinary Discussion Platforms**  
(c.f. NATO & European Summer Schools)